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Soil Taxonomy

A Basic System of Soil Classification for Making and Interpreting Soil Surveys

Second Edition, 1999

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By Soil Survey Staff

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Foreword

The second edition of *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys* is the result of the collective experience and contributions of thousands of pedologists from around the world.

This new edition includes many improvements. Two new soil orders, Andisols and Gelisols, are added. Low-activity clays are defined, and taxa are developed. The Aridisol, Alfisol, Histosol, Inceptisol, Mollisol, Oxisol, Spodosol, and Vertisol orders are updated. Aquic conditions, episaturation, and oxyaquic subgroups are defined. Additions and improvements are made at the family level.

We are indebted to our many colleagues throughout the world who contributed soil descriptions and data, comments, suggestions, and criticisms. We are especially grateful to all of those who organized and hosted workshops and training sessions. Many pedologists provided input to the International Committees (ICOM's), and we are thankful for their participation. Although we cannot list everyone who offered assistance, we do want to acknowledge the chairpersons of the various ICOM's.

ICOM	*Chairperson*	*Institute*
Low Activity Clays	Frank Moormann	Univ. of Utrecht
Oxisols	Stan Buol	North Carolina State Univ.
Andisols	Frank Leamy	Soil Bureau, Lower Hutt
Aquic Soils	Johan Bouma	Agricultural Univ., Wageningen
Spodosols	Robert Rouke	Univ. of Maine
Vertisols	Juan Comerma	Univ. Centro Venezuela
Aridisols	Ahmed Osman	Arab Center for the Studies of Arid Zones and Dry Lands
Soil Families	Ben Hajek	Auburn Univ.
Gelisols	James Bockheim	Univ. of Wisconsin

Although many improvements have been made since Dr. Guy Smith headed the effort to publish the first edition of *Soil Taxonomy*, there are still areas that will require a concerted effort to improve. The taxonomic system will continue to evolve as the science matures.

The taxonomic system does not adequately address the anthropogenic effects on soils. Soils in urban/industrial areas can be drastically altered by landfills, farming, earth movement, and heavy metal contamination. Agricultural areas have undergone erosion, ripping, and land leveling. Drastically disturbed soils are common in regions where precious metals, rock aggregate, and fossil fuels have been mined. The International Committee on Anthropogenic Soils (ICOMANTH), chaired by Dr. Ray Bryant, is currently meeting the challenge of developing appropriate taxa for these unique soils.

Soil moisture regimes and intergrades of soil moisture regimes need to be better defined. Some of the temperature regimes need refinement. The International Committee on Soil Moisture and Temperature Regimes (ICOMMOTR), chaired by Dr. Ron Paetzold, is gathering data to make needed improvements.

The system of soil taxonomy currently does not provide for paleosols formed under remarkably different paleoenvironments. With age, the properties of soils from paleo and contemporaneous environments become welded. Yet, when paleosols are well preserved, they are valuable proxies of the biological and physiochemical evolution of the earth. Many paleosols are deeper than the 2 m limit set by the current system of soil taxonomy. There is now and will continue to be pressure to observe and classify soils beyond the 2 m limit.

Many pedologists developed proposals, made comments and suggestions, and reviewed chapters for this second edition. Because of the concerted effort of many, the author of this publication is identified as the "Soil Survey Staff."

We would like to acknowledge those who helped write chapters or provide data for figures, maps, and tables. They include Dr. Arnt Bronger, Dr. Hari Eswaran, Dr. Samuel Indorante, Dr. John Kimble, Henry Mount, Loyal Quandt, Paul Reich, Sharon Waltman, and Dr. John Witty. Dr. Stanley Anderson had the arduous task of editing the second edition. Suzann Meierdierks and Dr. Patricia West provided their able assistance in the editing and formatting process. Adrian Smith, Christopher Roll, and Nathan Kress provided invaluable GIS expertise. Lastly, Dr. Robert Ahrens coordinated the effort. He and Robert Engel worked tirelessly during the past few years to prepare this edition.

Assistance in acquiring photographs for this publication was provided by the Kentucky Association of Soil Classifiers; the Washington Society of Professional Soil Scientists; the University of Nebraska Press and Andrew A. Aandahl; the Alaska/Yukon Society of Professional Soil Scientists; the Florida Association of Professional Soil Classifiers; the Society of Soil Scientists of Southern New England—Massachusetts; the Kansas Association of Professional Soil Classifiers; the Soil Classifiers Association of Michigan; the Professional Soil Classifiers Association of Alabama; the Professional Soil Scientists Association of Texas; and members of the National Cooperative Soil Survey.

Horace Smith
Director, Soil Survey Division

CHAPTER 1

The Soils That We Classify

The word "soil," like many common words, has several meanings. In its traditional meaning, soil is the natural medium for the growth of land plants, whether or not it has discernible soil horizons. This meaning is still the common understanding of the word, and the greatest interest in soil is centered on this meaning. People consider soil important because it supports plants that supply food, fibers, drugs, and other wants of humans and because it filters water and recycles wastes. Soil covers the earth's surface as a continuum, except on bare rock, in areas of perpetual frost or deep water, or on the bare ice of glaciers. In this sense, soil has a thickness that is determined by the rooting depth of plants.

About 1870, a new concept of soil was introduced by the Russian school led by Dokuchaiev (Glinka, 1927). Soils were conceived to be independent natural bodies, each with a unique morphology resulting from a unique combination of climate, living matter, earthy parent materials, relief, and age of landforms. The morphology of each soil, as expressed by a vertical section through the differing horizons, reflects the combined effects of the particular set of genetic factors responsible for its development.

This was a revolutionary concept. One did not need to depend wholly on inferences from the underlying rocks, the climate, or other environmental factors, considered singly or collectively; rather, the soil scientist could go directly to the soil itself and see the integrated expression of all these in its morphology. This concept made it not only possible but also necessary to consider all soil characteristics collectively, in terms of a complete, integrated, natural body, rather than individually. Thus, the effect of any one characteristic or a difference in any one depends on the others in the combination. Experience has shown that no useful generalizations about single characteristics can be made for all soils. Characteristics are given weight according to the knowledge gained through research and experience in soil genesis and the responses of soil to management or manipulation. Both research in genesis and the responses of soils have vital roles, but they are themselves one step removed from the taxonomy of the soil, which is based on combinations of soil characteristics. In short, the new concept made pedology possible.

The Russian view of soils as independent natural bodies that have genetic horizons led to a concept of soil as the part of the earth's crust that has properties reflecting the effects of local and regional soil-forming agents. The solum in that concept is the set of genetic horizons developed by soil-building forces, but the parent material beneath is nonsoil. This concept has limitations. If a solum is 1 or 2 m thick, there is little conflict between the concept of soil as solum and the concept of soil as the natural medium for the growth of terrestrial plants. If genetic horizons are thin or absent and unconsolidated parent material lies at or only a few centimeters below the surface, there is serious conflict between the concepts. Dokuchaiev realized this conflict and, despite the lack of horizons, included young alluvium and peat in his classification of soil.

Soil in this text is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter *or* the ability to support rooted plants in a natural environment. This definition is expanded from the previous version of *Soil Taxonomy* to include soils in areas of Antarctica where pedogenesis occurs but where the climate is too harsh to support the higher plant forms.

The upper limit of soil is the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose. Areas are not considered to have soil if the surface is permanently covered by water too deep (typically more than 2.5 m) for the growth of rooted plants. The horizontal boundaries of soil are areas where the soil grades to deep water, barren areas, rock, or ice. In some places the separation between soil and nonsoil is so gradual that clear distinctions cannot be made.

The lower boundary that separates soil from the nonsoil underneath is most difficult to define. Soil consists of the horizons near the earth's surface that, in contrast to the underlying parent material, have been altered by the interactions of climate, relief, and living organisms over time. Commonly, soil grades at its lower boundary to hard rock or to earthy materials virtually devoid of animals, roots, or other marks of biological activity. The lowest depth of biological activity, however, is difficult to discern and is often gradual. For purposes of classification, the lower boundary of soil is arbitrarily set at 200 cm. In soils where either biological activity or current pedogenic processes extend to depths greater than 200 cm, the lower limit of the soil for classification purposes is still 200 cm. In some instances the more weakly cemented bedrocks (paralithic materials, defined later) have been described and used to differentiate soil series (series control section, defined later), even though the paralithic materials below a paralithic contact are not considered soil in the true sense. In areas where soil has thin cemented horizons that are impermeable to roots, the soil extends as deep as the deepest cemented horizon, but not below 200 cm. For certain management goals, layers deeper than the lower boundary of the soil that is classified (200 cm) must also be described if they affect the content and movement of water and air or other interpretative concerns.

In the humid tropics, earthy materials may extend to a depth of many meters with no obvious changes below the upper 1 or 2 m, except for an occasional stone line. In many wet soils, gleyed soil material may begin a few centimeters below the surface and, in some areas, continue down for several meters apparently unchanged with increasing depth. The latter condition can arise through the gradual filling of a wet basin in which the A horizon is gradually added to the surface and becomes gleyed beneath. Finally, the A horizon rests on a thick mass of gleyed material that may be relatively uniform. In both of these situations, there is no alternative but to set the lower limit of soil at the arbitrary limit of 200 cm.

Soil, as defined in this text, does not need to have discernible horizons, although the presence or absence of horizons and their nature are of extreme importance in soil classification. Plants can be grown under glass in pots filled with earthy materials, such as peat or sand, or even in water. Under proper conditions all these media are productive for plants, but they are nonsoil here in the sense that they cannot be classified in the same system that is used for the soils of a survey area, county, or even nation. Plants even grow on trees, but trees are regarded as nonsoil.

Soil has many properties that fluctuate with the seasons. It may be alternately cold and warm or dry and moist. Biological activity is slowed or stopped if the soil becomes too cold or too dry. The soil receives flushes of organic matter when leaves fall or grasses die. Soil is not static. The pH, soluble salts, amount of organic matter and carbon-nitrogen ratio, numbers of micro-organisms, soil fauna, temperature, and moisture all change with the seasons as well as with more extended periods of time. Soil must be viewed from both the short-term and long-term perspective.

Buried Soils

A buried soil is covered with a surface mantle of new soil material that either is 50 cm or more thick or is 30 to 50 cm thick and has a thickness that equals at least half the total thickness of the named diagnostic horizons that are preserved in the buried soil. A surface mantle of new material that does not have the required thickness for buried soils can be used to establish a phase of the mantled soil or even another soil series if the mantle affects the use of the soil.

Any horizons or layers underlying a plaggen epipedon are considered to be buried.

A surface mantle of new material, as defined here, is largely unaltered, at least in the lower part. It may have a diagnostic surface horizon (epipedon) and/or a cambic horizon, but it has no other diagnostic subsurface horizons, all defined later. However, there remains a layer 7.5 cm or more thick that fails the requirements for all diagnostic horizons, as defined later, overlying a horizon sequence that can be clearly identified as the solum of a buried soil in at least half of each pedon. The recognition of a surface mantle should not be based only on studies of associated soils.

The Pedon, a Unit of Sampling

Few soil properties can be determined from the surface. To determine the nature of a soil, one must study its horizons, or layers. This study requires pits or some means of extracting samples of material from the surface to the base of the soil. The visible and tactile properties of samples can be studied in the field. Soil moisture and temperature regimes are studied by observations of changes over time at points selected to be representative. Other properties of a soil must be learned by studies of samples in an appropriate place, usually a laboratory. In other words, one learns about most of the properties of a soil by studying samples extracted to represent a sampling unit, not by study of the whole soil body that is classified. A concept of what to sample must be developed before soils can be classified in a manner that meets the needs of the soil survey, and different concepts might lead to different classifications. The concept presented in this text is not the only one possible, and, in fact, its logic has been scrutinized (Holmgren, 1988).

A soil commonly is not uniform in all its properties. Variability may be due to accidents; events that lack definite order, such as the development of fractures in a hard rock; variations in deposits left by running water; or the placement of seeds by wind or by animals. The influence of the biotic factors tends to produce many examples of variability in a soil. Burrowing animals, taprooted plants, falling trees, and plants that collect different elements do not operate uniformly over large areas. A filled burrow or a trace left by a taproot can result in holes in horizons filled by contrasting materials. Salts collected by a desert shrub remain concentrated below the shrub until it dies. Shrink-swell and freeze-thaw processes are other factors that contribute to soil variability.

The transition between two soils that differ in a particular property or set of properties may be of at least two kinds. Normally, a given horizon of one soil disappears over horizontal distance by a gradual weakening of its expression. However, in some places the horizons become intermittent either with or without a marked decrease in the strength of expression. The transitional forms having discontinuous horizons or horizons that vary greatly in thickness or other properties are not the rule, but the soils have been troublesome to classify. One must decide whether the area is one soil in which a horizon is discontinuous or variable, or two soils.

Trouble cannot be avoided by arbitrarily saying that two soils are present if a diagnostic property or horizon is present in some spots and not present in others. Some limit of area must be set. If one sets no limit, a vertical hole made by a burrowing animal would be considered “nonsoil.” It would become a soil when filled or, if a coating were present, the coating would be considered a soil. This would be absurd. Such a soil could not support plants, could not have structure, and could not be sampled for determination of its properties. The view that a minimum areal limit of “a soil” cannot be set, if carried to the extreme, leads to other odd conclusions. For example, if columns or prisms were present, the exteriors of the prisms would be different soils from the interiors wherever there are coatings on the exteriors. In a structureless soil, a definition of the smallest area of “a soil” as equivalent to the size of the largest ped would have no meaning. No escape from a minimum limit to the area of “a soil” seems possible. The concept of the pedon (Gr. *pedon*, ground; rhymes with head on) offers a partial solution to this problem and provides a clear basis for soil descriptions and for the selection of soil samples.

A pedon has the smallest volume for which one should describe and sample the soil to represent the nature and arrangement of its horizons and variability in the properties that are preserved in samples. A pedon is comparable in some ways to the unit cell of a crystal. It has three dimensions. Its lower limit is the somewhat vague limit between the soil and “nonsoil” below. Its lateral dimensions are large enough to represent the nature of any horizons and variability that may be present. A horizon may vary in thickness or in composition, or it may be discontinuous. The minimal horizontal area of a pedon is arbitrarily set at 1 m^2, but it ranges to 10 m^2, depending on the variability in the soil.

In the usual situation, where all horizons are continuous and of nearly uniform thickness and composition, the pedon has a horizontal area of about 1 m^2. Photo 1 shows the normal situation in which horizons are continuous and relatively

Photo 1.—A soil that has continuous horizons, in an area of Wyoming.

Photo 2.—A sandy soil near Brugge, Belgium.

uniform in thickness over considerable areas. The mollic epipedon and calcic horizon extend for hundreds of meters in areas of this Wyoming landscape. Each pedon includes the range of variability that is present in a small volume. The pedon is roughly polygonal. One lateral dimension does not differ greatly from any other. The size of a pedon can be determined only by examination of a volume that is appreciably larger than the pedon.

Where horizons are intermittent or cyclic and recur in linear intervals of 2 to 7 m (roughly 7 to 23 ft), the pedon includes one-half the cycle. Thus, each pedon includes the range of variability that occurs within these small areas, but not necessarily the total variability included in other similar pedons studied over a large area. Where the cycle is less than 2 m, the horizontal area of a pedon is the minimum size, 1 m^2.

Depending on the concept of soil and of the pedon, there could be different classifications of the soils. With the concept of soil and of the pedon that is outlined here, the pedons of some soils may include markedly differing sequences of horizons. The following examples clarify the concept of a pedon that has intermittent horizons.

Photo 2 illustrates a soil near Brugge, Belgium, in an area that is covered by eolian sand of Wisconsin (Wurm) age. The plow layer, 35 cm thick, is very dark brown fine sand or loamy fine sand. Most sand grains are free of visible coatings. The lower boundary of the plow layer is abrupt and irregular and shows many clear spade marks.

The next layer is a discontinuous B horizon that consists of at least three materials. The first of these is dark brown (7.5YR 3/4, moist) fine sand with nodules. The nodules range from about 5 to 20 cm in diameter and are firm or friable in the interior but have a very firm crust about one-half cm thick. The crust has stronger chroma and redder hue than the interior, suggesting the segregation of iron. The interiors of the nodules are free of roots.

The second material is very friable, massive, grayish brown (10YR 5/2, moist) fine sand that has many fine fibrous roots. It would normally be considered parent material, the C horizon,

Photo 3.—A soil in the Yukon Territory of Canada.

where it underlies the nodules of the B horizon; however, it surrounds the nodules and continues down with little change to a thin layer of buried muck that has been dated by radiocarbon as Allerod (Two Creeks), about 11,000 years B.P.

The third material is very friable, massive fine sand that is present in gross, more or less tubular forms as much as 60 cm in diameter. The sand is similar to the second material in color but has many weak, fine dark gray and very dark gray lamellae or fibers that are comparable to those in or below the B horizon of the sandy soils formed under heath.

The history of this soil has been studied by the staff of the Institute for Soil Survey, IRSIA, Ghent.[1] While under forest, the soil was brown and had no clearly expressed eluvial or illuvial horizons. After clearing of the forest and invasion of the heather (*Calluna vulgaris*), a dark colored illuvial horizon that contained amorphous compounds or mixtures of organic matter, iron, and aluminum (see spodic horizon) formed. During the 17th and 18th centuries, flax became an important crop in Flanders, and the linen was woven in the farm homes in the winter. To obtain high yields of high-quality flax, large amounts of manure and chalk were applied to the fields. The influence of the calcium and nitrogen was to destroy the B horizon of amorphous materials, first in spots and then completely. Photo 2 shows that the B horizon has been partly destroyed. Because discontinuous horizons recur at intervals of less than 1 m, the pedon has an area of 1 m^2.

The processes of either formation or destruction of many horizons may not operate uniformly and may first produce intermittent horizons. In places the forces operate with remarkable uniformity and produce faint but continuous horizons. Genetically, therefore, the discontinuous horizons can have significance equivalent to weakly expressed but continuous horizons.

Many cold soils are subject to physical disturbance as a result of freezing and thawing. The forces generated through freezing often produce cyclic or intermittent horizons. Photo 3 shows a soil from the Yukon Territory of Canada. The small orange squares mark the boundary between permafrost and the active layer. The organic layer is about 40 cm thick in the low-lying areas and about 20 cm thick in the areas of higher

[1] Personal communication from R. Tavernier.

microrelief. This pattern is repeated at linear intervals of about 1 m. The pedon in photo 3 is 1 m^2. Soil taxonomy has taxa at the subgroup level of Gelisols to deal with the range in thickness of the organic layers.

Although every pedon can be classified, not every pedon need be classified. The pedon should represent a segment of the landscape. Sometimes, pedons that represent a segment of the landscape are referred to as polypedons. Soil scientists should try to sample, characterize, and classify representative pedons. Soil taxonomy provides a means of comparing, describing, and differentiating these various pedons.

Summary

Since the genesis of a soil may not be understood or may be disputed, it can be used only as a guide to our thinking in selecting criteria and forming concepts. Generally, a more or less arbitrary definition of a pedon serves the purpose of classification better at this time than a genetic one. For that reason, the following definition is used: A pedon is a three-dimensional body of soil that has lateral dimensions large enough to include representative variations in the shape and relation of horizons and in the composition of the soil. Its horizontal area ranges from 1 to 10 m^2, depending on the nature of the variability in the soil, and its volume varies, depending on the depth of the soil. Where the cycle of variations is less than 2 m long and where all horizons are continuous and of nearly uniform thickness, the pedon has a horizontal area of approximately 1 m^2. Where horizons or other properties are intermittent or cyclic and recur at linear intervals of 2 to 7 m, the pedon includes one-half of the cycle. If horizons are cyclic but recur at intervals of more than 7 m, the pedon reverts to an area of approximately 1 m^2 and more than one soil is usually represented in each cycle.

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CHAPTER 2

Soil Taxonomy and Soil Classification

The primary objective of soil taxonomy is to establish hierarchies of classes that permit us to understand, as fully as possible, the relationship among soils and between soils and the factors responsible for their character. A second objective is to provide a means of communication for the discipline of soil science. Soil taxonomy was originally developed to serve the purposes of soil survey. During the last few decades, it has evolved into a means of communication in soil science.

Taxonomy is a narrower term than classification. Classification includes taxonomy, but it also includes the grouping of soils according to limitations that affect specific practical purposes, such as the soil limitations affecting the foundations of buildings. Taxonomy is the part of classification that is concerned primarily with relationships. Classifications are contrivances made by humans to suit their purposes. They are not themselves truths that can be discovered. A perfect classification would have no drawbacks when used for the purpose intended. Each distinctly different purpose, to be served best, demands a different classification.

For the different purposes of the soil survey, classes are needed that can be grouped or subdivided and regrouped to permit the largest number and the most precise predictions possible about responses to management and manipulation. Consequently, not one but many classifications can be drawn from the basic taxonomy. Flexibility in the classes of the taxonomic system is achieved by the use of phases and by the nomenclature. The phases are used to subdivide taxa according to the practical needs for the purposes of a particular survey or interpretation. They are discussed later in this chapter. Flexibility in the hierarchy permits grouping taxa into successively smaller numbers as one goes from lower to higher categories. For some purposes it is useful to group taxa that have been separated at a higher level in the system. For example, one might want a group that includes all soils that are waterlogged for extended periods. For other purposes one might want a group comprised of all soils that have a B horizon affected by sodium or of all soils that have a fragipan or permafrost. Some soils might be in several of these groups, so that no matter how a single hierarchy is arranged, it is not possible to have all desired groups. Therefore, no single hierarchy can best serve all our purposes. The way we attain flexibility in the hierarchy is explained in the discussion of the nomenclature.

As knowledge expands, new facts or closer approximations of truths not only make improvements in classification possible but also make some changes imperative. Thus, classifications are not static but require change as knowledge expands. Since the original edition of *Soil Taxonomy* was published in 1975, eight international committees have made proposals that have been approved and incorporated. These committees include the International Committee on Low Activity Clays (ICOMLAC), the International Committee on Oxisols (ICOMOX), the International Committee on Andisols (ICOMAND), the International Committee on Spodosols (ICOMOD), the International Committee on Aquic Moisture Regimes (ICOMAQ), the International Committee on Vertisols (ICOMERT), the International Committee on Aridisols (ICOMID), the International Committee on Families (ICOMFAM), and the International Committee on Permafrost-Affected Soils (ICOMPAS).

Taxonomy of soils is a controversial subject. In part, controversy reflects differences in the purposes for which taxonomic classifications are made and differences in concepts of soil as well as differences in opinion about the taxonomy of soils. One cannot say that one taxonomic classification is better than another without reference to the purposes for which both were made, and comparisons of the merits of taxonomies made for different purposes can be useless.

The Attributes of Soil Taxonomy

Soil surveys require many nontaxonomic classifications that can be related to the real bodies of soil and that facilitate comparisons of both similarities and differences among them for a great variety of purposes. These classifications are used to determine whether experience at one location is applicable to the soils of other locations. The classifications may have to be used by a pedologist to apply the experience of others for soils that are unfamiliar. Many persons with diverse backgrounds and training are expected to use the classifications accurately to transfer experience with the behavior of soils under a variety of uses. These intended uses of the classifications impose some specific requirements on the taxonomy that stands behind the classifications. The attributes of soil taxonomy are described in the following paragraphs.

First, the definition of each taxon carries as nearly as possible the same meaning to each user. Definitions in soil taxonomy are operational. It is insufficient to say that the soils in one taxon are differentiated from others by high organic-matter content because what is considered high in one place may be considered low in another. The disadvantage of definitions, of course, is that distinctions are made that may not be meaningful for every conceivable use of the soil. Only by operational definitions can competent pedologists with diverse backgrounds arrive at the same classification of the same kind of soil.

Second, soil taxonomy is a multicategoric system. Many taxa are needed in the lower categories because many properties are important to the use of a soil. Specific properties can vary independently of others, and their importance depends on their combination with other properties. Taxa in the lower categories, therefore, must be defined as specifically as possible in terms of many properties. This requirement results in more taxa in the lower categories than the mind can comprehend. Consequently, the taxa must be grouped on some rational basis into progressively smaller numbers of classes of higher categories in a manner that permits the mind to grasp the concepts and relationships of all taxa. The mind readily grasps 5 to 12 items, but it cannot deal simultaneously with 100 to 1,000 items without some ordering principle. Higher categories are necessary for organizing and understanding the lower categories and, in addition, they can be useful in comparing soils of large areas. They have only limited value for transferring experience to a specific site for a specific use.

Third, the taxa represent real bodies of soil that are known to occupy geographic areas. Pedologists are concerned with mapping real bodies of soil, and a classification related to these real bodies facilitates the mapping (Cline, 1963). Soil taxonomy does not try to provide for all possible combinations of properties because the classification of kinds of soil that have not been studied should not be prejudiced by a closed system that covers all contingencies. Rather, soil taxonomy provides a means to recognize new taxa when discovery leads to new combinations of properties important to our purposes.

Fourth, differentiae are soil properties that can be observed in the field or that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. Some of the most important properties of the soil are chemical properties, and soil taxonomy uses criteria in some taxa based on laboratory measurements. Often data from laboratory measurements can be interpolated to other areas, or pedologists discover physical or morphological properties that reflect chemical characteristics. Soil temperature, soil moisture, and other properties that fluctuate with the seasons are difficult to use in taxonomy unless they can be inferred by reasoning from the combined data of soil science and other disciplines, such as meteorology. Soil mineralogy can usually be inferred by reasoning from the combined data of soil science and geology. If there are no data that permit inferences about important but invisible soil properties, it is probably best to defer classifying a soil until some knowledge of its important properties is available. A classification that is based on extremely limited knowledge of an object has little utility.

Fifth, soil taxonomy is capable of modification to accommodate new knowledge with a minimum of disturbance. Taxa can be added or combined in any category without disturbance of the rest of the system at the same or a higher categorical level. If the highest category includes a number of taxa defined by a variety of properties, the number can be increased or decreased by combining or subdividing taxa whenever experience convinces us that this is advisable. If one taxon in the highest category is divided, no others in that category need be affected. If two or parts of two are combined, only those two or those parts are affected. Obviously, combining taxa at a high level changes classes of lower categories if they are members of those taxa. Adding taxa may have no effect on the lower categories if the soils concerned were not previously included in the system. If the addition is a consequence of combining classes, it affects the lower categories.

Sixth, the differentiae keep an undisturbed soil and its cultivated or otherwise human-modified equivalents in the same taxon insofar as possible. Changes produced by a single or repeated plowing that mixes the surface soil to a depth of 18 to 25 cm (7 to 10 in), for example, have the least possible effect on the placement of a soil in soil taxonomy. Truncation by erosion does not change the classification of a soil until horizons or diagnostic features important to the use or identification of the soil have been lost. Consequently, insofar as possible, the diagnostic horizons and features should be those below the part of the soil affected by human activities. However, significant changes in the nature of the soil by humans cannot be ignored.

Seventh, soil taxonomy is capable of providing taxa for all soils on a landscape. Soils form a continuum. The continuum is broken into a reasonable number of segments that have limited and defined ranges in properties so that quantitative interpretations of soil behavior can be made.

Eighth, soil taxonomy provides for all soils that are known, wherever they may be. Many kinds of soil are poorly represented or are unknown in the United States. A system that includes all known soils helps us to see the soils of the United States in better perspective, particularly if a kind of soil is poorly represented or is very extensive. It also helps us to draw on experience in other countries with kinds of soil that are poorly represented or are not extensive in the United States as a whole but that are extensive locally.

Selection of Differentiae

To serve the purpose of the soil survey, the pedon should be classified by its own properties and the taxa defined strictly in terms of soil properties. In soil definitions, a given property, such as particle-size distribution or pH, cannot be treated in an identical way for all soils. The significance of a difference in any one property depends on the others in the combination that makes a soil of a certain kind.

Soil color and the soil horizons are obvious properties that have been used as differentiating characteristics at high categoric levels in most taxonomies. Color *per se* seems to have no accessory characteristics. For example, if one considers all the soils that have brown color, no statement can be made about them except that they are brown. There are accessory characteristics for some colors in combination with other properties, and the use of color as a differentiating characteristic should be limited to these situations. A more useful classification can be devised if properties that have more accessory properties than color are used as differentiae in the highest categories.

Soil horizons are the result of the dominance of one or more sets of processes over other processes through time. The processes themselves are not now suitable for use as differentiae. The illuviation of clay, for example, cannot be observed or measured in a soil. If illuviation has been a significant process in the genesis of a soil, however, there should be marks in the soil that indicate this process. These marks need not be the same everywhere, but if the proper marks are selected, the classification can reflect the dominance of illuviation over other processes, such as those that mix horizons and those that prevent the movement of clay.

The nature of the horizons is useful in defining the taxa of soils that have horizons but is useless for soils that do not have them. Of course, the absence of horizons is itself a mark of significance. Many important properties of soils, however, are not necessarily reflected by the combinations of horizons, and many important processes do not themselves produce horizons. Intensive mixing of soil by animals can destroy horizons. The leaching of bases, particularly calcium, and the cycling of bases by plants in humid climates can be reflected by changes in base status with increasing depth but can be independent of the kinds of horizons in a soil. The horizons, therefore, are not the sole differentiating characteristics in defining taxa.

Some soil properties influence or control specific processes and, through them, the genesis of the soil. Silicate clays cannot form in a soil composed entirely of quartz, and apparently they do not form if a soil is too cold. The soil moisture regime influences the base status of a soil and the formation of horizons with an accumulation of illuvial clay or of carbonates. These are examples of soil properties that are causes of other properties and that require consideration when properties are selected to be used as differentiae for taxa.

The differentiae should be soil properties, but the most useful properties for the higher categories may be either those that result from soil genesis or those that affect soil genesis because they have the greatest number of accessory properties. For example, the clay percentage in soils commonly increases and then decreases with increasing depth. In many soils differences in the content of clay are the result of eluviation and illuviation. In other soils they may be only the result of stratification of the materials in which the soils developed. If the horizons are genetic, they have accessory properties, although the accessory properties may vary with the kind of soil. If the climate is humid, the eluvial horizons and at least part of the illuvial horizons are free of finely divided carbonates because carbonates tend to immobilize clay and because the leaching required to form an illuvial horizon is greater than the leaching required to dissolve and remove the carbonates. Time of the order of some thousands of years without significant erosion is required. During this time there is opportunity for nutrients used by plants to be systematically concentrated in various horizons. In soils that formed under grass in humid temperate regions, phosphorus seems to be concentrated in the surface horizons, a considerable part of it in organic compounds.

If the clay distribution in a soil is due solely to stratification of parent materials, few other statements can be made about that soil. The soil may be calcareous or acid. This example illustrates why properties that are the result of soil genesis or that affect soil genesis are important. They have accessory properties. Some of the accessory properties are known, but it is likely that many are still unknown.

In soil surveys the pedologist is commonly concerned with finding the boundaries between map units. The boundaries are in places where there has been or is a difference in one or more of the factors that control soil genesis. The mapper learns to look for these places and uses a knowledge of soil genesis to improve the accuracy and efficiency of mapping. Genesis is fundamental to soil taxonomy and to the soil survey. Genesis itself, however, is unsuitable for direct use in soil taxonomy. Because the genesis of a soil cannot be observed or measured, pedologists may have widely differing opinions about it, and the classification of a given pedon is affected by the background of the pedologist.

Forming and Defining Taxa

When forming and defining the taxa, one must consider all the known properties, although only a few can be differentiating. The differentiating properties should be the ones that are the most important for our purposes or that have the most important accessory characteristics.

Research and experience indicate that some properties are important to plant growth. Soil taxonomy attempts to make the most important statements possible about the taxa. Those properties that are important to plant growth and that result from or influence soil genesis are considered in the higher categories. Those that are important to plant growth but are unrelated to genesis should be considered only for the lowest categories. For example, in soils that are only slightly weathered, the nature and amount of clay may be the result of geologic accidents. If the differences are not extreme, the course of soil genesis is not necessarily affected. Although the difference between illite and smectite is important to plant growth, it is used as a differentiating characteristic only at a low category in the system, the family.

Determining the similarities among soils is not always a simple matter. There may be similarity in particle-size distribution to the members of one taxon and in base status to the members of another. One must decide which property is the more important, and this decision must rest on the nature of the statements that one can make about the classes if the kind of soil is grouped one way or the other. The best grouping determines the definition; the definition does not determine the grouping. If the grouping has imperfections, so does the definition. The statements are about the nature of the soils and the interpretations that can be made for the various phases of a taxon. Interpretations are predictions of the consequences of specific uses of soils, commonly in terms of plant growth under specified systems of management but also in terms of engineering soil behavior after a given manipulation. Interpretations of the soils indicate the reasonable alternatives for their use and management and the expected results. The best grouping is one that helps us to make the most precise and most important interpretations. Soil taxonomy must continue to be tested by the nature of the interpretations that can be made.

The taxonomic classification used in soil surveys requires flexibility in the classes. It is commonly necessary to subdivide taxa and regroup those subdivisions into new classes of another classification for the greatest number and most precise interpretations possible. Soil taxonomy was designed to facilitate interpretations, but the interpretations themselves require at least one additional step of reasoning (Cline, 1963). The interpretations may also require information that is not available from the taxonomy. Slope and stoniness are soil characteristics that must be known or assumed for one to predict consequences of farming with heavy machinery. Invasions of locusts, hurricanes, or frequent hailstorms are not soil characteristics, but their probability must be known or assumed when crop yields are predicted. These and other important characteristics may be used as bases for defining phases of taxa that are necessary for interpretations for specific fields or farms. The phases are not a part of the taxonomy. Their nature is determined by the foreseeable uses of the soils in a particular survey area. Quite different phases might be differentiated for the same soils in an area of general farming in contrast to a national forest or an area being developed for housing and in an irrigated area in contrast to the desert grazing land that is above the irrigation canal. The phases represent a number of classifications superimposed on the taxonomic classification to give part of the flexibility that is needed for the wide variety of uses made of soil.

Inevitably, the conclusions of a large group of scientists include some compromises of divergent points of view. Members of a group representing unlike interests and experience are likely to see soils differently. Different points of view about soil produce different ideas about its classification. Consequently, compromises between the conflicting desires of a number of individuals not only are necessary but also are likely to produce a system that has more general utility than a system that represents a single point of view. Compromise may not be the exact word. The truth has many facets; each person has a somewhat different view of the truth, and no person can see the whole truth clearly. Soil taxonomy allows changes in the system as new information about soils becomes available. Since its inception, soil taxonomy has been amended many times. Probably, no one person will approve of all the details of these changes; few will be able to agree on all the changes.

Literature Cited

Cline, M.G. 1963. Logic of the New System of Soil Classification. Soil Sci. 96: 17-22.

CHAPTER 3

Differentiae for Mineral Soils[1] and Organic Soils

Soil taxonomy differentiates between mineral soils and organic soils. To do this, first, it is necessary to distinguish mineral soil material from organic soil material. Second, it is necessary to define the minimum part of a soil that should be mineral if a soil is to be classified as a mineral soil and the minimum part that should be organic if the soil is to be classified as an organic soil.

Nearly all soils contain more than traces of both mineral and organic components in some horizons, but most soils are dominantly one or the other. The horizons that are less than about 20 to 35 percent organic matter, by weight, have properties that are more nearly those of mineral than of organic soils. Even with this separation, the volume of organic matter at the upper limit exceeds that of the mineral material in the fine-earth fraction.

Mineral Soil Material

Mineral soil material (less than 2.0 mm in diameter) *either*:

1. Is saturated with water for less than 30 days (cumulative) per year in normal years and contains less than 20 percent (by weight) organic carbon; *or*

2. Is saturated with water for 30 days or more cumulative in normal years (or is artificially drained) and, excluding live roots, has an organic carbon content (by weight) of:

   a. Less than 18 percent if the mineral fraction contains 60 percent or more clay; *or*

   b. Less than 12 percent if the mineral fraction contains no clay; *or*

   c. Less than 12 + (clay percentage multiplied by 0.1) percent if the mineral fraction contains less than 60 percent clay.

Organic Soil Material

Soil material that contains more than the amounts of organic carbon described above for mineral soil material is considered organic soil material.

In the definition of mineral soil material above, material that has more organic carbon than in item 1 is intended to include what has been called litter or an O horizon. Material that has more organic carbon than in item 2 has been called peat or muck. Not all organic soil material accumulates in or under water. Leaf litter may rest on a lithic contact and support forest vegetation. The soil in this situation is organic only in the sense that the mineral fraction is appreciably less than half the weight and is only a small percentage of the volume of the soil.

Distinction Between Mineral Soils and Organic Soils

Most soils are dominantly mineral material, but many mineral soils have horizons of organic material. For simplicity in writing definitions of taxa, a distinction between what is meant by a mineral soil and an organic soil is useful. To apply the definitions of many taxa, one must first decide whether the soil is mineral or organic. An exception is the Andisols (defined later). These generally are considered to consist of mineral soils, but some may be organic if they meet other criteria for Andisols. Those that exceed the organic carbon limit defined for mineral soils have a colloidal fraction dominated by short-range-order minerals or aluminum-humus complexes. The mineral fraction in these soils is believed to give more control to the soil properties than the organic fraction. Therefore, the soils are included with the Andisols rather than the organic soils defined later as Histosols.

If a soil has both organic and mineral horizons, the relative thickness of the organic and mineral soil materials must be considered. At some point one must decide that the mineral horizons are more important. This point is arbitrary and depends in part on the nature of the materials. A thick layer of sphagnum has a very low bulk density and contains less organic matter than a thinner layer of well-decomposed muck. It is much easier to measure the thickness of layers in the field than it is to determine tons of organic matter per hectare. The definition of a mineral soil, therefore, is based on the thickness of the horizons, or layers, but the limits of thickness must vary with the kinds of materials. The definition that follows is intended to classify as mineral soils those that have both thick mineral soil layers and no more organic material than the amount permitted in the histic epipedon, which is defined in chapter 4.

In the determination of whether a soil is organic or mineral, the thickness of horizons is measured from the surface of the

[1] Mineral soils include all soils except the suborder Histels and the order Histosols.

soil whether that is the surface of a mineral or an organic horizon, unless the soil is buried as defined in chapter 1. Thus, any O horizon at the surface is considered an organic horizon if it meets the requirements of organic soil material as defined later, and its thickness is added to that of any other organic horizons to determine the total thickness of organic soil materials.

Definition of Mineral Soils

Mineral soils are soils that have *either* of the following:

1. Mineral soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or have voids[2] that are filled with 10 percent or less organic materials *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with underlying cindery, fragmental, or pumiceous materials, total more than 10 cm between the soil surface and a depth of 50 cm; *or*

c. Constitute more than one-third of the total thickness of the soil to a densic, lithic, or paralithic contact or have a total thickness of more than 10 cm; *or*

d. If they are saturated with water for 30 days or more per year in normal years (or are artificially drained) and have organic materials with an upper boundary within 40 cm of the soil surface, have a total thickness of *either*:

(1) Less than 60 cm if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) Less than 40 cm if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

2. More than 20 percent, by volume, mineral soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest; *and*

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Definition of Organic Soils

Organic soils have organic soil materials that:

1. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

2. Meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[2] *and* directly below these materials have a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more; *or*

e. Are 80 percent or more, by volume, from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest.

It is a general rule that a soil is classified as an organic soil (Histosol) if more than half of the upper 80 cm (32 in) of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic materials.

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[2] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

CHAPTER 4

Horizons and Characteristics Diagnostic for the Higher Categories

This chapter defines the horizons and characteristics of both mineral and organic soils. It is divided into three parts—horizons and characteristics diagnostic for mineral soils, characteristics diagnostic for organic soils, and horizons and characteristics diagnostic for both mineral and organic soils.

The four highest categories of this taxonomy, in order of decreasing rank and increasing numbers of taxa, are distinguished by the presence or absence or a variety of combinations of diagnostic horizons and characteristics. The categories themselves are described in chapter 6.

The horizons and characteristics defined below are not in a key format. Some diagnostic horizons are mutually exclusive, and some are not. An umbric epipedon, for example, could not also be a mollic epipedon. A kandic horizon with clay films, however, could also meet the definition of an argillic horizon.

A soil horizon is a layer that is commonly parallel to the soil surface. In some orders, such as Gelisols, Vertisols, and Spodosols, however, horizons are not always parallel to the surface. A horizon has some set of properties that have been produced by soil-forming processes, and it has some properties that are not like those of the layers directly above and beneath it (USDA, SCS, 1993). A soil horizon commonly is differentiated from the horizons adjacent to it partly by characteristics that can be seen or measured in the field, such as color, structure, texture, rupture-resistance class, and the presence or absence of carbonates. In identifying a soil horizon, however, measurements in the laboratory are sometimes required to supplement field observations. According to the criteria we use, horizons are identified partly by their own morphology and partly by properties that differ from those of the overlying and underlying horizons.

Many of the layers that are differentiae for organic soils do not meet the definition of soil horizons. Unlike the layers of soil that are commonly called horizons, they are layers that formed in differing environments during the period when the materials that now constitute the soils accumulated. Some of the layers that serve as differentiae are soil horizons, but there are no operational methods that can always distinguish between "horizons" and "layers" that have similar properties. The importance of making a distinction between horizons and layers of organic soils is unknown. In the discussion that follows, the term "soil material" is commonly used as a broader term that includes both horizons and layers in organic soils.

The horizon designations used in this chapter are defined in the *Soil Survey Manual* (USDA, SCS, 1993) and the *Keys to Soil Taxonomy* (USDA, NRCS, 1998).

Horizons and Characteristics Diagnostic for Mineral Soils

The criteria for some of the following horizons and characteristics, such as histic and folistic epipedons, can be met in organic soils. They are diagnostic, however, only for the mineral soils.

Diagnostic Surface Horizons: The Epipedon

The epipedon (Gr. *epi*, over, upon, and *pedon*, soil) is a horizon that forms at or near the surface and in which most of the rock structure has been destroyed. It is darkened by organic matter or shows evidence of eluviation, or both. Rock structure as used here and in other places in this taxonomy includes fine stratification (less than 5 mm) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and saprolite derived from consolidated rocks in which the unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other.

Any horizon may be at the surface of a truncated soil. The following section, however, is concerned with eight diagnostic horizons that have formed at or near the soil surface. These horizons can be covered by a surface mantle of new soil material. If the surface mantle has rock structure, the top of the epipedon is considered the soil surface unless the mantle meets the definition of buried soils in chapter 1. If the soil includes a buried soil, the epipedon, if any, is at the soil surface and the epipedon of the buried soil is considered a buried epipedon and is not considered in selecting taxa unless the keys specifically indicate buried horizons, such as those in Thapto-Histic subgroups. A soil with a mantle thick enough to have a buried soil has no epipedon if the soil has rock structure to the surface or has an Ap horizon less than 25 cm thick that is underlain by soil material with rock structure. The melanic epipedon (defined below) is unique among epipedons. It forms commonly in volcanic deposits and can receive fresh deposits of ash. Therefore, this horizon is permitted to have layers within and above the epipedon that are not part of the melanic epipedon.

A recent alluvial or eolian deposit that retains stratifications (5 mm or less thick) or an Ap horizon directly underlain by such stratified material is not included in the concept of the epipedon because time has not been sufficient for soil-forming processes to erase these transient marks of deposition and for diagnostic and accessory properties to develop.

An epipedon is not the same as an A horizon. It may include part or all of an illuvial B horizon if the darkening by organic matter extends from the soil surface into or through the B horizon.

Anthropic Epipedon

The anthropic epipedon has the same limits as the mollic epipedon in color, structure, and organic-carbon content. It formed during long-continued use of the soil by humans, either as a place of residence or as a site for growing irrigated crops. In the former case, disposal of bones and shells has supplied calcium and phosphorus and the level of phosphorus in the epipedon is too high for a mollic epipedon. Such epipedons occur in the humid parts of Europe, the United States, and South America and probably in other parts of the world, mostly in kitchen middens. The high level of phosphorus in the anthropic epipedons is not everywhere accompanied by a base saturation of 50 percent or more, but it is accompanied by a relatively high base saturation if compared with the adjacent soils.

In arid regions some long-irrigated soils have an epipedon that is like the mollic epipedon in most chemical and physical properties. The properties of the epipedon in these areas are clearly the consequence of irrigation by humans. Such an epipedon is grouped with the anthropic epipedons, which developed under human habitation. If not irrigated, such an epipedon is dry in all its parts for more than 9 months in normal years. Additional data about anthropic epipedons from several parts of the world may permit future improvements in this definition.

Required Characteristics

In summary, the anthropic epipedon shows some evidence of disturbance by human activity and meets all of the requirements for a mollic epipedon, except for *one or both* of the following:

1. 1,500 milligrams per kilogram or more P_2O_5 soluble in 1 percent citric acid and a regular decrease in P_2O_5 to a depth of 125 cm; *or*

2. If the soil is not irrigated, all parts of the epipedon are dry for 9 months or more in normal years.

Folistic Epipedon

The folistic epipedon consists of organic material (defined in chapter 3), unless the soil has been plowed. This epipedon normally is at the soil surface, although it can be buried. If the soil has been plowed, the organic-carbon requirements are lower than the requirements for organic soil material because of the need to accommodate the oxidation that occurs when the soil is plowed. Folistic epipedons occur primarily in cool, humid regions of the world. They differ from histic epipedons because they are saturated with water for less than 30 days (cumulative) in normal years (and are not artificially drained). Taxa for soils with folistic epipedons above the series level are not currently recognized in this taxonomy. The folistic epipedon is used only with mineral soils.

Required Characteristics

The folistic epipedon is defined as a layer (one or more horizons) that is saturated for less than 30 days (cumulative) in normal years (and is not artificially drained) and *either*:

1. Consists of organic soil material that:

    a. Is 20 cm or more thick and either contains 75 percent or more (by volume) *Sphagnum* fibers or has a bulk density, moist, of less than 0.1; *or*

    b. Is 15 cm or more thick; *or*

2. Is an Ap horizon that, when mixed to a depth of 25 cm, has an organic-carbon content (by weight) of:

    a. 16 percent or more if the mineral fraction contains 60 percent or more clay; *or*

    b. 8 percent or more if the mineral fraction contains no clay; *or*

    c. 8 + (clay percentage divided by 7.5) percent or more if the mineral fraction contains less than 60 percent clay.

Most folistic epipedons consist of organic soil material (defined in chapter 3). Item 2 provides for a folistic epipedon that is an Ap horizon consisting of mineral soil material.

Histic Epipedon

The histic epipedon consists of organic soil material (peat or muck) if the soil has not been plowed. If the soil has been plowed, the epipedon normally has a high content of organic matter that results from mixing organic soil material with some mineral material. The histic epipedon either is characterized by saturation and reduction for some time in normal years or has been artificially drained. It is normally at the soil surface, although it can be buried.

Photo 4 shows a very dark histic epipedon that is saturated for long periods and meets criterion 1 below.

Required Characteristics

The histic epipedon is a layer (one or more horizons) that is characterized by saturation (for 30 days or more, cumulative) and reduction for some time during normal years (or is artificially drained) and *either*:

1. Consists of organic soil material that:

a. Is 20 to 60 cm thick and either contains 75 percent or more (by volume) *Sphagnum* fibers or has a bulk density, moist, of less than 0.1; *or*

b. Is 20 to 40 cm thick; *or*

2. Is an Ap horizon that, when mixed to a depth of 25 cm, has an organic-carbon content (by weight) of:

a. 16 percent or more if the mineral fraction contains 60 percent or more clay; *or*

b. 8 percent or more if the mineral fraction contains no clay; *or*

c. 8 + (clay percentage divided by 7.5) percent or more if the mineral fraction contains less than 60 percent clay.

Most histic epipedons consist of organic soil material (defined in chapter 3). Item 2 provides for a histic epipedon that is an Ap horizon consisting of mineral soil material. A histic epipedon consisting of mineral soil material can also be part of a mollic or umbric epipedon.

Melanic Epipedon

The melanic epipedon is a thick, dark colored (commonly black) horizon at or near the soil surface (photo 5). It has high concentrations of organic carbon, generally associated with short-range-order minerals or aluminum-humus complexes. The intense dark colors are attributed to the accumulation of organic matter from which "Type A" humic acids are extracted. This organic matter is thought to result from large amounts of root residues supplied by a gramineous vegetation and can be distinguished from organic matter formed under forest vegetation by the melanic index.

The suite of secondary minerals generally is dominated by allophane, and the soil material has a low bulk density and a high anion adsorption capacity.

Required Characteristics

The melanic epipedon has *both* of the following:

1. An upper boundary at, or within 30 cm of, either the mineral soil surface or the upper boundary of an organic layer with andic soil properties (defined below), whichever is shallower; *and*

2. In layers with a cumulative thickness of 30 cm or more within a total thickness of 40 cm, *all* of the following:

a. Andic soil properties throughout; *and*

b. A color value, moist, and chroma (Munsell designations) of 2 or less throughout and a melanic index of 1.70 or less throughout; *and*

c. 6 percent or more organic carbon as a weighted average and 4 percent or more organic carbon in all layers.

Mollic Epipedon

The mollic epipedon is a relatively thick, dark colored, humus-rich surface horizon (or horizons) in which bivalent cations are dominant on the exchange complex and the grade of structure is weak to strong (photos 6 and 7). These properties are common in the soils of the steppes in the Americas, Europe, and Asia.

Properties

The mollic epipedon is defined in terms of its morphology rather than its genesis. It consists of mineral soil material and is at the soil surface, unless it underlies a histic epipedon or thin surface mantle, as explained earlier in this chapter. If the surface layer of organic material is so thick that the soil is recognized as a Histosol (defined below), the horizon that at one time was a mollic epipedon is considered to be buried and no longer meets the definition of an epipedon.

The mollic epipedon has soil structure strong enough that less than one-half of the volume of all parts has rock structure and one-half or more of the horizon is not both hard, very hard, or harder and massive when dry. In this definition very coarse prisms, with a diameter of 30 cm or more, are treated as if they were the same as massive unless there is secondary structure within the prisms. The restriction against hardness and structure applies only to those epipedons that become dry. A mollic epipedon can directly overlie deposits with rock structure, including fine stratifications, if the epipedon is 25 cm or more thick. The epipedon does not include any layer in which one-half or more of the volume has rock structure, including fine stratifications.

The mollic epipedon has dark color and low chroma in 50 percent or more of its matrix. It typically has a Munsell color value of 3 or less when moist and of 5 or less when dry and chroma of 3 or less when moist. If its structure is fine granular or fine blocky, the sample, when broken, may show only the color of the coatings of peds. The color of the matrix in such situations can be determined only by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-manganese concretions are present. Crushing should be just sufficient to mix the coatings with the matrix. The dry color value should be determined after the crushed sample is dry enough for continued drying to produce no further change and the sample has been smoothed to eliminate shadows.

Normally, the color value is at least 1 Munsell unit lower or the chroma at least 2 units lower (both moist and dry) than that of the 1C horizon (if one occurs). Some parent materials, such as loess, cinders, basalt, or carbonaceous shale, can also have dark color and low chroma. Soils that formed in such materials can accumulate appreciable amounts of organic matter but commonly have no visible darkening in the epipedon. In these dark colored materials, the requirement that the mollic epipedon have a lower color value or chroma than the C horizon is waived if the surface horizon(s) meets all of the other requirements for a mollic epipedon and, in addition, has at least 0.6 percent more organic carbon than the C horizon.

Finely divided $CaCO_3$ acts as a white pigment and causes soils to have a high color value, especially when dry. To compensate for the color of the carbonates, the mollic epipedon is allowed to have lighter color than normal if the epipedon averages more than 15 percent carbonates.

If the fine-earth fraction has a calcium carbonate equivalent of 15 to 40 percent, the limit for the dry color value is waived. If it has a calcium carbonate equivalent of 40 percent or more, the limit for the dry color value is waived and the moist color value is 5 or less.

The mollic epipedon forms in the presence of bivalent cations, particularly calcium. The base saturation by the NH_4OAc method is required to be 50 percent or more throughout the epipedon.

The mollic epipedon is thought to be formed mainly through the underground decomposition of organic residues in the presence of these cations. The residues that are decomposed are partly roots and partly organic residues from the surface that have been taken underground by animals. Accumulation and turnover of the organic matter in the mollic epipedon probably are rapid. The radiocarbon age (mean residence time) of the organic carbon is mostly 100 to 1,000 years. A high percentage of the organic matter is so-called “humic acid.” The minimum organic-carbon content throughout the thickness of the mollic epipedon is 0.6 percent in most mollic epipedons. Exceptions are (1) a minimum of 2.5 percent organic carbon in epipedons that have a color value, moist, of 4 or 5 and a fine-earth fraction with a calcium carbonate equivalent of 40 percent or more and (2) a minimum of 0.6 percent more organic carbon than in the C horizon in epipedons in which the C horizon has a color as dark as or darker than the color of the epipedon.

The maximum organic-carbon content of a mollic epipedon is the same as for mineral soil material. Some Ap horizons that approach the lower limit of a histic epipedon can be part of the mollic epipedon.

The minimum thickness of the mollic epipedon depends on the depth and texture of the soil. The minimum thickness is for soils with an epipedon that is loamy very fine sand or finer and that is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan. These soils have a minimum thickness of 10 cm. Soils that are 10 to 18 cm deep have a mollic epipedon if the whole soil meets all of the criteria for a mollic epipedon when mixed.

The minimum thickness is 25 cm for: (1) all soils with a texture throughout the epipedon of loamy fine sand or coarser; (2) all soils that have no diagnostic horizons or features below the epipedon; and (3) soils that are 75 cm or more deep to a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan, are more than 75 cm deep to the upper boundary of any identifiable secondary carbonates, and are more than 75 cm deep to the lower boundary of any argillic, cambic, kandic, natric, oxic, or spodic horizon (all defined below).

The minimum thickness is one-third of the thickness from the mineral soil surface to any of the features described in the paragraph above if (1) the texture throughout the epipedon is loamy very fine sand or finer and (2) depth to the feature described in the paragraph above is between 54 and 75 cm.

The minimum thickness is 18 cm for all other soils.

The mollic epipedon has less than 1,500 milligrams per kilogram of P_2O_5 soluble in 1 percent citric acid or has an irregular decrease in the amounts of P_2O_5 with increasing depth below the epipedon, or there are phosphate nodules within the epipedon. This restriction is intended to exclude plow layers of very old arable soils and kitchen middens that, under use, have acquired the properties of a mollic epipedon and to include the epipedon of a soil developed in highly phosphatic parent material.

Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm is 5 °C or higher and the soil is not irrigated.

Sediments that have been continuously under water since they were deposited have a very high water content and are unable to support livestock. Although many soils that have a mollic epipedon are very poorly drained, the mollic epipedon is required to have an *n* value (defined below) of less than 0.7.

Several accessory properties are common in soils that have a mollic epipedon. Most natural environments (not made by humans) that produce a mollic epipedon also produce 2:1 lattice clays from minerals that can be altered, preclude serious toxicity from aluminum or manganese, and ensure a reasonable reserve of calcium, magnesium, and potassium and of nitrogen if the soil has not been cultivated for a long time. These are accessory properties that are important to plant growth. Permeability is another accessory property important to most uses of the soil. The structure of the mollic epipedon facilitates the movement of moisture and air whenever the soil is not saturated with water.

The content of organic matter indicates that the soil has received enough moisture to support fair to luxuriant plant growth in normal years. The mollic epipedon must be moist in at least some part for 90 days or more (cumulative) in normal years at times when the soil temperature is 5 °C or higher at a depth of 50 cm and when the soil is not irrigated.

Although the mollic epipedon is a surface horizon that can be truncated by erosion, its many important accessory properties suggest its use as a diagnostic horizon at a high categoric level. Some soils have eroded to the extent that the epipedon is no longer thick enough to meet the requirements for a mollic epipedon. In this case human activities have altered the surface horizon, changing a mollic epipedon into an ochric epipedon (defined below).

Required Characteristics

The mollic epipedon consists of mineral soil materials and has the following properties:

1. When dry, *either or both*:

a. Structural units with a diameter of 30 cm or less or secondary structure with a diameter of 30 cm or less; *or*

b. A moderately hard or softer rupture-resistance class; *and*

2. Rock structure, including fine (less than 5 mm) stratifications, in less than one-half of the volume of all parts; *and*

3. *One* of the following:

a. *All* of the following:

(1) Colors with a value of 3 or less, moist, and of 5 or less, dry; *and*

(2) Colors with chroma of 3 or less, moist; *and*

(3) If the soil has a C horizon, the mollic epipedon has a color value at least 1 Munsell unit lower or chroma at least 2 units lower (both moist and dry) than that of the C horizon or the epipedon has at least 0.6 percent more organic carbon than the C horizon; *or*

b. A fine-earth fraction that has a calcium carbonate equivalent of 15 to 40 percent and colors with a value and chroma of 3 or less, moist; *or*

c. A fine-earth fraction that has a calcium carbonate equivalent of 40 percent or more and a color value, moist, of 5 or less; *and*

4. A base saturation (by NH_4OAc) of 50 percent or more; *and*

5. An organic-carbon content of:

a. 2.5 percent or more if the epipedon has a color value, moist, of 4 or 5; *or*

b. 0.6 percent more than that of the C horizon (if one occurs) if the mollic epipedon has a color value less than 1 Munsell unit lower or chroma less than 2 units lower (both moist and dry) than the C horizon; *or*

c. 0.6 percent or more; *and*

6. After mixing of the upper 18 cm of the mineral soil or of the whole mineral soil if its depth to a densic, lithic, or paralithic contact, petrocalcic horizon, or duripan (all defined below) is less than 18 cm, the minimum thickness of the epipedon is as follows:

a. 10 cm or the depth of the noncemented soil if the epipedon is loamy very fine sand or finer and is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan that is within 18 cm of the mineral soil surface; *or*

b. 25 cm or more if the epipedon is loamy fine sand or coarser throughout or if there are no underlying diagnostic horizons (defined below) and the organic-carbon content of the underlying materials decreases irregularly with increasing depth; *or*

c. 25 cm or more if *all* of the following are 75 cm or more below the mineral soil surface:

(1) The upper boundary of any pedogenic lime that is present as filaments, soft coatings, or soft nodules; *and*

(2) The lower boundary of any argillic, cambic, natric, oxic, or spodic horizon (defined below); *and*

(3) The upper boundary of any petrocalcic horizon, duripan, or fragipan; *or*

d. 18 cm if the epipedon is loamy very fine sand or finer in some part and one-third or more of the total thickness between the top of the epipedon and the shallowest of any features listed in item 6-c is less than 75 cm below the mineral soil surface; *or*

e. 18 cm or more if none of the above conditions apply; *and*

7. Phosphate:

a. Content less than 1,500 milligrams per kilogram soluble in 1 percent citric acid; *or*

b. Content decreasing irregularly with increasing depth below the epipedon; *or*

c. Nodules are within the epipedon; *and*

8. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher, if the soil is not irrigated; *and*

9. The *n* value (defined below) is less than 0.7.

Ochric Epipedon

The ochric epipedon fails to meet the definitions for any of the other seven epipedons because it is too thin or too dry, has too high a color value or chroma, contains too little organic carbon, has too high an *n* value or melanic index, or is both massive and hard or harder when dry (photos 8 and 9). Many ochric epipedons have either a Munsell color value of 4 or more, moist, and 6 or more, dry, or chroma of 4 or more, or they include an A or Ap horizon that has both low color values and low chroma but is too thin to be recognized as a mollic or umbric epipedon (and has less than 15 percent calcium carbonate equivalent in the fine-earth fraction). Ochric epipedons also include horizons of organic materials that are too thin to meet the requirements for a histic or folistic epipedon.

The ochric epipedon includes eluvial horizons that are at or near the soil surface, and it extends to the first underlying diagnostic illuvial horizon (defined below as an argillic, kandic, natric, or spodic horizon). If the underlying horizon is a B horizon of alteration (defined below as a cambic or oxic horizon) and there is no surface horizon that is appreciably darkened by humus, the lower limit of the ochric epipedon is the lower boundary of the plow layer or an equivalent depth (18 cm) in a soil that has not been plowed. Actually, the same horizon in an unplowed soil may be both part of the epipedon and part of the cambic horizon; the ochric epipedon and the subsurface diagnostic horizons are not all mutually exclusive. The ochric epipedon does not have rock structure and does not include finely stratified fresh sediments, nor can it be an Ap horizon directly overlying such deposits.

The ochric epipedon by itself has few or no accessory characteristics, but an ochric epipedon in combination with other diagnostic horizons and features has many accessory characteristics. For example, if there is an underlying horizon in which clay has accumulated (defined later as an argillic horizon) and if the epipedon is seldom or never dry, carbonates are absent and base saturation is moderate or low in the major part of the epipedon unless the soil has been limed. If the texture is loamy, the structure breaks down easily when the soil is cultivated.

Plaggen Epipedon

The plaggen epipedon is a human-made surface layer 50 cm or more thick that has been produced by long-continued manuring (photo 10). In medieval times, sod or other materials commonly were used for bedding livestock and the manure was spread on fields being cultivated. The mineral materials brought in by this kind of manuring eventually produced an appreciably thickened Ap horizon (as much as 1 m or more thick). In northwestern Europe this custom was associated with the poorly fertile, sandy Spodosols. The practice more or less ceased at the turn of the 19th century, when fertilizers became available.

The color of a plaggen epipedon and its organic-carbon content depend on the materials used for bedding. If the sod was cut from the heath, the plaggen epipedon tends to be black or very dark gray, to be rich in organic matter, and to have a wide carbon-nitrogen ratio. If the sod came from forested soils, the plaggen epipedon tends to be brown, to have less organic matter, and to have a narrower carbon-nitrogen ratio. Commonly, the organic-carbon content ranges from 1.5 to 4 percent. Values commonly range from 1 to 4, moist, and chromas are 2 or less.

A plaggen epipedon can be identified by several means. Commonly, it contains artifacts, such as bits of brick and pottery, throughout its depth. There may be chunks of diverse materials, such as black sand and light gray sand, as large as the size held by a spade. The plaggen epipedon normally shows spade marks throughout its depth and also remnants of thin stratified beds of sand that were probably produced on the soil surface by beating rains and were later buried by spading. A map unit delineation of soils with plaggen epipedons would tend to have straight-sided rectangular bodies that are higher than the adjacent soils by as much as or more than the thickness of the plaggen epipedon.

Umbric Epipedon

The umbric epipedon is a relatively thick, dark colored, humus-rich surface horizon or horizons (photo 11). It cannot be distinguished by the eye from a mollic epipedon, but laboratory studies show that the base saturation is less than 50 percent (by NH_4OAc) in some or all parts.

The umbric epipedon is used for defining taxa at different levels. For those soils in which the content of organic matter is roughly proportional to the darkness of the color, the most satisfactory groupings appear to be those that assign soils with a thick, dark colored surface horizon and soils with a light colored or thin surface horizon to different suborders. Structure, bulk density, cation-exchange capacity, and other properties are related to the amount and type of organic matter in these soils. In those kinds of soil where dark color is not related to the content of organic matter, the soils that have light colored epipedons are separated from the soils that have dark colored epipedons only at lower categoric levels, if at all.

Properties

The umbric epipedon consists of mineral soil material and is at the soil surface, unless it underlies either a recent deposit that is less than 50 cm thick and has fine stratification if not plowed or a thin layer of organic soil material. If the surface layer of organic material is so thick that the soil is recognized as a Histosol (defined below), the umbric epipedon is considered to be buried.

The umbric epipedon has soil structure strong enough so that one-half or more of the horizon is not both hard, very hard, or harder and massive when dry. Very coarse prisms, with a diameter of 30 cm or more, are treated as if they were the same as massive if there is no secondary structure within the prisms. The restriction against massive and hardness applies only to those epipedons that become dry.

The umbric epipedon has dark color and low chroma in 50 percent or more of its matrix. It has a Munsell color value of 3 or less, moist, and of 5 or less, dry, and chroma of 3 or less. If its structure is fine granular or fine blocky, the sample when broken may show only the color of the coatings of peds. The color of the matrix in such situations can be determined only by crushing or briefly rubbing the sample. Prolonged rubbing should be avoided because it may cause darkening of a sample if soft iron-manganese concretions are present. Crushing should be just sufficient to mix the coatings with the matrix. The dry color value should be determined after the crushed sample is dry enough for continued drying to produce no further change and the sample has been smoothed to eliminate shadows.

Normally, the color value is at least 1 Munsell unit lower or the chroma at least 2 units lower (both moist and dry) than that of the C horizon (if present). Some parent materials, such as loess, cinders, alluvium, or shale, can also have dark color and low chroma. Soils that formed in such materials can accumulate appreciable amounts of organic matter but commonly show no visible darkening in the epipedon. In these dark colored materials, the requirement that the umbric epipedon have a lower color value or chroma than the C horizon is waived if the surface horizon(s) meets all of the other requirements for an umbric epipedon and, in addition, has at least 0.6 percent more organic carbon than the C horizon.

Base saturation by the NH_4OAc method is required to be less than 50 percent in some or all parts of the epipedon.

The umbric epipedon is thought to be formed mainly by the decomposition of organic residues. The residues that are decomposed are partly roots and partly organic residues from the surface that have been taken underground by animals. Accumulation and turnover of the organic matter in the umbric epipedon probably are slower than in the mollic epipedon. The aluminum ions may be somewhat toxic to some kinds of soil micro-organisms. The minimum organic-carbon content throughout the thickness of the umbric epipedon is 0.6 percent.

The minimum thickness of the umbric epipedon is dependent on the depth and texture of the soil. The minimum thickness is for soils with an epipedon that is loamy very fine sand or finer (when mixed) and that is directly above a densic, lithic, or paralithic contact, a petrocalcic horizon, or a duripan. These soils have a minimum thickness of 10 cm. Soils that are 10 to 18 cm deep have an umbric epipedon if the whole soil meets all of the criteria for an umbric epipedon when mixed.

The minimum thickness is 25 cm for (1) all soils with a texture throughout the epipedon of loamy fine sand or coarser; (2) all soils that have no diagnostic horizons or features below the epipedon; and (3) soils that are 75 cm or more deep to a densic, lithic, or paralithic contact or a duripan and are more than 75 cm deep to the lower boundary of any argillic, cambic, kandic, natric, oxic, or spodic horizon (all defined below).

The minimum thickness is one-third of the thickness from the mineral soil surface to any of the features in the paragraph above if (1) the texture in some or all parts of the epipedon is loamy very fine sand or finer and (2) depth to the feature listed in the paragraph above is between 54 and 75 cm below the mineral soil surface.

The minimum thickness is 18 cm for all other soils.

The umbric epipedon has less than 1,500 milligrams per kilogram of P_2O_5 soluble in 1 percent citric acid or has an irregular decrease in the amounts of P_2O_5 with increasing depth below the epipedon, or there are phosphate nodules within the epipedon. This restriction is intended to exclude plow layers of very old arable soils and kitchen middens that, under use, have acquired the properties of an umbric epipedon and to include the epipedon of a soil developed in highly phosphatic parent material.

Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher and the soil is not irrigated.

Sediments that have been continuously under water since deposition have a very high water content and are unable to support livestock. Although some soils that have an umbric epipedon are very poorly drained, the umbric epipedon is required to have an *n* value (defined below) of less than 0.7.

Several accessory properties are common in soils that have an umbric epipedon. These soils have the potential for toxicity from aluminum, and they are commonly low in calcium, magnesium, and potassium if lime and fertilizer have not been applied. These are accessory properties important to plant growth. The structure of the umbric epipedon facilitates the movement of moisture and air whenever the soil is not saturated with water.

The content of organic matter indicates that the soil has received enough moisture to support fair to luxuriant plant growth in normal years. The umbric epipedon must be moist in at least some part for 3 months or more (cumulative) in normal years at times when the soil temperature is 5 ^{o}C or higher at a depth of 50 cm and when the soil is not irrigated.

Although the umbric epipedon is a surface horizon that can be truncated by erosion, its many important accessory properties suggest its use as a diagnostic horizon at a high categoric level.

Some plaggen epipedons meet all of the requirements for an umbric epipedon but also show evidence of a gradual addition of materials during cultivation, whereas the umbric epipedon does not have the artifacts, spade marks, and raised surfaces that are characteristic of the plaggen epipedon.

Required Characteristics

The umbric epipedon consists of mineral soil materials and has the following properties:

1. When dry, *either or both*:

    a. Structural units with a diameter of 30 cm or less or secondary structure with a diameter of 30 cm or less; *or*

    b. A moderately hard or softer rupture-resistance class; *and*

2. *All* of the following:

a. Colors with a value of 3 or less, moist, and of 5 or less, dry; *and*

b. Colors with chroma of 3 or less, moist; *and*

c. If the soil has a C horizon, the umbric epipedon has a color value at least 1 Munsell unit lower or chroma at least 2 units lower (both moist and dry) than that of the C horizon or the epipedon has at least 0.6 percent more organic carbon than that of the C horizon; *and*

3. A base saturation (by NH_4OAc) of less than 50 percent in some or all parts; *and*

4. An organic-carbon content of:

a. 0.6 percent more than that of the C horizon (if one occurs) if the umbric epipedon has a color value less than 1 Munsell unit lower or chroma less than 2 units lower (both moist and dry) than the C horizon; *or*

b. 0.6 percent or more; *and*

5. After mixing of the upper 18 cm of the mineral soil or of the whole mineral soil if its depth to a densic, lithic, or paralithic contact or a duripan (all defined below) is less than 18 cm, the minimum thickness of the epipedon is as follows:

a. 10 cm or the depth of the noncemented soil if the epipedon is loamy very fine sand or finer and is directly above a densic, lithic, or paralithic contact or a duripan that is within 18 cm of the mineral soil surface; *or*

b. 25 cm or more if the epipedon is loamy fine sand or coarser throughout or if there are no underlying diagnostic horizons (defined below) and the organic-carbon content of the underlying materials decreases irregularly with increasing depth; *or*

c. 25 cm or more if the lower boundary of any argillic, cambic, natric, oxic, or spodic horizon (defined below) is 75 cm or more below the mineral soil surface; *or*

d. 18 cm if the epipedon is loamy very fine sand or finer in some part and one-third or more of the total thickness between the top of the epipedon and the shallowest of any features listed in item 5-c is less than 75 cm below the mineral soil surface; *or*

e. 18 cm or more if none of the above conditions apply; *and*

6. Phosphate:

a. Content less than 1,500 milligrams per kilogram soluble in 1 percent citric acid; *or*

b. Content decreasing irregularly with increasing depth below the epipedon; *or*

c. Nodules are within the epipedon; *and*

7. Some part of the epipedon is moist for 90 days or more (cumulative) in normal years during times when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher, if the soil is not irrigated; *and*

8. The *n* value (defined below) is less than 0.7; *and*

9. The umbric epipedon does not have the artifacts, spade marks, and raised surfaces that are characteristic of the plaggen epipedon.

Diagnostic Subsurface Horizons

The horizons described in this section form below the surface of the soil, although in some areas they form directly below a layer of leaf litter. They may be exposed at the surface by truncation of the soil. Some of these horizons are generally regarded as B horizons, some are considered B horizons by many but not all pedologists, and others are generally regarded as parts of the A horizon.

Agric Horizon

The agric horizon is an illuvial horizon that has formed under cultivation and contains significant amounts of illuvial silt, clay, and humus. When a soil is brought under cultivation, the vegetation and the soil fauna as a rule are changed drastically. The plow layer is mixed periodically, and, in effect, a new cycle of soil formation is started. Even where the cultivated crops resemble the native vegetation, stirring of the plow layer and the use of amendments, especially lime, nitrogen, and phosphate, normally produce significant changes in soil structure, flora, and fauna.

After a soil has been cultivated for a long time, changes in the horizon directly below the plow layer become apparent and cannot be ignored in classifying the soil. The large pores in the plow layer and the absence of vegetation immediately after plowing permit a turbulent flow of muddy water to the base of the plow layer. The water can enter wormholes or fine cracks between peds at the base of the plow layer, and the suspended materials are deposited as the water is withdrawn into capillary pores. The worm channels, root channels, and surfaces of peds in the horizon underlying the plow layer become coated with a dark colored mixture of organic matter, silt, and clay. The accumulations on the sides of wormholes become thick and can eventually fill the holes. If worms are scarce, the accumulations may take the form of lamellae that range in thickness from a few millimeters to about 1 cm. The lamellae and the coatings on the sides of wormholes always have a lower color value and chroma than the soil matrix.

The agric horizon can have somewhat different forms in different climates if there are differences in soil fauna. In areas of a humid, temperate climate where soils have a udic moisture regime and a mesic soil temperature regime (defined below), earthworms can become abundant. If there are wormholes that, including their coatings, constitute 5 percent or more (by volume) of the horizon and if the coatings are 2 mm or more thick and have a color value, moist, of 4 or less and chroma of 2 or less, the horizon is an agric horizon. After long cultivation, the content of organic matter in the agric horizon is not likely to be high, but the carbon-nitrogen ratio is low (generally less than 8). The pH value of the agric horizon is close to neutral (6 to 6.5).

In areas of a Mediterranean climate where soils have a xeric soil moisture regime (defined below), earthworms are less common and the illuvial materials accumulate as lamellae directly below the Ap horizon. If these lamellae are 5 mm or more thick, have a color value, moist, of 4 or less and chroma of 2 or less, and constitute 5 percent or more (by volume) of a horizon 10 cm or more thick, this horizon is an agric horizon.

The agric horizon in these xeric soils is also part of an argillic horizon. An agric horizon may form in several of the other diagnostic horizons, but not in a mollic or anthropic epipedon. A soil in which an illuvial horizon has formed in the mollic epipedon is distinguished by other means.

Required Characteristics

The agric horizon is directly below an Ap horizon and has the following properties:

1. A thickness of 10 cm or more and *either*:

   a. 5 percent or more (by volume) wormholes, including coatings that are 2 mm or more thick and have a value, moist, of 4 or less and chroma of 2 or less; *or*

   b. 5 percent or more (by volume) lamellae that have a thickness of 5 mm or more and have a value, moist, of 4 or less and chroma of 2 or less.

Albic Horizon

The albic horizon (photo 12) is an eluvial horizon, 1.0 cm or more thick, that has 85 percent or more (by volume) albic materials (defined below). It generally occurs below an A horizon but may be at the mineral soil surface. Under the albic horizon there generally is an argillic, cambic, kandic, natric, or spodic horizon or a fragipan (defined below). The albic horizon may lie between a spodic horizon and either a fragipan or an argillic horizon, or it may be between an argillic or kandic horizon and a fragipan. It may lie between a mollic epipedon and an argillic or natric horizon or between a cambic horizon and an argillic, kandic, or natric horizon or a fragipan. The albic horizon may separate horizons that, if they were together, would meet the requirements for a mollic epipedon. It may separate lamellae that together meet the requirements for an argillic horizon. These lamellae are not considered to be part of the albic horizon.

In some soils the horizon underlying the albic horizon is too sandy or too weakly developed to have the levels of accumulation required for an argillic, kandic, natric, or spodic horizon. Some soils have, directly below the albic horizon, either a densic, lithic, or paralithic contact or another relatively impervious layer that produces a perched water table with stagnant or moving water.

Argillic Horizon

An argillic horizon is normally a subsurface horizon with a significantly higher percentage of phyllosilicate clay than the overlying soil material (photo 13). It shows evidence of clay illuviation. The argillic horizon forms below the soil surface, but it may be exposed at the surface later by erosion.

Genesis

Because there is little or no evidence of illuvial clay movement in soils on the youngest landscapes, soil scientists have concluded that the formation of an argillic horizon requires at least a few thousand years. On some late-Pleistocene landscapes, argillic horizons are more strongly expressed in soils under forest vegetation than in soils under grass. Therefore, the kind of flora and associated fauna is thought to have an influence on the rate of development or degree of expression of the argillic horizon. Climate also is a factor. There are few or no examples of clay films in soils with perudic soil moisture regimes, such as the soils in parts of southeastern Alaska, the Olympic Peninsula of Washington, and the British highlands where water percolates through the soils during all seasons. Argillic horizons are common on the adjacent lowlands in Great Britain, under climates where the soils undergo wetting and drying cycles.

Textural differentiation in soils with argillic horizons results from one or more processes acting simultaneously or sequentially, affecting surface horizons, subsurface horizons, or both. The degree to which a process or several processes operate varies widely from soil to soil. In some soils clay illuviation is significant, while in others clay illuviation is overshadowed by *in situ* weathering. Not all of the processes are completely understood. The ones thought to be most important are summarized in the following paragraphs.

1. Clay eluviation and illuviation.—Some suspended clay is carried downward in the soil water. The movement of clay can take place from one horizon to another or within a horizon. There is a strong mineralogical similarity between the fine clay in an eluvial horizon and that in a deeper illuvial horizon. This similarity supports the idea that clay migrates dominantly as clay rather than as the products of decomposition that were later synthesized to form clay-sized particles.

Clay mobility is influenced by a number of factors. If clay platelets are aggregated by sesquioxides or other cementing agents, the cement must be dissolved prior to clay movement. Phyllosilicates with thick, diffuse double layers of adsorbed cations are dispersed more easily than those with thin double layers. If the ionic strength of the soil solution is high, clays tend to flocculate. Wetting a dry soil seems to lead to disruption of the fabric and to dispersion of clay unless the ionic concentration is high. Sodium ions in solution, between critical limits of activity, increase clay dispersion. Optimal clay dispersion occurs when the pH at the zero point of net charge on the clay particle is distinctly different from the pH of the soil solution. This dispersion commonly occurs between pH values of 4.5 and 6.5.

In soils that are periodically dry, the clay suspension moves downward and stops in the dry subsoil as the soil solution is absorbed. During absorption of the soil solution, the surface of the ped acts as a filter and keeps clays from entering the interior of the ped. The clay platelets then coat the surface of the ped or void wall and are oriented with their long axes parallel to the surface on which they were deposited. They are called clay films. These layers of oriented clay can be distinguished from the rest of the clay through the use of a petrographic microscope.

As soil solution enters unsaturated subsoils, water movement occurs in fine pores. Pore water velocity is reduced as a function of pore wall friction. Some clay deposition may occur simply because fluid velocity is too low to keep the clay suspended.

Capillarity affects water movement both downward and into the peds. If a soil horizon is underlain by a horizon of considerably coarser texture (i.e., larger pores), capillary continuity is broken and water tends to remain in the fine capillaries above the zone of contact. When water evaporates or is withdrawn by roots, suspended and/or dissolved materials, including clay, are left. This action accentuates the original difference in pore-size distribution, and clay is deposited directly above the coarse textured strata or lenses.

Clays that are deposited from suspension in sediments, such as shale or glacial till, are commonly oriented parallel to the depositional or stress surface. In contrast, clays formed in place within the soil generally are oriented according to the crystal structure of the original mineral grains from which they formed. Neither the mineral grains nor the planes in the shale or till are consistently oriented with respect to any pedogenic features. Consequently, the thin sections of many soils indicate layers of oriented clays in peds and on the surfaces of pores and peds.

Accumulation of clay in some soils occurs predominantly through flocculation. The dispersed clay stops moving downward if a layer with different pH or electrolyte concentration, or both, is present in the subsoil. The flocculated clays will have little or no orientation with respect to the features of the microfabric. Thus, distinguishing flocculated clays from clays formed *in situ* is difficult.

The above discussion is not intended to imply that all of the clay increase in an argillic horizon is the result of illuviation. The conclusions of many studies range from those indicating that most of the clay increase is the result of translocation to those indicating that most of the clay formed *in situ* with minimal translocation.

2. Clay dissolution in the epipedon.—Dissolution of clay-sized phyllosilicates can lead to a loss of clay in soils. The loss generally is greatest in the upper horizons, where weathering processes are most intense. Because this process generally affects surface horizons more than subsurface horizons, a vertical textural differentiation can result.

3. Selective erosion.—Raindrop splash and subsequent surface soil erosion cause the smaller soil particles to be moved farther downslope than the larger particles. Eventually, part of the fine fraction is eliminated from the surface layer of sloping soils, leaving a concentration of the coarser textured part. The speed of this process depends on many factors. In areas where highly erosive rain falls on soils with little surface cover, the process can occur rapidly. The surficial movement of clay downslope seems to be widespread, and selective erosion likely is a process that contributes to textural differentiation in some soils.

4. *In situ* clay formation.—Vertical textural differentiation is enhanced in some soils when the surface horizon dries and evaporation ceases but the subsoil remains moist. The presence of water allows hydrolysis in the subsoil and the subsequent production of clay. This process is important in many soils.

5. Clay destruction in a subsurface horizon.—Clay destruction may occur in a soil through the process of ferrolysis. Ferrolysis causes loss of clay from the upper horizons by decomposition from the upper layers. The process consists of a sequence of repetitive cycles involving an oxidative phase and a reductive phase. During the reductive phase, the ferrous iron displaces exchangeable cations, which are then removed by leaching. During the oxidative stage, oxidation of exchangeable ferrous iron produces exchangeable hydrogen, part of which attacks the phyllosilicate. In every cycle, cations are removed by leaching and part of the phyllosilicate is destroyed. With continued ferrolysis, a seasonally wet soil, even if base saturated, can develop a gray, silty or sandy horizon with a low clay content and a low cation-exchange capacity. Ferrolysis is the process that may help to develop albic material in a number of soils, including Albolls and Albaqualfs.

Regardless of the process responsible for textural differentiation, clay illuviation in one form or another is common to all argillic horizons.

Significance to Soil Classification

The argillic horizon represents a time-landscape relationship that is locally and regionally important. A taxon that includes all soils that have an argillic horizon would have very few other common properties. Yet, the horizon is a mark of landscape stability with respect to the formation and preservation of a finer textured subsurface horizon, as opposed to processes that destroy or remove clay from the horizon or that mix horizons. Because an argillic horizon forms at a relatively slow rate, its presence indicates that the geomorphic surface has been relatively stable and that the period of stability has been long.

If the argillic horizon occurs in an area of an aridic moisture regime (defined below) and is rarely moist or has free carbonates throughout, it probably indicates an old soil and stable geomorphic surface of such great age that the climate has changed since the formation of the horizon. In the present environment, the precipitation is not sufficient to remove carbonates from the soil or to translocate clay to the base of the argillic horizon.

On the steppes, savannas, and grasslands in areas of subhumid climates, the argillic horizon is a useful means of distinguishing between surfaces of Holocene or late-Pleistocene age and older surfaces.

In cool, humid regions the argillic horizon seems to be impermanent. It forms slowly, but there is evidence that with time it is moved to a greater depth in the soil and is finally destroyed. In its place, a glossic or spodic horizon may form.

In humid, temperate and tropical regions, the presence of an argillic horizon has other meanings. In humid, temperate regions that are forested, the argillic horizon is mainly a mark of a stable surface. In the humid tropics the clay fraction of the argillic horizon commonly is low in silicon because of intense weathering. The high degree of weathering is reflected by a dominance of 1:1 layer lattice clays and oxyhydroxides of iron and by a general absence of 2:1 layer lattice clays, except for hydroxy-interlayered vermiculite. Gibbsite can occur in the most weathered argillic horizons. In humid, temperate and tropical regions where cycling of bases by plants is the chief mechanism by which basic cations are retained against leaching from the soils, the available nutrients of ped exteriors relative to ped interiors are significant to root development. In some of these soils, the roots do not enter the peds of the argillic horizon but occur along faces of the peds. The peds are coated by continuous clay films with significantly more nitrogen, phosphorus, and potassium than the available nutrients in the interior of the peds.

Identification

Since the argillic horizon can result from one or more processes acting simultaneously or sequentially and affecting surface horizons, subsurface horizons, or both, one or more sets of properties can be used for its identification. Positive identification of the argillic horizon is difficult in some situations. No one feature is common to all argillic horizons and absent from all other horizons. Nearly all argillic horizons have at least two of the following features:

1. There is more silicate clay in the argillic horizon than in an overlying horizon. The boundary between the eluvial horizon and the argillic horizon is generally clear or abrupt, and commonly it is irregular. The clay content (percent, by weight, less than 2 micrometers, excluding clay-sized carbonates) of the argillic horizon must be at least 1.2 times the clay content of an overlying eluvial horizon, and generally the increase must be larger to be consistently detected in the field. The required increase in clay content occurs within a vertical distance of 15 cm in most pedons, but it can occur within a vertical distance as great as 30 cm and still meet the requirements for an argillic horizon.

2. There are coatings of oriented clay on the surfaces of pores and peds or orientated clay as coatings or as bridges between sand grains somewhere within many argillic horizons. An experienced pedologist can often identify the layers of oriented clay on the surfaces of peds and in pores, called clay films, with a 10 X hand lens. The clay films used to identify an argillic horizon should occur on more than just the vertical sides of peds. Examination of the surfaces of peds and pores under a 10- to 20-power hand lens usually discloses one or more of the features common to most clay films. The films may differ from the interiors of the peds in color as well as texture. Clay films should also have an observable thickness, whereas many pressure faces do not. Pores that are open on the lower side of a ped can have irregular lips where the clay protrudes. Commonly, the surfaces have an irregular shape and show channels and flow lines that apparently were formed by soil solution moving through the soil. Photo 14 shows a prominent clay film in a pore and a faint clay film on the surface of a ped of an argillic horizon in a medium textured soil under magnification. The pore has a prominent, dark gray coating, and the surface of the ped has a distinct, brownish coating. The broken surface that reveals the interior of the ped, on the right, has no coating. The scale is 2 mm. Photo 15 shows illuvial clay in sand. The clay coats the sand grains, and an occasional pore has a clay film. Very commonly, the coatings occur only in part of the horizon. Some argillic horizons have clay films only toward the base of the argillic horizon.

3. The ratio of fine clay (particles less than 0.2 micrometer in diameter) to total clay can be larger in an argillic horizon than in the overlying horizons. This difference is more common in soils with higher amounts of 2:1 phyllosilicates than 1:1 phyllosilicates. The table "Clay Distribution and Ratio of Fine Clay to Total Clay in Two Soils That Have Argillic Horizons" illustrates the difference in the size of clay particles in the various horizons. The ratio of fine clay to total clay is typically, but not always, highest in the argillic horizons with 2:1 phyllosilicates.

4. Rock structure is evident in less than half of the volume of the argillic horizon. In this context rock structure includes fine stratification (less than 10 mm) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and saprolite derived from consolidated rocks in which unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other.

Clay Distribution and Ratio of Fine Clay to Total Clay in Two Soils That Have Argillic Horizons

(Data for the argillic horizons are printed in italic type)

Depth (cm)	Clay distribution			Fine clay: total clay
	Less than 0.002 mm	0.002 to 0.0002 mm	Less than 0.0002 mm	
	Percent	*Percent*	*Percent*	*Ratio*
0-18	22.6	15.8	6.8	0.30
18-25	26.2	18.8	7.4	.28
25-36	*45.3*	*25.1*	*20.2*	*.45*
36-58	*42.8*	*26.6*	*16.2*	*.38*
58-74	34.7	25.2	9.5	.27
74-89	32.9	24.0	8.9	.27
0-18	33.1	24.6	8.5	.26
18-25	32.4	23.2	9.2	.28
25-40	*40.4*	*24.6*	*15.8*	*.39*
40-53	*45.0*	*25.0*	*20.0*	*.45*
53-71	*41.4*	*23.3*	*18.1*	*.44*
71-120	*38.0*	*23.3*	*14.7*	*.39*
120-140	20.5	15.6	4.9	.23
140-205	20.3	15.3	5.0	.25
205-250	12.3	9.5	2.8	.23

5. The argillic horizon is commonly parallel or nearly parallel to the surface. If the epipedon has been truncated, the argillic horizon can occur at the soil surface.

Special Problems

This section is divided into five parts: (1) soils that formed in uniform parent materials with clay illuviation; (2) truncated soils, cultivated soils, and soils that formed in stratified parent materials; (3) problems associated with determining the top of the argillic horizon; (4) problems associated with determining the base of the argillic horizon; and (5) destruction of the argillic horizon.

1. Soils that formed in uniform parent materials with clay illuviation.—It is believed that many soils are derived from multiple parent materials rather than a single, uniform material. Argillic horizons forming in uniform parent materials are described first because they are the least complicated. In soils that formed in uniform parent material and have 15 to 40 percent clay in the overlying eluvial horizon, no truncation, and no Ap horizon directly above the illuvial horizon, the clay content in the illuviated horizon is at least 1.2 times greater than the clay content in the eluvial horizon. The thickness of the illuvial horizon must be at least one-tenth that of the overlying horizons, but as a minimum an illuvial horizon must be at least 7.5 cm thick before it is considered an argillic horizon. The thickness of the transition zone from the eluvial horizon to the argillic horizon must be 30 cm or less. The ratio of fine clay to total clay in the argillic horizon is commonly at least 1.2 times greater than the ratio in the eluvial horizon.

In soils with less than 15 percent clay in any part of the overlying eluvial horizon, the illuvial horizon can be either continuous vertically or composed of lamellae (photo 16). The required ratio of clay in the illuvial horizon to that in the eluvial horizon is somewhat higher than is required in both medium textured and clayey soils. Soils that have less than 15 percent clay in any part of the eluvial horizon must have at least 3 percent (absolute) more clay in the illuvial horizon. For example, if the eluvial horizon has 4 percent clay, then the illuvial horizon must have at least 7 percent clay.

In soils with less than 15 percent clay, the illuvial horizon must be 15 cm or more thick to be an argillic horizon. If the argillic horizon is composed of lamellae, which can be spaced at intervals ranging from a few centimeters to a few decimeters or more, only the lamellae 0.5 cm or more thick are considered in determining whether the horizon meets the clay content and thickness requirements for an argillic horizon.

In soils that have at least 40 percent clay in the eluvial horizon, that formed in uniform material, and have no truncation, the difference in clay content between the eluvial horizon and the illuvial horizon must be 8 percent (absolute difference) or more. For example, if the eluvial horizon has 42 percent clay, the illuvial horizon must have at least 50 percent clay before it can be considered an argillic horizon. The thickness of the illuvial horizon should be at least one-tenth that of the overlying horizons. As a minimum, the illuvial horizon must be at least 7.5 cm thick.

In areas where climates have distinct wet and dry seasons and illuvial horizons have clayey textures and expansive 2:1 phyllosilicates, appreciable interped pressures are generated as the clays swell. The pressures produce irregular but smooth surfaces of peds and a strong degree of stress orientation of clay throughout the ped. In many such clayey horizons, identifying clay films is difficult or impossible.

If the coefficient of linear extensibility of the horizon exceeds 0.04 and there are periods with distinct differences in moisture content, the evidence of clay illuviation is satisfied if the ratio of fine clay to total clay in the illuvial horizon is greater by 1.2 times or more than the ratio in an overlying horizon.

2. Truncated soils, cultivated soils, and soils that formed in stratified parent materials.—Soils that formed in stratified parent materials and truncated soils in which the eluvial horizon has been removed or the illuvial horizon has been mixed into an Ap horizon present special problems in the identification of the argillic horizon. If both the eluvial horizons and the illuvial horizons formed in materials with different amounts of clay initially, differences in clay content between the horizons cannot always be used to identify the argillic horizon. Likewise, in soils that have been cultivated and in which the Ap horizon is directly above the argillic horizon, the argillic horizon may not be recognizable on the basis of a clay increase. The plow layer may contain the most clayey part of the original argillic horizon.

For soils that have an Ap horizon and do not have a sufficient clay increase between the Ap horizon and the illuvial horizon (as described above), the argillic horizon is determined by the identification of evidence of clay illuviation, such as clay films, clay linings on pores, or oriented clay in thin sections of the matrix in some subhorizon.

In soils that have a lithologic discontinuity at the boundary between the eluvial horizon and the illuvial horizon, clay illuviation is evidence of an argillic horizon. Since it is critical in these soils, clay illuviation must be prominent enough to obscure fine sand grains on at least 10 percent of the surfaces of peds, the clay illuviation must be nearly continuous in some pores, or thin sections must show oriented clay coatings on at least 1 percent of the horizon before the horizon is considered to be an argillic horizon.

3. The top of the argillic horizon.—The top of the argillic horizon in soils that are not truncated and that have no lithologic discontinuity between the eluvial and illuvial horizons occurs at the depth where the requirement for clay increase is met. Soils that have an abrupt or clear boundary between the eluvial and illuvial horizons have an argillic horizon that starts near the top of the illuvial layer. If properties of an argillic horizon are present but the upper boundary is gradual, the top of the argillic horizon is the depth at which the percentage of clay exceeds that of a horizon higher in the profile by the appropriate amount after fitting a smooth curve. Although the top of the argillic horizon is defined on the basis of a clay increase, there are other properties that provide clues to its identification. In many soils the argillic horizon has stronger chroma, redder hue, or larger structural units than the eluvial horizon. Clay films may or may not be present at the depth designated as the top of the argillic horizon.

In soils where the argillic horizon is degrading, such as soils that have a glossic horizon, the top of the argillic horizon is the point where the clay increase is met after mixing. For example, an E/Bt horizon may be part of the argillic horizon if its clay content, after mixing, exceeds the clay content of the overlying horizon by the required amount. More commonly, Bt/E horizons rather than E/Bt horizons have the required clay increase.

The top of the argillic horizon in truncated soils that do not exhibit the required clay increase and that do not have a lithologic discontinuity is the bottom of the Ap horizon.

For soils that have a lithologic discontinuity between the eluvial horizon and the illuvial horizon and that do not have the required clay increase described above, the top of the argillic horizon is considered to be at the contact between the two materials.

4. The base of the argillic horizon.—The base of the argillic horizon is obvious in many soils that overlie root-limiting layers, such as duripans or bedrock. In other soils the lower boundary of the argillic horizon is gradual and commonly is irregular. In these soils describing the base of the argillic horizon is difficult, but a definition is needed for identification of proper taxa.

The bottom of argillic horizons that have clay films is at the depth where the combination of both structure with mean horizontal dimensions of 10 cm or less and clay illuviation are no longer identifiable. In sandy soils that have argillic horizons without structure, the bottom of the argillic horizon is at the depth where clay bridging of the sand grains is no longer identifiable. The base of the argillic horizon is allowed to have less total clay than the eluvial horizon.

Argillic horizons that do not have clay films, such as some of the argillic horizons with a high shrink-swell potential, have different criteria. The base of the argillic horizon in soils with a high shrink-swell potential and no clay films is at the depth where both the pressure faces and structure with mean horizontal dimensions of 10 cm or less are no longer identifiable.

5. Destruction of the argillic horizon.—An argillic horizon can be formed and later destroyed. Destruction of argillic horizons can occur in many ways and is by no means limited to the following examples.

Argillic horizons that formed in paleoenvironments with more effective precipitation than that in the present environment can be engulfed by carbonates and more soluble salts. This process commonly occurs in areas that are presently arid. As the argillic horizon is engulfed, salt crystals grow and plug the horizon. Concurrently, the salt crystals disrupt the soil fabric and the cutans, including the clay films. In time, the entire argillic horizon could be engulfed by salts and all evidence of clay illuviation could be destroyed.

Mixing of horizons by animals, by frost, or by shrinking and swelling can destroy argillic horizons or inhibit their formation. Humans can rapidly change a soil and in some cases destroy an argillic horizon.

Detailed studies of the micromorphology of some soils that have an argillic horizon (e.g., Glossudalfs) provide evidence of the destruction of argillic horizons. Clay films are absent from the surfaces of peds, and skeletans, which are bleached silt or sand grains that result from the loss of clay and iron, are common. Oriented clay within the peds apparently persists. In a degrading argillic horizon, the clay films on surfaces of peds or in pores commonly are most abundant in the lower part of the argillic horizon and in the underlying transitional horizon. In advanced stages of degradation, there may be no clay films within or on peds in the upper part of the argillic horizon. Normally, a degrading argillic horizon also has an irregular upper boundary that is marked by narrow to broad penetrations of the eluvial horizon. Small nodular remnants of the argillic horizon commonly occur in the lower part of the present eluvial horizon.

An argillic layer that is being degraded or is subject to pedoturbation must meet the requirements for clay increase outlined above before it is considered an argillic horizon.

Required Characteristics

1. All argillic horizons must meet *both* of the following requirements:

a. *One* of the following:

(1) If the argillic horizon is coarse-loamy, fine-loamy, coarse-silty, fine-silty, fine, or very-fine or is loamy or clayey, including skeletal counterparts, it must be at least 7.5 cm thick or at least one-tenth as thick as the sum of the thickness of all overlying horizons, whichever is greater. For example, if the overlying horizons are more than 150 cm thick, then the argillic horizon must be 15 cm or more thick; *or*

(2) If the argillic horizon is sandy or sandy-skeletal, it must be at least 15 cm thick; *or*

(3) If the argillic horizon is composed entirely of lamellae, the combined thickness of the lamellae that are 0.5 cm or more thick must be 15 cm or more; *and*

b. Evidence of clay illuviation in at least *one* of the following forms:

(1) Oriented clay bridging the sand grains; *or*

(2) Clay films lining pores; *or*

(3) Clay films on both vertical and horizontal surfaces of peds; *or*

(4) Thin sections with oriented clay bodies that are more than 1 percent of the section; *or*

(5) If the coefficient of linear extensibility is 0.04 or higher and the soil has distinct wet and dry seasons, then the ratio of fine clay to total clay in the illuvial horizon is greater by 1.2 times or more than the ratio in the eluvial horizon; *and*

2. If an eluvial horizon remains and there is no lithologic discontinuity between it and the illuvial horizon and no plow layer directly above the illuvial layer, then the illuvial horizon must contain more total clay than the eluvial horizon within a vertical distance of 30 cm or less, as follows:

a. If any part of the eluvial horizon has less than 15 percent total clay in the fine-earth fraction, the argillic horizon must contain at least 3 percent (absolute) more clay (10 percent versus 13 percent, for example); *or*

b. If the eluvial horizon has 15 to 40 percent total clay in the fine-earth fraction, the argillic horizon must have at least 1.2 times more clay than the eluvial horizon; *or*

c. If the eluvial horizon has 40 percent or more total clay in the fine-earth fraction, the argillic horizon must contain at least 8 percent (absolute) more clay (42 percent versus 50 percent, for example).

Calcic Horizon

The calcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to a significant extent (photo 17). Calcic horizons must be 15 cm or more thick. They must have 15 percent calcium carbonate equivalent and either have at least 5 percent more calcium carbonate equivalent than the underlying horizon or have 5 percent or more identifiable secondary carbonates unless the particle-size class is sandy, sandy-skeletal, coarse-loamy, or loamy-skeletal and the clay content is less than 18 percent. If the clay content is less than 18 percent and the particle-size class is sandy, sandy-skeletal, coarse-loamy, or loamy-skeletal, there must be at least 5 percent more calcium carbonate equivalent than in an underlying horizon. In order to indicate pedogenic accumulations of calcium carbonate, calcic horizons require either identifiable secondary carbonates or more calcium carbonate equivalent than an underlying horizon. If a horizon with secondary carbonates is indurated or cemented to such a degree that it meets the requirements for a petrocalcic horizon, it is considered a petrocalcic horizon (defined below). A calcic horizon may occur in conjunction with various other horizons, such as a mollic epipedon, an argillic horizon, or a natric horizon.

Most calcic horizons have identifiable secondary carbonates. For reasons not fully understood, accumulations of carbonate in some soils do not form filaments but are disseminated. Disseminated carbonates have been observed in soils that are high in gypsum or sodium and in soils where accumulations of carbonate form through capillary rise.

The genetic implications of a calcic horizon vary. In arid and semiarid regions with parent materials, including the dust that falls, high in calcium carbonate, the precipitation is insufficient to leach bases and salts. In these situations carbonates accumulate in the larger voids, often first as filaments along root channels and as thin, discontinuous coatings on the bottom of rock fragments. With time, continuous coatings of carbonate form on the rock fragments, the carbonate filaments enlarge, and carbonate nodules and concretions can form. With continued deposition of carbonates, the horizon becomes plugged with carbonates. Finally, some parts of a calcic horizon may become cemented or indurated, though typically air-dry fragments of a calcic horizon slake in water, except for disconnected carbonate concretions and pendants under rock and pararock fragments.

In soils where ground water near the surface contains appreciable amounts of calcium bicarbonate, capillary rise and evaporation and transpiration cause precipitation of calcium carbonate. Depending on the depth from the surface to the capillary fringe, the top of the zone of calcium carbonate accumulation may be from the surface to a depth of about 60 cm. In such soils, the accumulation of calcium carbonate is comparable to the accumulation of more soluble salts in desert playas. Depending on the position of the water table, these soils may occupy depressions. If water was ponded, a soil that has a calcic horizon commonly forms a circular outline around the deeper depressions and can also occur on microhighs in the depressions.

In the situations above, one might attach a high genetic significance to a calcic horizon. In some other circumstances, however, one can attach little genetic significance to the absolute amount of carbonates in a horizon or layer of carbonate accumulation. Deposition from ground water at a depth of 3 m or more is likely a geologic rather than a pedologic process. In soils that formed in calcareous materials on steppes, the amount of calcium carbonate in horizons that contain secondary calcium carbonate is a partial function of the amount of calcium carbonate in the parent materials.

Some plant species growing in soils with calcic horizons often exhibit "lime-induced chlorosis," in which micronutrients, such as iron, manganese, and zinc, are rendered unavailable to the plants. Plant species that occur naturally in arid environments frequently do not exhibit this chlorosis, but many agriculturally grown plant species, such as citrus, avocados, corn, and beans, are susceptible to micronutrient deficiencies in calcareous soils.

Required Characteristics

The calcic horizon has *all* of the following properties:

1. Is 15 cm or more thick; *and*

2. Is not indurated or cemented to such a degree that it meets the requirements for a petrocalcic horizon; *and*

3. Has *one or more* of the following:

   a. 15 percent or more $CaCO_3$ equivalent (see below), and its $CaCO_3$ equivalent is 5 percent or more (absolute) higher than that of an underlying horizon; *or*

   b. 15 percent or more $CaCO_3$ equivalent and 5 percent or more (by volume) identifiable secondary carbonates; *or*

   c. 5 percent or more calcium carbonate equivalent and has:

      (1) Less than 18 percent clay in the fine-earth fraction; *and*

      (2) A sandy, sandy-skeletal, coarse-loamy, or loamy-skeletal particle-size class; *and*

      (3) 5 percent or more (by volume) identifiable secondary carbonates or a calcium carbonate equivalent (by weight) that is 5 percent or more (absolute) higher than that of an underlying horizon.

Cambic Horizon

A cambic horizon (photo 18) is the result of physical alterations, chemical transformations, or removals or of a combination of two or more of these processes.

Physical alterations are the result of the movement of soil particles by freezing and thawing, shrinking and swelling, root proliferation, wetting and drying, or animal activities (including human activities) to such an extent as to destroy one-half or more of the original rock structure or to form aggregations of the soil particles into peds, or both. Rock structure in this context includes fine stratification (less than 5 mm thick) in unconsolidated sediments (eolian, alluvial, lacustrine, or marine) and saprolite or residuum derived from bedrock in which the unweathered minerals and pseudomorphs of weathered minerals retain their relative positions to each other.

Chemical transformations in the cambic horizon are the result of (1) hydrolysis of primary minerals, which forms clays and liberates sesquioxides; (2) solution and redistribution or removal of carbonates or gypsum; (3) reduction and segregation or removal of iron; or (4) a combination of these processes.

Alteration by the accumulation of silicate clay, sesquioxides, or organic matter or by the removal of calcium carbonate or gypsum can also produce a cambic horizon. The accumulation of clay and sesquioxides can be identified by field or laboratory tests. The accumulation must be too little or the layer too thin to meet the requirements for any other diagnostic subsurface horizon. The cambic horizon also excludes layers that are part of an anthropic, plaggen, folistic, histic, melanic, mollic, or umbric epipedon but can include parts of some ochric epipedons in unplowed soils. The cambic horizon and the ochric horizon are not necessarily mutually exclusive.

The cambic horizon is commonly a subsurface horizon. It normally lies in the position of a B horizon and in most pedons is considered to be a B horizon, but it can include some A, E, and transitional horizons. The cambic horizon is considered part of the solum, and it normally occurs within the zone that is reached by the roots of native plants. Some truncated soils have a cambic horizon at the surface. Otherwise, the cambic horizon is below one of the diagnostic epipedons. Regardless of its mode of formation or position in a soil, the cambic horizon must be 15 cm or more thick. The thickness requirement can be met by combining lamellae that are 0.5 cm or more thick if the other required criteria are met. The cambic horizon can also include the illuvial materials that occur between the lamellae. Although a cambic horizon requires a thickness of only 15 cm, the base of the horizon must be 25 cm for most taxa. (See the "Key to Soil Orders" in chapter 8.)

Below many argillic and spodic horizons, there are BC and CB horizons that are transitional to the C horizon and in which weathering and alteration have occurred. The alteration of these transitional horizons in many soils is comparable to that of other cambic horizons. There are also transitional horizons, such as AB, EB, or BA horizons between an A or E horizon and an argillic or kandic horizon, that may have the diagnostic properties of a cambic horizon. Such transitional horizons are considered cambic horizons. These cambic horizons are not considered diagnostic above the series level in this taxonomy.

Identification

Cambic horizons may have several somewhat contrasting forms, but each of these grades in places imperceptibly into the others. The genetic significance of the cambic horizon varies somewhat with the kind of soil. The properties of a cambic horizon consistently carry the implication of a horizon that has been altered. One could define several kinds of cambic horizons and give them distinctive names, but understanding the limits of the transitional forms would be difficult. The possible benefits of separating the contrasting forms do not seem to justify the complications that would result if one tried to distinguish clearly the transitional forms. Nevertheless, it is important to understand that cambic horizons vary in appearance and in genetic significance. The typical forms that the cambic horizon may have under varying combinations of the soil-forming factors are described in the following paragraphs.

1. A cambic horizon can form in the presence of aquic conditions. If the level of ground water fluctuates near the soil surface, free iron generally is removed from the individual particles of sand, silt, and clay. Either this iron is lost from the horizon, or some of it is concentrated, forming redoximorphic concentrations. Gray redox depletions and red, brown, and black redox concentrations are associated with the fluctuating ground water. Because these features can develop rapidly in a wet soil, they alone do not indicate sufficient alteration for the identification of a cambic horizon. The processes of reduction or of reduction and segregation of the iron must have been intense enough to produce a horizon dominated by low chroma. In addition, there must be soil structure or rock structure in less than one-half of the volume before a layer can be identified as a cambic horizon.

A cambic horizon normally does not form if aquic conditions are present in a horizon at all times. Soils that formed under these conditions have a reduced matrix with colors that are commonly neutral or consist of shades of green or blue. Soils with a reduced matrix change color on exposure to air. Ordinarily, these changes are visible within a few minutes if a moist clod is briefly exposed to the air and then is broken so that the colors of the interior and the exterior can be compared. Horizons with a reduced matrix are excluded from the concept of the cambic horizon on the assumption that losses of iron have been negligible.

A horizon forming under aquic conditions is a cambic horizon if it has fluctuating aquic conditions within 50 cm of the surface or the soil is artificially drained and the dominant colors (moist) on faces of peds or in the matrix are characterized by the following:

a. No change in hue on exposure to air; *and*

b. A value of 3 or less and chroma of 0; *or*

c. A value of 4 or more and chroma of 1 or less; *or*

d. Any value, chroma of 2 or less, and redox concentrations.

2. Cambic horizons that are in subhumid and humid, temperate regions and do not have aquic conditions near the surface normally are brownish. Because free iron oxides have been liberated, the chroma commonly is higher or the hue is redder in the cambic horizon than in the C horizon or the overlying horizon. Feldspars, volcanic glass, and easily weatherable minerals, such as biotite, some pyroxenes, and some amphiboles, show evidence of alteration under the microscope. Oxides of iron derived from iron removed from primary minerals can form coatings on individual soil paticles. These coatings may be responsible for brownish and reddish colors in the horizon. In humid, tropical regions the colors commonly are more reddish than brownish.

Considerable time is required for the partial destruction of iron-bearing minerals necessary for the development of color or for the formation of clay. Structure, however, can form in short periods. If there is sufficient clay and the soil material has a relatively high coefficient of linear extensibility, expression of structure takes place within a few years of the deposition of sediment. Illuviation is insufficient to meet the requirements for diagnostic horizons, and the peds generally do not show distinctive coatings. In thin sections the microfabric characteristics may include some distinctive features, such as stress-oriented plasma domains. Illuviation argillans are generally rare in cambic horizons. If there is a marked change in pH because of the presence of calcareous materials underlying the horizon or there is saprolitic material underlying the cambic horizon, however, these underlying materials may have significant amounts of translocated clay. The presence of this clay implies that clay movement has taken place in the soil, but the B horizon is not characterized by an accumulation of translocated clay.

3. A cambic horizon that forms under a humid or subhumid climate and from highly calcareous material commonly has granular structure produced by soil fauna. In areas of temperate and warm climates, earthworms, in particular, are ordinarily active in mixing material from different horizons. Consequently, the soil commonly is calcareous throughout its

thickness, even though there has been a considerable loss of carbonates. In calcareous materials there may be little or no evidence of the weathering of feldspars and other silicate materials. Evidence of the loss of carbonates is furnished by weathered remnants of limestone fragments, by solution pitting that can be seen on the faces of limestone pebbles, or by an increasing content of carbonates with increasing depth. In addition, the percentage of silicate clay commonly decreases gradually with increasing depth.

4. In areas of arid and semiarid climates, the cambic horizon commonly has still other forms. Gypsum and, especially, calcium carbonate are common but are not present everywhere. Except in areas that have *Cicadidae* or other burrowing insects, the soil fauna are less significant to soil structure than in humid regions. Changes in volume accompanying seasonal changes in moisture content tend to produce prismatic structure, and in some soils the prisms are very coarse. In arid regions the tops of the prisms commonly lie only a very few centimeters below a platy surface horizon. Other things being equal, it appears that, up to a point, the lower the mean annual precipitation, the closer the prisms are to the surface. Rock structure, including fine stratification of sediments, is absent in at least one-half of the volume of the cambic horizon, primarily because the materials have been moved by roots and by animals. In addition to soil structure or the absence of rock structure, the cambic horizon shows evidence of the redistribution of carbonates or gypsum. The mere redistribution of salts more soluble than gypsum is insufficient evidence of a cambic horizon because salt removal and accumulation can occur very rapidly and change with the season. Calcium carbonate and/or gypsum in transit through the cambic horizon may be reprecipitated there, particularly on the undersides of rock fragments, in pores, and on the faces of peds.

If calcium carbonate and gypsum are absent from the parent material and from the dust that falls, there may be no secondary carbonates or gypsum in the soil. In this situation, the cambic horizon is identified by soil structure or the absence of rock structure in more than one-half of the volume of the horizon and any combination of redder hues and higher chromas than in the underlying material or accumulations of clays or sesquioxides. The clay content commonly decreases with increasing depth in cambic horizons. Because of the presence of lithologic discontinuities, however, determining whether clay has been formed in the soil is difficult.

Features Common to Cambic Horizons

In spite of the diversity in appearance of cambic horizons, there are some common features.

The degree of alteration of primary minerals may be slight to very strong, but some weatherable minerals are present in most cambic horizons. These include the clay minerals that have a 2:1 lattice and amorphous clays as well as the various alterable minerals that yield bases or iron to the soil solution.

Cambic horizons normally have soil structure, but some are structureless.

A cambic horizon does not include layers that are part of the following diagnostic horizons—an anthropic, histic, folistic, melanic, mollic, plaggen, or umbric epipedon; an argillic, calcic, gypsic, natric, oxic, petrocalcic, petrogypsic, placic, or spodic horizon; or a duripan or fragipan (all defined in this chapter).

A cambic horizon can include layers that are part of the following diagnostic horizons—an ochric epipedon and an agric, albic, glossic, or sombric horizon.

Required Characteristics

In summary, the cambic horizon is an altered horizon 15 cm or more thick. If it is composed of lamellae, the combined thickness of the lamellae must be 15 cm or more. In addition, the cambic horizon must meet *all* of the following:

1. Has a texture of very fine sand, loamy very fine sand, or finer; *and*

2. Shows evidence of alteration in *one* of the following forms:

a. Aquic conditions within 50 cm of the soil surface or artificial drainage and *all* of the following:

(1) Soil structure or the absence of rock structure in more than one-half of the volume; *and*

(2) Colors that do not change on exposure to air; *and*

(3) Dominant color, moist, on faces of peds or in the matrix as follows:

(a) Value of 3 or less and chroma of 0; *or*

(b) Value of 4 or more and chroma of 1 or less; *or*

(c) Any value, chroma of 2 or less, and redox concentrations; *or*

b. Does not have the combination of aquic conditions within 50 cm of the soil surface or artificial drainage and colors, moist, as defined in item 2-a-(3) above, and has soil structure or the absence of rock structure in more than one-half of the volume and *one or more* of the following properties:

(1) Higher chroma, higher value, redder hue, or higher clay content than the underlying horizon or an overlying horizon; *or*

(2) Evidence of the removal of carbonates or gypsum; *and*

3. Has properties that do not meet the requirements for an anthropic, histic, folistic, melanic, mollic, plaggen, or umbric epipedon, a duripan or fragipan, or an argillic, calcic, gypsic, natric, oxic, petrocalcic, petrogypsic, placic, or spodic horizon; *and*

4. Is not part of an Ap horizon and does not have a brittle manner of failure in more than 60 percent of the matrix.

Duripan

A duripan (L. *durus*, hard; meaning hardpan) is a subsurface horizon that is cemented by illuvial silica to the degree that less than 50 percent of the volume of air-dry fragments slake in water or during prolonged soaking in acid (HCl). See photos 19 and 20. Duripans vary in the degree of cementation by silica. In addition, they commonly contain accessory cements, chiefly calcium carbonate. As a consequence, duripans vary in appearance. They generally are very firm or firmer and are always brittle, even after prolonged wetting. They grade into and can occur in conjunction with petrocalcic horizons, mostly in semiarid and arid regions. They also grade into noncemented earthy materials and into the fragipans of humid regions.

Genesis

Duripans occur mostly in soils with a xeric or aridic moisture regime (defined later), that is, in soils that are seasonally dry or are usually dry. Most soils that have a duripan have a moisture regime in which soluble silica might be expected to be translocated into lower horizons but not out of the soils.

Geographically, duripans are largely in areas affected by volcanism. Soils may show evidence of recent ash deposition, or they may be forming in sediments derived from pyroclastic materials, such as tuffs and ignimbrites. Many duripans occur in soils that contain an appreciable amount of volcanic glass in the overlying horizons, which suggests the importance of soluble silica to the genesis. Glass tends to weather readily, and the weathering can liberate soluble silicates at a rapid rate. Duripans are not limited to soils derived from volcanic materials. Weathering of ferromagnesian minerals and feldspars may also contribute to the formation of a duripan.

The parent materials of many soils that have a duripan contain only a small amount of calcium. If calcium is abundant, a calcic or petrocalcic horizon tends to occur with the duripan.

In the initial stages of duripan formation, much of the silica cementation appears to occur at or close to the weathering site of the mineral grain or glass chard. Monosilicic acid in the solution is adsorbed on soil grains, polymerizes, and precipitates as the soil dries. Silt- and clay-sized particles can then be cemented to the grains by the precipitated silica, forming microaggregates. These microaggregates can grow in size.

Alternatively, silica is adsorbed to the surface of the soil particles, forming bridges that cement grains without completely plugging small voids between the grains. This process continues until roots and the downward movement of the soil solution are stopped. At this point laminar caps composed dominantly of silica and calcite can develop.

Once formed, a duripan may become broken into blocky fragments, perhaps by earthquakes or slight volume changes resulting from wetting and drying. Before a layer can be considered a duripan, the lateral spacing of cracks wide enough to allow the entry of feeder roots must average 10 cm or more.

Appearance in an Arid Climate

The strongly cemented to indurated duripans in areas of arid climates (an aridic moisture regime, defined later) have an abrupt upper boundary and are commonly platy. The plates are roughly 1 to 15 cm thick. In many of these pans, the pores and the surfaces of the plates are coated with opal and with some birefringent material that is probably a microcrystalline form of silica. Carbonates generally are present in small to large amounts. Roots commonly are between the plates. More than 50 percent of the cementation can be destroyed by alternately soaking fragments of the pan in acid and concentrated alkali. The acid is used to destroy any cementation by carbonates. If some of the cements are carbonates or if a petrocalcic horizon is present, less than 50 percent of the cementation is destroyed by soaking the fragments in acid, but more than 50 percent is destroyed by soaking the fragments in concentrated alkali, either as a single treatment or by alternating treatments with acid. The presence of a thin, continuous layer of opal, which is insoluble in acid, indicates enough cementation by silica to satisfy the requirements for a duripan. A duripan and a petrocalcic horizon can occur together within the same horizon. If a horizon is cemented and meets the criteria for a petrocalcic horizon, any continuous horizon within the cemented layers that does not slake, in 50 percent or more of the volume, in acid is also considered a duripan. Commonly, a nearly continuous layer of secondary silica occurs in the part of the horizon that does not slake in acid.

The forms of a duripan that are transitional to regolith in arid regions are mostly massive and firm or very firm when moist and are brittle at all moisture states. Laminar caps of silica and coatings of silica on plates are uncommon. For a horizon to be a duripan, more than 50 percent of the horizon must not slake in water or in HCl and the horizon must have at least (1) a few vertical opal coatings, (2) some opal or other forms of silica partly filling interstices or forming bridges between sand-sized mineral grains, or (3) some silica coatings or pendants on the undersides of rock and pararock fragments. Moistened specimens of these forms of the duripan commonly show a dull glassy luster when viewed under a hand lens. The most weakly cemented forms of these transitional duripans can be penetrated with some difficulty by a hand-powered soil auger. Under irrigation, such horizons commonly are slowly permeable to water, and, except in cracks, they are virtually impenetrable to the roots of most plants.

Appearance in a Mediterranean Climate

In areas of Mediterranean climates (a xeric moisture regime, defined later), the pan commonly has an abrupt upper boundary and is broken into very coarse prisms or into polyhedrons that are roughly 30 cm to 3 m or more in diameter. Coatings of opal partly line the faces of the prisms and many of the pores. Roots are absent in the prisms, except in cracks, and are commonly matted on the upper boundary of the pan and on the sides of the prisms. The prisms may have been formed by the slight volume changes that result from wetting and drying. This process of formation is suggested by the absence of prisms in the duripans of arid regions.

The more strongly cemented pans of Mediterranean regions have opal coatings over the tops of the polyhedrons as well as on the sides, and the coatings are thicker than in the more weakly cemented pans. Water often perches on top of the pan during the rainy season. Coatings of iron, manganese, and oriented clay may be observed on many of these pans. Subsequent deposits of opal could engulf such coatings and give rise to a cementation that can be broken down only by repeated alternating treatments with solutions of acid and concentrated alkali. Carbonates may be present above the pan or in any part of it, or they may be completely absent. These observations indicate that carbonates are not an essential part of the pans.

The most weakly cemented forms of the duripans in a Mediterranean region are mostly transitional to regolith. Brittleness is pronounced at all moisture states, but most of the pans can be penetrated with some difficulty by a hand-powered soil auger. When dry, most of the pans are very hard and are slowly permeable.

In areas of more humid climates (a udic moisture regime, defined later), many of the duripans are in soils that have andic soil properties (defined later) in some overlying horizons. Some have characteristics transitional to a fragipan (described later). Some have redoximorphic features of gray and strong brown. Secondary carbonates and salts are absent in these pans. The cementation in the pan must be strong enough for less than 50 percent of dry pan fragments to slake when placed in water. Some horizons meet the requirements for a fragipan if more than 50 percent of dry pan fragments slake when placed in water.

Required Characteristics

A duripan is a silica-cemented subsurface horizon with or without auxiliary cementing agents. It can occur in conjunction with a petrocalcic horizon.

A duripan must meet *all* of the following requirements:

1. The pan is cemented or indurated in more than 50 percent of the volume of some horizon; *and*

2. The pan shows evidence of the accumulation of opal or other forms of silica, such as laminar caps, coatings, lenses, partly filled interstices, bridges between sand-sized grains, or coatings on rock and pararock fragments; *and*

3. Less than 50 percent of the volume of air-dry fragments slakes in 1N HCl even during prolonged soaking, but more than 50 percent slakes in concentrated KOH or NaOH or in alternating acid and alkali; *and*

4. Because of lateral continuity, roots can penetrate the pan only along vertical fractures with a horizontal spacing of 10 cm or more.

Fragipan

A fragipan (modified from L. *fragilis*, brittle, and pan; meaning brittle pan) is an altered subsurface horizon, 15 cm or more thick, that restricts the entry of water and roots into the soil matrix. It may, but does not necessarily, underlie an argillic, cambic, albic, or spodic horizon. It is commonly within an argillic horizon, but some are within an albic horizon. The fragipan has strongly developed fragic properties (defined below). Commonly, it has a relatively low content of organic matter and a high bulk density relative to the horizons above it. The fragipan has a hard or harder rupture-resistance class when dry. When moist, it has a brittle manner of failure in 60 percent or more of the volume. The term “manner of failure” refers to the tendency of a ped or clod to rupture suddenly rather than to undergo slow deformation when pressure is applied. Air-dried fragments slake when submerged in water.

Most fragipans have redoximorphic features, show evidence of translocation of clay, and have low or very low saturated hydraulic conductivity. Some fragipans consist of albic materials (defined below).

Most fragipans have very coarse prismatic structure. Some have weak to strong, thick platy or lenticular structure within the prisms. In others, the secondary structure is more nearly weak coarse blocky than platy. Some fragipans have transitional structure between platy and blocky. Some have no secondary structure, and some appear to be massive. Many have bleached, roughly vertical faces or borders of prisms that look like seams in vertical cross section. The spacing of any separations or bleached seams that are between the structural units and allow the entry of roots averages 10 cm or more on the horizontal dimensions.

The seams commonly have less clay in the upper part than in the lower part. They form a polygonal pattern in horizontal cross section. Most commonly, a fragipan has an abrupt or clear upper boundary at a depth of 50 to 100 cm below the original soil surface. The pan ranges from about 15 to 200 cm in thickness. The lower boundary commonly is gradual or diffuse. A fragipan is virtually free of roots, except in the bleached seams and on the faces of prisms. In many fragipans the bleached materials are not brittle when moist, although they may be hard when dry. Photo 21 shows a fragipan that begins at a depth of about 50 cm and has bleached seams between peds. Clay films are on the faces of peds or on pore fillings. Oriented clay is in the matrix of some fragipans. Fragipans consisting of albic materials commonly do not have bodies of oriented clay.

Significance to Soil Classification

Any continuous horizon that impedes movement of water and the growth of roots is important to soil classification, particularly for interpretations of soils for plant growth and for engineering manipulations. Water stands above the pan in a level soil and moves laterally along the top of the pan in a sloping soil. Even though the processes that produce fragipans are imperfectly known, these pans are restricted in their climatic range and natural vegetation and are believed to be genetic.

Genesis

The genesis of fragipans is obscure (Grossman and Carlisle, 1969). The formation of the density and brittleness of a fragipan has been variously attributed to physical ripening, the weight of glaciers, permafrost processes, and other events during the Pleistocene. Some of the properties of some fragipans are inherited from buried paleosols. The authors cited in the review by Grossman and Carlisle all consider fragipans to be pedogenic soil horizons, regardless of whether or not the density and brittleness are pedogenic, on the basis of the following evidence:

1. Fragipans show evidence of pedogenesis, other than density and brittleness, including one or more of the following—oriented clay in the matrix or on the faces of peds, albic materials or coatings of albic materials on the faces of peds or in seams, soil structure, and redoximorphic features in the matrix or on the faces of peds.

2. The fragipan is roughly parallel to the soil surface.

3. The upper boundary of most fragipans has a narrow depth range of about 50 to 100 cm below the surface, if the soil is not eroded. This range in depth has been observed in northern Michigan, in southern Mississippi, in New Zealand, in Scotland, and in Italy. The extreme range in depth from the surface in soils that have not been eroded or buried seems to be from about 25 to 150 cm. This narrow range would be a remarkable coincidence if the fragipans were not soil horizons.

4. The parent materials have common features, including a loamy texture, few or no carbonates, and an appreciable content of silt or very fine sand.

5. Fragipans of similar morphology underlie a variety of horizons, including spodic, argillic, cambic, and albic horizons.

6. Fragipans form only in soils in which water moves downward through the profile. They are commonly at depths that rarely freeze.

7. If a soil has an E´ horizon and a B´t horizon, the fragipan may be in the lower part of an argillic horizon or even in the eluvial horizon that separates the two B horizons. Thus, it occurs in otherwise eluvial or illuvial horizons.

8. Fragipans most commonly occur in soils that formed under forest vegetation.

The polygonal network of bleached materials is formed by reduction of free iron after water has saturated the cracks. The bleached materials commonly are bounded by a thin zone in which iron has been concentrated. Other things being equal, the structural units are smallest in the finest textured materials. For a given texture, structure tends to be larger if the dry season is short or mild rather than long or intense. Structural units, with bleached surfaces, are rare or absent in the coarsest textured materials.

If an argillic horizon overlies a fragipan, movement of clay down the faces of structural units generally is indicated by relatively thick clay films on the lower parts of the structural units and by pedotubules within the peds.

Examination of the interiors of prisms shows close packing of the mineral grains and bodies of oriented clay. The close packing is consistent with the high bulk density of the fragipan relative to the density of the overlying horizons.

The hardness of the fragipan when dry is largely attributed to the close packing and to binding by clay. Binding by clay alone, however, does not account for the brittleness of the pan when it is moist. The brittleness may be the result of weak chemical binding by one or more agents, not necessarily the same in all kinds of soil. The higher pH of a fragipan that underlies a spodic horizon suggests some consistent difference. Hydrogen bonding with amorphous aluminosilicates has been suggested in the literature. One piece of field evidence supporting the hypothesis of weak chemical binding is that one can find fragipans in which the brittleness appears to have been partly or completely destroyed. Some soils in very old arable fields in Belgium lack brittleness, but they retain the color pattern. A weak fragipan is present in the adjacent fields. The patterns of polygonal bleaching can be very well developed, but the brittleness may be observable in only a small part of the horizon near the center of the prisms. Fine feeder roots ramify the nonbrittle parts of the prisms. The amount of nonbrittle materials ranges from none to well over two-thirds of the volume of the horizon.

A second piece of field evidence for weak chemical binding is that, when exposed on streambanks, at least some fragipans seem more stable than either the overlying horizons or the underlying materials. The overlying and underlying materials commonly slump in the exposures, and the fragipan protrudes. The bleached materials on the sides of the prisms in the protruding fragipan are commonly washed out by rain, after which the brittle parts are exposed as separated prisms. At this time, the evidence about the cause of the brittleness is conflicting.

Where a fragipan formed in till, its relatively high bulk density may be attributed partly to the weight of the glaciers, to physical ripening, or to consolidation within a layer of permafrost. Yet, many if not all of the fragipans seem to reflect the influence of other factors. One factor is presumed to be pressure generated by very slight shrinking and swelling. When dry, a pan normally has very fine cracks between the prisms, and very fine sand, silt, and clay might be washed into these cracks when the dry season ends. Then, when the pan is remoistened, it swells very slightly. The force of swelling, however, is opposed by the materials that have moved into the cracks between the prisms and by the weight of the soil above. The internal pressure thus generated may be responsible for part of the compaction. A second factor is the inertness of the pan. Swelling and shrinking produce little soil movement. Soil fauna seem to be absent, and roots, restricted to the bleached zones between the prisms, are mostly oriented vertically and do not lift the soil as they grow. The pressure generated by the growth of the woody tree roots is lateral, not vertical. The common flattened shape of the roots attests to the pressure. Freezing and thawing are minimal. In areas that support native vegetation, it is doubtful that many fragipans ever freeze. Freezing is unlikely because of the depth of the fragipan and the insulation provided by the O horizons and by snow.

Identification

Four factors are important in identifying a fragipan.

First, a fragipan must have a minimum thickness. A thickness of 15 cm or more is thought to be thick enough to impart the interpretations for plant growth and for engineering manipulations and to separate the fragipan from plowpans, other compacted surface layers, or compacted layers near the surface.

Second, a fragipan shows evidence of pedogenesis, in addition to density and brittleness. This evidence, in the matrix, on faces of peds, or in seams, is in the form of bodies of oriented clay, clay films, albic materials, and/or both redoximorphic features and soil structure. The evidence of pedogenesis is needed to separate the fragipan from dense parent materials (densic materials), such as dense till and volcanic mudflow material.

Third, a fragipan has a combination of properties that restrict the penetration of roots and water from 60 percent or more of the volume of the horizon. Roots are restricted, except in nearly vertical zones that form the boundaries between very coarse structural units. The structural units are commonly polyhedral in horizontal cross section and average 10 cm or more across. Material within the structural units is massive, is platy, or has weak blocky structure and has a firm or firmer rupture-resistance class and a brittle manner of failure at or near field capacity. Some fragipans are massive and are restrictive throughout the horizon.

Fourth, air-dry fragments of the natural soil fabric, 5 to 10 cm in diameter, from more than 50 percent of the horizon slake when they are submerged in water. This property separates fragipans from duripans and other cemented horizons.

In the United States, soils that have a small amount of plinthite normally are brittle in at least some parts of the horizons that contain the plinthite. Some of these horizons meet the requirements for a fragipan. At this stage of knowledge, it is not clear that such horizons should be considered fragipans. Where they are at depths comparable to those of fragipans in other soils, however, the effects on plants and on engineering uses of the soils are the same. For pragmatic reasons, therefore, such horizons that have an upper boundary within 100 cm of the mineral soil surface are considered fragipans.

Required Characteristics

To be identified as a fragipan, a layer must have *all* of the following characteristics:

1. The layer is 15 cm or more thick; *and*

2. The layer shows evidence of pedogenesis within the horizon or, at a minimum, on the faces of structural units; *and*

3. The layer has very coarse prismatic, columnar, or blocky structure of any grade, has weak structure of any size, or is massive. Separations between structural units that allow roots to enter have an average spacing of 10 cm or more on the horizontal dimensions; *and*

4. Air-dry fragments of the natural soil fabric, 5 to 10 cm in diameter, from more than 50 percent of the horizon slake when they are submerged in water; *and*

5. The layer has, in 60 percent or more of the volume, a firm or firmer rupture-resistance class, a brittle manner of failure at or near field capacity, and virtually no roots.

Glossic Horizon

The glossic horizon (Gr. *glossa*, tongue) develops as a result of the degradation of an argillic, kandic, or natric horizon from which clay and free iron oxides are removed (photo 22). The material between the peds resulting from this removal is albic material (defined below). The process of eluviation gradually progresses from the exteriors of the peds to their interiors. In the early stages of development, the peds of the remnant argillic, kandic, or natric horizon still form structural units that extend throughout the glossic horizon, constituting close to 85 percent of its volume. In this early stage, the albic materials, when viewed in vertical cross section, resemble tongues extending into the horizon from the top. In the later stages, some of these structural units no longer extend throughout the horizon, and in the most advanced stages of the degradation process, remnant peds constitute little more than 15 percent (by volume) of the glossic horizon and are completely surrounded by albic materials. The boundary between the illuvial and eluvial parts of the glossic horizon may be either abrupt or clear and either irregular or broken.

A glossic horizon generally occurs between an overlying albic horizon and an underlying argillic, kandic, or natric horizon or fragipan. It can lie between an argillic, cambic, or kandic horizon and a fragipan. In the early stages of the degradation process described above, a glossic horizon can be within an argillic, kandic, or natric horizon or within a fragipan if the fragipan shows evidence of the degradation of an argillic horizon. An albic horizon may be below, or between subhorizons of, the glossic horizon.

Argillic horizons consisting of lamellae and intervening albic materials are not within the concept of the glossic horizon.

Required Characteristics

The glossic horizon is 5 cm or more thick and consists of:

1. An eluvial part, i.e., albic materials (defined below), which constitute 15 to 85 percent (by volume) of the glossic horizon; *and*

2. An illuvial part, i.e., remnants (pieces) of an argillic, kandic, or natric horizon (defined below).

Gypsic Horizon

The gypsic horizon is an illuvial horizon in which secondary gypsum has accumulated to a significant extent (photo 23). Most gypsic horizons occur in arid environments where the parent materials are rich in gypsum. In soils that have ground water near the surface, capillary rise and evaporation plus transpiration can result in significant accumulations of gypsum.

Gypsum may accumulate uniformly throughout a matrix of sand and finer textured material or as masses or clusters of crystals. In gravelly or stony material, it may accumulate in pendants below the rock fragments.

Because of its solubility, gypsum can dissolve in soils and cause damage to buildings, roads, irrigation delivery systems, earthen dams, and other structures.

Required Characteristics

A gypsic horizon has *all* of the following properties:

1. Is 15 cm or more thick; *and*

2. Is not cemented or indurated to such a degree that it meets the requirements for a petrogypsic horizon; *and*

3. Is 5 percent or more gypsum and 1 percent or more (by volume) secondary visible gypsum; *and*

4. Has a product of thickness, in cm, multiplied by the gypsum content percentage of 150 or more.

Thus, a horizon 30 cm thick that is 5 percent gypsum qualifies as a gypsic horizon if it is 1 percent or more (by volume) visible gypsum and is not cemented or indurated to such a degree that it meets the requirements for a petrogypsic horizon.

The gypsum percentage can be calculated by multiplying the milliequivalents of gypsum per 100 g soil by the milliequivalent weight of $CaSO_4 \cdot 2H_2O$, which is 0.086.

Kandic Horizon[1]

Genesis

A kandic horizon is a subsurface horizon that has a significantly higher percentage of clay than the overlying horizon or horizons and has an apparent CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7) and an apparent ECEC of 12 cmol(+) or less per kg clay (sum of bases extracted with 1N NH_4OAc pH 7 plus 1N KCl-extractable Al) in 50 percent or more of the soil volume in the upper 100 cm or to a densic, lithic, paralithic, or petroferric contact if shallower. The clay-sized fraction is composed predominantly of 1:1 layer silicate clays, mainly kaolinite, with varying amounts of oxyhydroxides of iron and aluminum. Clay films may or may not be present. (The percentage of clay is either measured by the pipette method or estimated to be 2.5 times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100.)

Textural differentiation in pedons with kandic horizons may result from one or more processes acting simultaneously or sequentially, affecting surface horizons, subsurface horizons, or both. These processes are not all clearly understood, although the most important ones can be summarized as follows:

1. Clay eluviation and illuviation.—In some soils it is often difficult to find clear evidence, even by micromorphological analysis, that the higher clay content in the B horizon is a result of accumulation by illuviation of layer silicate clays. Specifically, clay films (cutans) may be completely absent, or they may be present only at depths below the control section used in classification. In other soils clay films may have been destroyed by biological activity or pedoturbation processes. High concentrations and strong activity of soil fauna in soils of tropical and subtropical areas, where kandic horizons are common, may cause the partial or total disappearance of clay films to a considerable depth over time.

Many of the soils with kandic horizons that probably have formed by illuvial processes occur on stable geomorphic surfaces. On stable surfaces the illuviation process may no longer be operative or at least may be acting so slowly that mixing by soil organisms is more rapid than the formation of

[1] The concept of the kandic horizon and the “kandi” and “kanhapli” great groups of soils represent the work of the International Committee on the Classification of Low Activity Clays (ICOMLAC), chaired by Dr. Frank R. Moormann.

clay films. Under these conditions, clay films may be evident in some pedons but not in other nearby pedons that otherwise have similar morphology. Even within the same horizon of a single pedon, some peds may have clay films while others do not.

2. Clay destruction in the epipedon.—Weathering of layer silicates may lead to a relative loss of clay in soils. The loss generally is greatest in the upper horizons, where weathering processes are most intense. Elimination of bases and some silica is enhanced by high surface soil temperatures in well drained soils with high rates of leaching. Because this process affects surface horizons more than subsoil horizons, a vertical textural differentiation may result. This process may also have resulted in the absence of clay films in the lower horizons of highly weathered soils on old stable surfaces. A related process that occurs in surface horizons that are periodically wet may also result in similar textural differentiation.

3. Selective erosion.—Raindrop splash and subsequent surface soil erosion cause the smallest soil particles to be moved farther downslope than the larger particles. Eventually, part of the fine fraction may be eliminated from the surface layer of sloping soils, leaving a coarser textured surface layer. The speed of this process depends on many factors. It may be very rapid in climates with highly erosive rains or on soils with little plant cover. The surficial movement of clay downslope seems to be widespread, and selective erosion probably is a major process leading to textural differentiation. The process appears to be enhanced by periodic fire or by intermittent cultivation, such as the shifting cultivation practiced for thousands of years in areas where these soils occur.

4. Sedimentation of coarse textured surface materials.—Lithologic discontinuities are probable on stable landscapes in many intertropical areas. In many of the soils of these areas, the surface layer is coarser textured than the subsoil. Because all of the soil material is highly weathered, however, stratification is not evident. If the finer textured subsoil fulfills the requirements for the kandic horizon and the surface layer is not composed of fine strata of recent material, the subsoil horizon is classified as a kandic horizon.

Significance to Soil Classification

The kandic horizon provides a basis for differentiation among soils with clay accumulation in the subsoil. The argillic horizon alone does not provide an adequate diagnostic criterion to differentiate all Ultisols and Alfisols from Oxisols and Inceptisols. The kandic horizon is a diagnostic horizon that separates Ultisols and Alfisols in which the clay fraction has clay minerals with low CEC, comparable to Oxisols, from Ultisols and Alfisols that have clay minerals with high CEC. Textural differentiation in most low-activity clay soils by itself is believed to be sufficiently important for the understanding of soil development and use and should be recognized at a high level of the classification system. In soils with clayey surface horizons, however, the textural differentiation loses much of its significance. Most low-activity clay (LAC) soils that have, after mixing of the upper 18 cm, more than 40 percent clay in the surface horizon will be Oxisols, although a few that have LAC and the clay increase necessary for an argillic or kandic horizon but have significant amounts of weatherable minerals will remain “kandi” Ultisols or Alfisols.

The presence of a kandic horizon indicates a high degree of weathering of the mineral soil material, such as that in soils on old surfaces where weathering has taken place under warm climatic conditions with moderate to high precipitation. The high degree of weathering is reflected by a dominance of 1:1 layer silicate clays and oxyhydroxides of iron and aluminum, although small amounts of 2:1 layer silicate clays may also be present. There is a general absence of short-range-order minerals, such as allophane or imgolite. The composition of the 0.02 to 0.2 mm fraction does not always reflect the same degree of weathering, especially in soils that formed in weathering products of crystalline rocks. Thus, no weatherable mineral content is specified in the definition of the kandic horizon.

Identification

The kandic horizon is a vertically continuous subsurface horizon (not composed of lamellae) with a significantly finer texture than the overlying horizon or horizons. It may underlie an ochric, umbric, anthropic, or mollic epipedon. The upper boundary normally is clear or gradual, although it may be abrupt. It is never diffuse. The increase in clay content is reached within a vertical distance of 15 cm or less.

The top of the kandic horizon is within *one* of the following depths:

1. If the particle-size class throughout the upper 100 cm is sandy, the upper boundary is at a depth between 100 and 200 cm from the soil surface in most of the pedon.

2. If the clay content of the surface horizon is less than 20 percent and the particle-size class (of part or all of the upper 100 cm) is finer than sandy, the upper boundary is at a depth of less than 125 cm from the soil surface.

3. If the clay content of the surface horizon is 20 percent or more, the upper boundary is at a depth of less than 100 cm from the mineral soil surface.

Textures coarser than loamy very fine sand are excluded from the definition of the kandic horizon. The presence or absence of clay films, identified by field examination, or cutans in thin sections, is not a differentiating characteristic for kandic horizons.

Other field characteristics of kandic horizons are not normally diagnostic, since these horizons may have properties of the argillic, cambic, or oxic horizon. Some soils with kandic horizons resemble those with argillic horizons in that they have a well developed subangular blocky structure, while bleached grains of sand and silt may be present in the overlying coarser textured horizon or horizons. The ratio of fine clay (particles smaller than 0.2 micrometer) to total clay may be larger in the kandic horizon than in the overlying coarser textured horizon or horizons but is not diagnostic.

Other kandic horizons have one or more properties of oxic horizons and would be called oxic horizons if they did not have a distinct increase in content of clay at the upper boundary. This rationale is comparable to that used for pedons dominated by more active clays where an argillic horizon would be called a cambic horizon if it did not have the characteristic increase in content of clay at the upper boundary.

A kandic horizon is not overlain by layers more than 30 cm thick that show fine stratification and/or have an organic-carbon content that decreases irregularly with increasing depth, unless it is a buried horizon. The kandic horizon also does not show fine stratification and/or have an organic-carbon content that decreases irregularly with increasing depth.

Required Characteristics

The kandic horizon:

1. Is a vertically continuous subsurface horizon that underlies a coarser textured surface horizon. The minimum thickness of the surface horizon is 18 cm after mixing or 5 cm if the textural transition to the kandic horizon is abrupt and there is no densic, lithic, paralithic, or petroferric contact (defined below) within 50 cm of the mineral soil surface; *and*

2. Has its upper boundary:

a. At the point where the clay percentage in the fine-earth fraction, increasing with depth within a vertical distance of 15 cm or less, is *either*:

(1) 4 percent or more (absolute) higher than that in the surface horizon if that horizon has less than 20 percent total clay in the fine-earth fraction; *or*

(2) 20 percent or more (relative) higher than that in the surface horizon if that horizon has 20 to 40 percent total clay in the fine-earth fraction; *or*

(3) 8 percent or more (absolute) higher than that in the surface horizon if that horizon has more than 40 percent total clay in the fine-earth fraction; *and*

b. At a depth:

(1) Between 100 cm and 200 cm from the mineral soil surface if the particle-size class is sandy or sandy-skeletal throughout the upper 100 cm; *or*

(2) Within 100 cm from the mineral soil surface if the clay content in the fine-earth fraction of the surface horizon is 20 percent or more; *or*

(3) Within 125 cm from the mineral soil surface for all other soils; *and*

3. Has a thickness of *either*:

a. 30 cm or more; *or*

b. 15 cm or more if there is a densic, lithic, paralithic, or petroferric contact within 50 cm of the mineral soil surface and the kandic horizon constitutes 60 percent or more of the vertical distance between a depth of 18 cm and the contact; *and*

4. Has a texture of loamy very fine sand or finer; *and*

5. Has an apparent CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7) and an apparent ECEC of 12 cmol(+) or less per kg clay (sum of bases extracted with 1N NH_4OAc pH 7 plus 1N KCl-extractable Al) in 50 percent or more of its thickness between the point where the clay increase requirements are met and either a depth of 100 cm below that point or a densic, lithic, paralithic, or petroferric contact if shallower. (The percentage of clay is either measured by the pipette method or estimated to be 2.5 times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever is higher, but no more than 100); *and*

6. Has a regular decrease in organic-carbon content with increasing depth, no fine stratification, and no overlying layers more than 30 cm thick that have fine stratification and/or an organic-carbon content that decreases irregularly with increasing depth.

Natric Horizon

The natric (modified from *natrium*, sodium; implying the presence of sodium) horizon is a special kind of argillic horizon (photo 24). The dispersive properties of sodium accelerate clay illuviation. Research has shown that natric horizons form in Holocene-age soils, even in arid or semiarid environments.

The effect of sodium on dispersion of clay and on the formation of a B horizon of illuvial clay has long been recognized. The effect of magnesium ions on dispersion of clay, however, is still inconclusive. Laboratory studies seem to show but slight difference between the effects of magnesium and the effects of calcium. Yet, it is common for soils with a large amount of exchangeable magnesium to have poor physical properties. The reasons for the poor physical condition are uncertain. Magnesium is considered in the definition of the natric horizon because, as sodium is removed, magnesium follows in the leaching sequence if chlorides are low and sulfates high. If leaching continues, the magnesium is eventually replaced. When replacement reaches the point where the amount of exchangeable sodium is less than 15 percent and the amount of magnesium and sodium is less than that of calcium and exchange acidity in upper subhorizons that have a total thickness of 40 cm or more, the horizon is no longer considered natric. The remains of such former natric horizons are evident in soils in which the columnar structure is clearly evident but all other properties have been altered because of a greatly changed environment or continued leaching.

Required Characteristics

The natric horizon has, in addition to the properties of the argillic horizon:

1. *Either:*

 a. Columns or prisms in some part (generally the upper part), which may break to blocks; *or*

 b. Both blocky structure and eluvial materials, which contain uncoated silt or sand grains and extend more than 2.5 cm into the horizon; *and*

2. *Either:*

 a. An exchangeable sodium percentage (ESP) of 15 percent or more (or a sodium adsorption ratio [SAR] of 13 or more) in one or more horizons within 40 cm of its upper boundary; *or*

 b. More exchangeable magnesium plus sodium than calcium plus exchange acidity (at pH 8.2) in one or more horizons within 40 cm of its upper boundary if the ESP is 15 or more (or the SAR is 13 or more) in one or more horizons within 200 cm of the mineral soil surface.

Ortstein

Ortstein is a cemented horizon that consists of spodic materials.

Ortstein has *one* of the following orientations:

1. As a relatively horizontal layer. This type of orientation tends to be root restrictive and occurs primarily in Aquods.

2. As vertical to irregular columns, tongues, pillars, or bridges. This orientation tends to be less root restrictive than the horizontal orientation. Vertical orientation occurs primarily in Orthods.

3. As nodules. These may be remnants of one of the orientations listed above.

Ortstein is 25 mm or more thick and 50 percent or more (by volume) cemented. Continuous ortstein is 90 percent or more cemented and has lateral continuity. Because of this continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more.

Ortstein is differentiated from a placic horizon within spodic materials solely on the basis of thickness. Placic horizons within spodic materials are less than 25 mm thick, and ortstein is 25 mm or more thick.

Required Characteristics

Ortstein has *all* of the following:

1. Consists of spodic materials; *and*

2. Is in a layer that is 50 percent or more cemented; *and*

3. Is 25 mm or more thick.

Oxic Horizon

The oxic horizon is a mineral subsurface horizon of sandy loam or a finer texture with a low cation-exchange capacity and a low content of weatherable minerals. It is at least 30 cm (12 in) thick. The clay-sized fraction generally is dominated by kaolinite with or without iron and aluminum oxyhydrates and with few or no other lattice silicate minerals, except for hydroxy interlayered vermiculites. The silt and sand fraction of the oxic horizon is generally dominated by quartz with some other resistant minerals. Weatherable minerals that are potential sources of plant nutrients (K, Ca, and Mg) may be present only if they do not exceed 10 percent of the 50- to 200-micron fraction. Rock fragments or lithorelicts may be present only if they are coated with sesquioxides or if the included weatherable minerals are completely altered.

Where dispersion is a problem, 3 times (percent water retained at 1500 kPa tension minus percent organic carbon) is used to estimate clay content. The apparent CEC, by the 1N NH_4OAc pH 7 method, is equal to or less than 16 cmol(+) per kg of clay, and the apparent effective CEC (ECEC), as determined by the sum of NH_4OAc displaced bases plus 1N KCl-extractable aluminum, is equal to or less than 12 cmol(+) per kg of clay. The mineralogy and charge characteristics exclude horizons containing significant quantities of short-range-order minerals. The oxic horizon does not have andic soil properties. Some oxiclike horizons may have high amounts of low-charge illite, but they have more than 10 percent muscovite in the 50- to 200-micron fraction and are thus excluded from oxic horizons because muscovite is considered a weatherable mineral.

The upper boundary of the oxic horizon is either 18 cm below the mineral soil surface or at the lower boundary of an Ap horizon, whichever is deeper, or it is at a greater depth where mineralogical and charge characteristics meet the requirements for the oxic horizon. Any increase in clay content at the upper boundary must be diffuse. The lower boundary of the oxic horizon is also defined by its mineralogical and charge requirements and may, in addition, be defined by the presence of saprolite with rock structure.

Significance to Soil Classification and Use

One important attribute of the oxic horizon is that it is almost devoid of primary weatherable minerals. Thus, further weathering will release few plant nutrients.

Another important attribute is that in many soils with oxic horizons the clay content is relatively constant with increasing depth, indicating little or no clay mobility, which suggests a high order of stability in the clay fraction of these soils. This stability has been attributed to cementation by sesquioxides. Oxic horizons generally have only traces of water-dispersible clay if their net charge is near zero, but this characteristic is also shared by some other horizons.

A third attribute of most oxic horizons is a stable fine and very fine granular structure and thus the friable and porous nature of the horizon. Bulk densities are generally low, commonly near 1 g/cm^3 in fine and very-fine particle-size classes. Macrostructure may be angular or subangular blocky, but the grade of blocky structure is generally weak.

These and other attributes directly or indirectly influence the performance of soils having oxic horizons. The very low cation-exchange capacity is an important consideration in soil management. In addition, some oxic horizons have a high capacity to adsorb anions and make some of the anions, especially phosphates, unavailable to plants. Large amounts of phosphate may need to be added as an initial amendment to overcome the fixation capacity. Cations may need to be added frequently and in small amounts to compensate for leaching losses. The low CEC, where dominated by exchangeable Al, is often an advantage in that only small amounts of basic cations are needed to increase the base saturation percentage. Further, the ease with which basic cations are leached makes the chemical deepening of the root zone feasible via continued applications of lime or gypsum.

Although oxic horizons commonly contain high amounts of clay, their tendency to form a strong grade of very fine or fine granular structure may give them characteristics similar to those of sands. The horizons have a low available water-holding capacity because most of the pores are either very large between the granules (and thus do not retain water against the forces of gravity) or are very small within the granules (and thus retain water at too great a tension to be extracted by plants). Plants may show evidence of moisture stress after only a week without rain. Although the low available water-holding capacity is most limiting to shallow-rooted plants, yields of deep-rooted trees, such as rubbertree and oil palm, are also known to decline because of moisture stress.

It is considered desirable to identify soil horizons that are nearly sterile mineralogically because they are unable to supply basic cations through the continued weathering of primary minerals. As such, the oxic horizon can be considered a counterpart of the cambic horizon, which has a greater content of weatherable minerals. As with the cambic horizon, the exclusion of certain sandy textures is admittedly arbitrary. In the case of the oxic horizon, however, it is considered necessary to preserve the uniformity of the horizon with materials that have enough clay to reflect the low CEC nature and structural tendencies.

When considered in the vertical sequence of a soil profile, an increase in clay content with increasing depth may be associated with increased grades of blocky structure not common to the central concept of the oxic horizon. Where the increase in clay content is below coarser textured surface horizons, a small increase in the amount of clay appears more significant to moisture relationships than where the surface horizon is clayey. This increase is especially significant in the interpretation of soils that have been subject to accelerated erosion. Where the coarser textured surface horizons are eroded in cultivated areas and finer textured subsoil material becomes incorporated into the plow layer, spatial heterogeneity with respect to the characteristics of the plow layer develops. Thus, this pattern is considered more closely related to soils that have argillic horizons than to soils that do not have rather abrupt increases in clay content with increasing depth. Therefore, some horizons with many oxic horizon properties, such as low CEC and an absence of weatherable minerals, are classified as kandic horizons and may be part of Ultisols and Alfisols rather than Oxisols if there is less than 40 percent clay in the upper 18 cm.

The identification of an oxic horizon in most soils requires that the increase in clay content with increasing depth not exceed 1.2 times the clay content in the overlying horizons within a vertical distance of 15 cm (gradual boundary limit) if the surface horizon contains 20 to 40 percent clay. If the surface horizon contains more than 40 percent clay, an oxic horizon must have an absolute clay content increase of less than 8 percent within a vertical distance of 15 cm. If the surface horizon contains less than 20 percent clay, the oxic horizon must have an absolute clay content increase of less than 4 percent in a vertical distance of 15 cm. These are admittedly arbitrary limits, but they lend themselves to consistent identification in the field and rather easy verification by laboratory techniques.

Genesis

Oxic horizons are generally in soils on very old stable geomorphic surfaces. They may occur in soils on younger surfaces if the parent rock is basalt, serpentine, or other easily weathered rock or if the parent material is preweathered. Oxic horizons are not common in soils on steep slopes where rejuvenation of the soils takes place through erosion, truncation, or lateral flow of base-enriched subsurface water.

Soils on old geomorphic surfaces that may date to the mid or late Tertiary generally have been reworked. Many of the surficial deposits are preweathered, transported over short distances, and deposited, perhaps several times. After deposition and stabilization of the landscape, weathering and soil formation start anew. Stone lines composed of quartz or petroplinthite are common in some of these soils if the original material could supply the stones. Quartz veins may be traced through the saprolite but end abruptly or taper off at the stone line, indicating that the material above the stone line has been transported. Particle-size sorting may take place during transport and deposition, and lithologic discontinuities are common, although materials are very similar.

As was indicated earlier, the parent materials may be strongly preweathered. Weathering continues after deposition. The intensity of the weathering is a function of environmental conditions. In areas of aridic climates, this is minimal, and it is supposed that the oxic properties were attained during previous, more humid phases of the climate or in poorly drained environments or developed as the material weathered in transport.

In the more easily weathered parent materials and when climatic conditions are favorable, oxic horizons form in soils on young surfaces and over a relatively short period. Leaching and desilicification are the most important processes, resulting in a deep solum. The weathering front moves rapidly down the soils, and on many basic and ultrabasic rocks, there is no real saprolitic zone because the oxic horizon rests on rock or on a thin weathering crust. Primary minerals are altered to kaolinite, and, simultaneously or at a later stage, gibbsite and geothite also accumulate. Accidents of nature may occur, leaving behind some partially weathered rock or mineral fragments in the oxic horizon. These fragments are generally rare and, if present, are frequently coated with sesquioxides. Pseudomorphs of olivine and augite may be present in some oxic horizons, but these are not considered indicators of a lack of weathering.

On stable surfaces time has permitted homogenization of the soil material by pedoturbation processes. It is also possible that the active pedoturbation has disrupted and assimilated any evidence of lessivage, such as clay films. Consequently, most oxic horizons are uniform in color, texture, and other mineralogical or chemical properties to great depths in the soil. The pedoturbation processes have also disrupted any rock structure. In some saprolites weathering results in a pseudomorphic alteration of feldspar phenocrysts to gibbsite, the aggregates of which retain the original fabric. Mineralogically and chemically, the saprolite may meet the requirements for an oxic horizon, but it is not considered an oxic horizon if it retains more than 5 percent rock fabric. Booklets of kaolinite that formed through the pseudomorphic alteration of biotite are considered weatherable minerals. In an oxic horizon, these are disrupted and assimilated in the soil material.

Soils with oxic horizons frequently occupy the upper part of the landscape. The silica potential is very low in such soils. These soils have a leaching environment in which there is no possibility for synthesis of 2:1 clay minerals. Even in the wet soils with oxic horizons, the recharging water may be so low in bases and silica that, despite a high water table, the soils are continuously flushed and leached. Isohyperthermic soil temperature regimes and udic or perudic soil moisture regimes are often considered optimal for the formation of oxic horizons, but soils with oxic horizons are common in areas with ustic soil moisture regimes or with isothermic soil temperature regimes. They are rare in areas with aridic soil moisture regimes and isomesic soil temperature regimes. Some oxic horizons are present in areas of soil temperature regimes other than *iso* regimes, and, although paleoclimatic factors have been attributed to their formation, parent material is also probably a major contributor.

Required Characteristics

In summary, the oxic horizon is a subsurface horizon that does not have andic soil properties (defined below) and has *all* of the following characteristics:

1. A thickness of 30 cm or more; *and*

2. A texture of sandy loam or finer in the fine-earth fraction; *and*

3. Less than 10 percent weatherable minerals in the 50- to 200-micron fraction; *and*

4. Rock structure in less than 5 percent of its volume, unless the lithorelicts with weatherable minerals are coated with sesquioxides; *and*

5. A diffuse upper boundary, i.e., within a vertical distance of 15 cm, a clay increase with increasing depth of:

   a. Less than 4 percent (absolute) in its fine-earth fraction if the fine-earth fraction of the surface horizon contains less than 20 percent clay; *or*

   b. Less than 20 percent (relative) in its fine-earth fraction if the fine-earth fraction of the surface horizon contains 20 to 40 percent clay; *or*

   c. Less than 8 percent (absolute) in its fine-earth fraction if the fine-earth fraction of the surface horizon contains 40 percent or more clay); *and*

6. An apparent CEC of 16 cmol(+) or less per kg clay (by 1N NH_4OAc pH 7) and an apparent ECEC of 12 cmol(+) or less per kg clay (sum of bases extracted with 1N NH_4OAc pH 7 plus 1N KCl-extractable Al). (The percentage of clay is either measured by the pipette method or estimated to be 3 times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100).

Petrocalcic Horizon

The petrocalcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to the extent that the horizon is cemented or indurated (photo 25).

In some soils forming in parent materials that are rich in carbonates or that receive regular additions of carbonates in dust, the calcic horizon tends in time to become plugged with carbonates and cemented into a massive, continuous horizon. There is also evidence that a petrocalcic horizon can form through a process of limestone alteration by *in situ* dissolution and reprecipitation of carbonates. Petrocalcic horizons are mainly in soils older than the Holocene and seem to be a mark of advanced soil evolution.

In areas with an abundant source of carbonates and silica, petrocalcic horizons and duripans can occur within the same pedon.

The petrocalcic horizon is indurated or cemented throughout each pedon by calcium carbonate or, less commonly, by calcium and magnesium carbonate, with or without accessory silica, to such a degree that dry fragments do not slake in water and roots cannot enter, except in cracks that have a horizontal spacing of 10 cm or more. If the fragments are soaked in acid, cementation of the petrocalcic horizon is destroyed in half or more of its lateral extent in each pedon. The horizon is commonly massive or platy and is very hard or harder when dry and very firm or firmer when moist. Its saturated hydraulic conductivity commonly is moderately low to very low unless the horizon is fractured.

A laminar cap may be present but is not required. If one is present, carbonates normally constitute half or more, by weight, of the laminar horizon. Gravel, sand, and silt grains have been separated by the crystallization of carbonates in at least parts of the laminar subhorizon. Sand and gravel have been largely pushed aside by crystallization of calcium carbonate at the surface of the laminar horizon. Radiocarbon dates of the organic and inorganic carbon indicate that this laminar horizon is late Wisconsinan to Holocene in age and that the cementation of the underlying gravel took place during the late Pleistocene.

Required Characteristics

A petrocalcic horizon must meet the following requirements:

1. The horizon is cemented or indurated by carbonates, with or without silica or other cementing agents; *and*

2. Because of lateral continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

3. The horizon has a thickness of:

  a. 10 cm or more; *or*

  b. 1 cm or more if it consists of a laminar cap directly underlain by bedrock.

Petrogypsic Horizon

The petrogypsic horizon is an illuvial horizon, 10 cm or more thick, in which secondary gypsum has accumulated to the extent that the horizon is cemented or indurated (photo 26). Dry fragments do not slake in water, and roots cannot enter, except in vertical fractures that have a horizontal spacing of 10 cm or more. The minimum gypsum content is 5 percent, and the product of the thickness, in cm, multiplied by the gypsum content percentage is 150 or more. Commonly, the gypsum content is far greater than the minimum requirements. In many pedons it is 60 percent or more. Petrogypsic horizons are known to occur only in arid regions and develop in parent materials that are rich in gypsum. They are rare in the United States but are common in parts of Africa and Asia

Required Characteristics

A petrogypsic horizon must meet the following requirements:

1. The horizon is cemented or indurated by gypsum, with or without other cementing agents; *and*

2. Because of lateral continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

3. The horizon is 10 cm or more thick; *and*

4. The horizon is 5 percent or more gypsum, and the product of its thickness, in cm, multiplied by the gypsum content percentage is 150 or more.

Placic Horizon

The placic horizon (Gr. base of *plax*, flat stone; meaning a thin cemented pan) is a thin, black to dark reddish pan that is cemented by iron (or iron and manganese) and organic matter. It is generally between 2 and 10 mm thick but may be as thin as 1 mm. The placic horizon has a maximum thickness of 25 mm where it is associated with spodic materials. Where not associated with spodic materials, it has no maximum thickness. It is often associated with stratification in parent materials, such as an abrupt discontinuity of hydraulic conductivity associated with different particle sizes in ash layers. The placic horizon is commonly within 50 cm of the mineral soil surface and is roughly parallel with the mineral soil surface. It has a pronounced wavy or even convoluted form. Commonly, it occurs as a single pan rather than as multiple sheets (one underlying another), but it may be bifurcated. It is a barrier to water and roots. Placic horizons have been described in Andisols, Histosols, Inceptisols, and Spodosols. In New Zealand they also have been reported in young alluvial soils.

Most placic horizons occur in areas of cool, moist climates with low evapotranspiration. They are known to occur in the British Isles, New Zealand, Canada, and southeastern Alaska. They also have been reported in the Tropics.

Placic horizons range in color from dark red to black. Chemical data indicate that carbon and iron are major components and aluminum and manganese minor components in most placic horizons. In some areas, however, manganese is a significant constituent of the horizons. There appears to be little relationship between the chemical composition and the color of the placic horizon.

Research on genesis suggests that placic horizons form from iron that is reduced and mobilized in the surface horizons and oxidized and precipitated in the B horizon, where it can adsorb soluble organic matter. The iron, however, does not form organo-metallic complexes. The most common forms of iron in the placic horizon are ferrihydrite and poorly crystalline goethite. These minerals have a large capacity for adsorbing anions, including humic substances.

Conditions for the reduction and mobilization of iron are favored in strongly leached, acid soils with organic surface horizons containing anaerobic micro-organisms. In some soils placic horizons form at the boundary between layers with contrasting particle-size classes, which restrict the soil solution. Placic horizons also can form above lithic, densic, or paralithic contacts. They are by no means restricted to the conditions described above.

Most placic horizons in the British Isles have formed within the last 3,000 years, but there is evidence to support incipient formation of placic horizons within 100 years.

Placic horizons form in material with a variety of textures ranging from sands to clays. The native vegetation in the different climates includes tropical rain forest, *Sphagnum*, and other rain-loving plants. In the British Isles placic horizons occur under peat-forming ericaceous or grassy seminatural vegetation, which is subject to periodic burns and was likely forest within the last 3,000 years.

Unless the thickness of the placic horizon is minimal, identification of the horizon is seldom difficult because the hard, brittle pan differs so much from the material in which it occurs and is so close to the mineral soil surface. The presence of organic carbon and the shape and position of the placic horizon distinguish the horizon from the ironstone sheets that may form where water hangs, or moves laterally, at a lithologic discontinuity. Where placic horizons occur within spodic materials, they are arbitrarily differentiated from ortstein by thickness. Ortstein has a minimum thickness of 25 mm.

Required Characteristics

A placic horizon must meet the following requirements:

1. The horizon is cemented or indurated with iron or iron and manganese and organic matter, with or without other cementing agents; *and*

2. Because of lateral continuity, roots can penetrate only along vertical fractures with a horizontal spacing of 10 cm or more; *and*

3. The horizon has a minimum thickness of 1 mm and, where associated with spodic materials, is less than 25 mm thick.

Salic Horizon

A salic horizon is a horizon of accumulation of salts that are more soluble than gypsum in cold water (photo 27). A common salt is halite, the crystalline form of sodium chloride. In some areas soluble sulfates may also accumulate with the crystalline forms, such as thernadite, hexahydrite, epsomite, and mirabilite. Two of the commonly occurring bicarbonates are trona and natron. Under extreme aridic conditions and at low temperatures, evaporites of calcium chloride, nitrates, and other soluble salts may accumulate. Identification of the kinds of crystalline salts requires detailed mineralogical analyses.

In extremely arid areas, such as parts of Chile and Antarctica, where measurable precipitation is rare, salic horizons have a hard or rigid rupture-resistance class. These types of salic horizons are physical barriers to roots, but they slake in water and, therefore, are not considered cemented.

Required Characteristics

A salic horizon is 15 cm or more thick and has, for 90 consecutive days or more in normal years:

1. An electrical conductivity (EC) equal to or greater than 30 dS/m in the water extracted from a saturated paste; *and*

2. A product of the EC, in dS/m, and thickness, in cm, equal to 900 or more.

Sombric Horizon

A sombric horizon (F. *sombre*, dark) is a subsurface horizon in mineral soils that has formed under free drainage. It contains illuvial humus that is neither associated with aluminum, as is the humus in the spodic horizon, nor dispersed by sodium, as is common in the natric horizon. Consequently, the sombric horizon does not have the high cation-exchange capacity in its clay that characterizes a spodic horizon and does not have the high base saturation of a natric horizon. It does not underlie an albic horizon.

Sombric horizons are thought to be restricted to the cool, moist soils of high plateaus and mountains in tropical or subtropical regions. Because of strong leaching, their base saturation is low (less than 50 percent by NH_4OAc).

The sombric horizon has a lower color value or chroma, or both, than the overlying horizon and commonly contains more organic matter. It may have formed in an argillic, cambic, or oxic horizon. If peds are present, the dark colors are most pronounced on surfaces of peds.

In the field a sombric horizon is easily mistaken for a buried A horizon. It can be distinguished from some buried epipedons by lateral tracing. In thin sections the organic matter of a sombric horizon appears more concentrated on peds and in pores than uniformly dispersed throughout the matrix.

Spodic Horizon

A spodic horizon is an illuvial layer with 85 percent or more spodic materials (defined below). Spodic materials contain illuvial active amorphous materials composed of organic matter and aluminum, with or without iron. The term “active” is used here to describe materials that have a high pH-dependent charge, a large surface area, and high water retention. In uncultivated soils the spodic horizon normally lies below an albic horizon (a light colored eluvial horizon defined earlier). Less commonly, it either is under an ochric epipedon that does not meet the color requirements for an albic horizon or is in or under an umbric epipedon. In some soils the spodic horizon is at the surface of the mineral soil, directly below a thin O horizon. In cultivated soils it generally occurs directly below the Ap horizon. Spodic materials may remain in some cultivated soils where the spodic horizon has been destroyed. If 85 percent of the spodic materials remain in the Ap horizon and the soil meets the other criteria listed in the “Key to Soil Orders” in chapter 8, the soil is considered a Spodosol.

Genesis

Spodic horizons form only in a humid environment. They are commonly associated with cold or temperate climates but also occur in hot climates. They do not occur in an arid environment, although some occur in Mediterranean climates that have long, dry summers.

The types of vegetation and litter covering the surface are important in the formation of spodic horizons. In cool climates spodic horizons occur in soils that have had a heath vegetation (*Erica* and *Calluna*) or forest (broadleaf or coniferous) vegetation. In a mixed forest, the spodic horizon generally is more strongly expressed under certain species, such as hemlock (*Tsuga canadensis*) or kauri (*Agathis australis*), than under other species. In warm climates spodic horizons occur under savanna, palm trees, and mixed forests.

A spodic horizon forms mostly in sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty materials or in andic soil materials (defined below), but it occasionally develops in finer textured material. Some spodic horizons that are not associated with an albic horizon may have been overlooked in the past. If the parent materials are rich in clay, the formation of a spodic horizon is likely to be delayed until eluviation or weathering has reduced the clay content below a critical level. A spodic horizon then forms in the eluvial horizon, and the underlying argillic horizon is either destroyed or moved to a greater depth as the spodic horizon thickens. There seems to be an antagonism between a spodic horizon and phyllosilicates. If a spodic horizon and an argillic horizon occur in the same soil, they generally are separated by an eluvial horizon (E´), but under heath vegetation a spodic horizon may rest directly on, and may tongue into, an argillic horizon. In calcareous parent material, a spodic horizon does not begin to develop until carbonates have been leached from the upper part of the soil. A spodic horizon can form either in relatively fresh parent material containing abundant weatherable minerals or in nearly pure quartz sand.

A spodic horizon can form either in a well drained soil or in a soil with a shallow, fluctuating level of ground water. If the water table remains within the spodic horizon for long periods, the horizon may contain little or no iron. A spodic horizon does not seem to develop in a soil that is permanently saturated with water.

Under optimum conditions, a spodic horizon can form within a few hundred years. Its biological destruction can be equally rapid, at least in some cultivated soils where lime and fertilizers are applied.

Most spodic horizons are horizons in which organic matter, aluminum, and iron have accumulated. As far as is known, aluminum is always present and may be essential. Almost all spodic horizons have a maximum content of organic matter, iron, or aluminum in their upper few centimeters, although iron may be absent in some, or the iron and aluminum maxima may be below the organic-matter maximum, and the aluminum maximum may be below the iron maximum. Most spodic horizons have hue of 7.5YR or redder. The presence of hue of 7.5YR or redder in a spodic horizon that does not contain iron, the persistence of the hue after reduction if iron is present, and, if iron is absent, the destruction of the color by ignition suggest that organic compounds are important to the color of the spodic horizon.

The mobile sesquioxides in spodic horizons can result from the dissolution of primary minerals and from cycling by plants. In eluvial horizons that overlie spodic horizons, the aluminosilicates appear pitted as if by solution. Pitting is particularly evident on mafic minerals. In some soils a well developed spodic horizon is the upper mineral horizon, overlain only by an O horizon. Although mixing of horizons by animals or by falling trees generally can be demonstrated in such soils, more than one source of the materials accumulated in the spodic horizon is possible.

Some older theories concerning the formation of spodic horizons postulated a mutual flocculation of positively charged colloidal sesquioxides and negatively charged colloidal organic matter. Others assumed a flocculation of sesquioxides or of organic matter by changes in the redox potential or pH with increasing depth.

According to newer theories, an association between organic matter and iron and aluminum is formed by chelation and electrostatic bonding. The compounds thus formed are soluble if the sesquioxide concentration is low, but they are precipitated when the sesquioxide concentration reaches a critical level. Other research has demonstrated that large amounts of inorganic aluminum and iron in a Spodosol can be translocated as a sol from an A horizon to a B horizon before complexing with organic matter.

Consequently, if solutions of organic compounds or sols that are moving through the soil pick up sesquioxides from primary minerals and from part of the spodic horizon, the compounds are eventually precipitated somewhere in the spodic horizon. The movement either can be downward (as a result of gravity) or can be lateral or upward. Upward movement resulting from capillary forces is suggested by the black, humus-rich subhorizon above and on the sides of tongues of the E horizon that commonly penetrate at various angles into the spodic horizon. Immobilization of sesquioxides may also be the result of a hydrolysis of the organometallic complex induced by changes in pH or by biological destruction of organic ligands. Two of the specific properties of the immobilized material that becomes the active fraction of a spodic horizon are (1) high concentrations of carboxyl and hydroxyl sites that are destroyed on heating and (2) solubilization of organic matter and sesquioxides on treatment with a strong complexing agent, such as ammonium oxalate.

Distinctions Between Spodic Horizons and Andic Soil Materials

The central concept of andic soil materials is that of a soil developing in weatherable, silica-rich parent materials, such as volcanic ejecta or volcaniclastic materials, which have a colloidal fraction dominated by short-range-order minerals or aluminum-humus complexes. Under some environmental conditions, weathering of primary aluminosilicates in parent materials of nonvolcanic origin may also lead to the formation of short-range-order minerals. The dominant process in most soils with andic soil materials is one of weathering and mineral transformation. Translocation within the soils and accumulation of the translocated compounds are normally minimal.

The central concept of soils with spodic horizons is one of aluminum, or aluminum and iron, and organic matter illuviating and precipitating when critical levels are reached.

Some areas, for example some areas in Alaska, periodically receive volcanic ejecta (photo 28). These areas also have climatic and vegetative conditions conducive to the formation of spodic materials. The soils in these areas of Alaska exhibit features of both andic and spodic materials. Because it represents evidence of eluviation, the albic horizon is used to separate Andisols from Spodosols; however, a layer of volcanic ash should not be mistaken for an albic horizon.

Distinctions Between Spodic and Argillic Horizons

Argillic horizons are illuvial, and so are spodic horizons. As an argillic horizon forms, discrete crystalline clay particles are moved from an eluvial horizon to an illuvial horizon. Consequently, the clays in the eluvial and illuvial horizons of a soil that has an argillic horizon are similar, except where one kind of clay mineral has moved in preference to others. The silica-sesquioxide (SiO_2 to R_2O_3) ratio of the whole soil is at a minimum in the argillic horizon, but that of the clay fraction remains virtually constant throughout the profile.

In soils that have a spodic horizon, the dominant processes are dissolution of primary minerals in any eluvial horizon; movement of iron, aluminum, and organic matter; and precipitation of complexes of amorphous organic matter and metal. Typically, the clay mineralogy in the eluvial horizon differs greatly from that in the illuvial horizons, and the ratio of SiO_2 to R_2O_3 both in the whole soil and in the clay fraction is at a minimum in the spodic horizon.

In a particle-size separation, at least some of the illuviated iron and aluminum is dispersed and becomes part of the measured clay fraction. Consequently, data commonly show a clay maximum in the spodic horizon. Both the spodic horizon and the argillic horizon may be a horizon of accumulation of free iron. In well drained soils that have an argillic horizon, the ratio of free iron to clay tends to be constant in all horizons. In soils that have a spodic horizon, however, this ratio tends to vary.

There are large differences in micromorphology between an argillic horizon and a spodic horizon. The birefringent crystalline clay coatings of the argillic horizon differ sharply from the isotropic amorphous coatings of the spodic horizon. Most spodic horizons, however, contain some illuviated crystalline clay.

Distinctions Between Spodic and Cambic Horizons

A cambic horizon can be formed either by alteration of parent materials in place, resulting in the release of iron and the formation of structure, or by solution and removal or accumulation of carbonates or gypsum. There is not enough illuviation to form a spodic horizon. Two situations in which a spodic horizon and a cambic horizon might be confused in the field are possible. A cambic horizon may grade laterally by imperceptible stages into a spodic horizon as a result of increasing accumulation of complexes of organic matter and sesquioxides. A very weakly developed spodic horizon, however, contains more of these complexes relative to phyllosilicates than a cambic horizon, and the two kinds of horizons can be separated either on the basis of their morphology or by chemical techniques described below, in the section on spodic materials.

It may be difficult to distinguish a spodic horizon from a cambic horizon in a soil that has developed in pyroclastic materials in a cool, perhumid climatic region. Under those conditions, part of the amorphous mineral material in a cambic horizon may form complexes with organic matter that are similar to those of a spodic horizon. In this situation, a distinction may be made on the basis of evidence of eluviation and the typical color pattern of a spodic horizon. If an overlying eluvial (albic) horizon is present in more than 50 percent of the pedon, it can be inferred that the underlying horizon is illuvial. Likewise, the presence of a spodic horizon is suggested if, in a freely drained soil, there is an abrupt boundary between an Ap horizon and an underlying horizon that contains 85 percent or more spodic materials.

Morphology

A typical spodic horizon is easily recognized in the field by its color and structure. Commonly, it has a sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty particle-size class. The upper boundary of the horizon is commonly abrupt, and the hue, color value, and chroma of the horizon change markedly with increasing depth within a few centimeters of its upper boundary. The lowest color value, the reddest hue, and the lowest chroma occur in the upper part of the horizon. The lower part of the spodic horizon, or the horizon directly below it, has a higher chroma or a yellower hue than the main part, or it has some combination of these colors. Structure is either absent or is granular, platy, blocky, or prismatic. Cracked coatings of an isotropic amorphous mixture of organic matter, iron, and aluminum can be detected on mineral sand grains in a sandy or coarse-loamy spodic horizon viewed under a 40- to 60-power lens.

Commonly, cracked coatings are dominant in the lower part of the spodic horizon. If the coatings are very thick, the horizon may be ortstein. In a dry soil the coatings may be cracked. Clay films are not present on peds or in pores within a spodic horizon. Coatings on sand grains in a spodic horizon may not be distinguishable under a hand lens, however, from thin clay coatings in an argillic horizon.

If an albic horizon overlies a spodic horizon, there is seldom any difficulty in determining that the spodic horizon is of illuvial origin. Commonly, there is a second maximum of organic carbon in the spodic horizon. In some tropical and subtropical areas, the albic horizon may be extremely thick and the spodic horizon may occur at a depth of 200 cm or more below the mineral soil surface. The presence of organic carbon and the characteristics of the exchange complex distinguish a cemented spodic horizon (ortstein) from the ironstone layer (petroferric contact, defined below) at a lithologic discontinuity below many soils. In undisturbed soils without an albic horizon, there is commonly a thin, dark eluvial horizon in which many of the sand grains are free of humus and of sesquioxide coatings. Many spodic horizons, however, are so close to the mineral soil surface that the horizons overlying them are easily destroyed by plowing or even by the disturbances associated with logging. In some soils the albic or other overlying horizons seem to have been mixed with the spodic horizon by falling trees or by animals or may never have existed. In a disturbed soil it may be difficult or impossible to establish the illuvial nature of the spodic horizon, although it has all of the morphological, chemical, and physical properties of a spodic horizon, which is clearly illuvial. The presence of an overlying eluvial horizon is not required in the definition of a spodic horizon, although its identification is facilitated by the presence of an eluvial horizon.

Identification

A spodic horizon normally underlies an O, A, Ap, or E horizon. The hue and chroma may remain constant with increasing depth if the horizon is thin and overlies a densic, lithic, or paralithic contact (defined below). Generally, the subhorizon with the reddest hue or the lowest chroma, or both, is near the top of the spodic horizon. The hue becomes yellower or the chroma higher, or both, within subhorizons of the spodic horizon or in an underlying BC, C, E´, or Bx horizon.

Spodic horizons must contain at least 85 percent spodic materials. There are many useful clues from field evidence to help identify spodic materials. Among these are an albic horizon in 50 percent or more of the pedon and amorphous aluminum (or aluminum and iron), which, when present in sufficient amounts, provides color clues to the existence of spodic materials. These colors are listed in the section on spodic materials. Spodic materials cannot be positively identified from field evidence alone. They must also have a pH value of 5.9 or less and an organic-carbon content of 0.6 percent or more. Not all soils with spodic materials have albic horizons. When albic horizons are absent, spodic materials must still meet specific color requirements and have at least one additional feature. Such features can be morphological or chemical, or both. The additional morphological features include (1) ortstein that has a horizontal continuity through 50 percent or more of the pedon and a very firm or firmer rupture-resistance class and (2) cracked coatings on 10 percent or more of the sand grains. In some soils the presence of isotropic cracked coatings may have to be confirmed with the aid of a petrographic microscope. Optical identification may not be feasible if there are significant inclusions of mica or of other anisotropic clay or if the presence of volcanic glass or other pyroclastic materials leads one to suspect that the horizon is a cambic horizon containing amorphous clay.

If a pedon does not have an albic horizon, ortstein, or sand grains with cracked coatings, then the definition of spodic materials requires that specific color and chemical criteria be met. Two chemical criteria are used to evaluate spodic materials. If at least one of these, in addition to the color requirements, is satisfied, the definition of spodic materials is met.

The first chemical criterion is that the percentages of ammonium-oxalate-extractable aluminum plus one-half the ammonium-oxalate-extractable iron in spodic materials must total 0.50 or more and must be 2 times or more the amounts present in an overlying umbric (or subhorizon of an umbric) epipedon or in an ochric epipedon or albic horizon. The increase in ammonium-oxalate-extractable iron and aluminum from an A and/or E horizon to a B horizon is indicative of the illuvial process. Ammonium oxalate will extract both iron and aluminum associated with humus and inorganic amorphous compounds, and it will also dissolve magnetite and ferrihydrite, both of which contribute to the ammonium-oxalate-extractable iron values. Ferrihydrite is believed to be associated with both spodic and nonspodic materials in soils associated with wetness.

The second chemical criterion is that the optical-density-of-oxalate-extract (ODOE) value should be 0.25 or more and at least double from an eluvial horizon to the spodic horizon. The ODOE is assumed to result mostly from extracted fulvic acids.

Photo 4.—A histic epipedon.

Photo 5.—A melanic epipedon approximately 90 cm thick in a Melanudand from Japan.

Photo 6.—A mollic epipedon approximately 25 cm thick over a calcic horizon in a soil from Idaho.

Photo 7.—A mollic epipedon approximately 57 cm thick in an Argiustoll from Kansas.

Photo 8.—An ochric epipedon from an Oxisol in Hawaii. The ochric epipedon has high value and chroma.

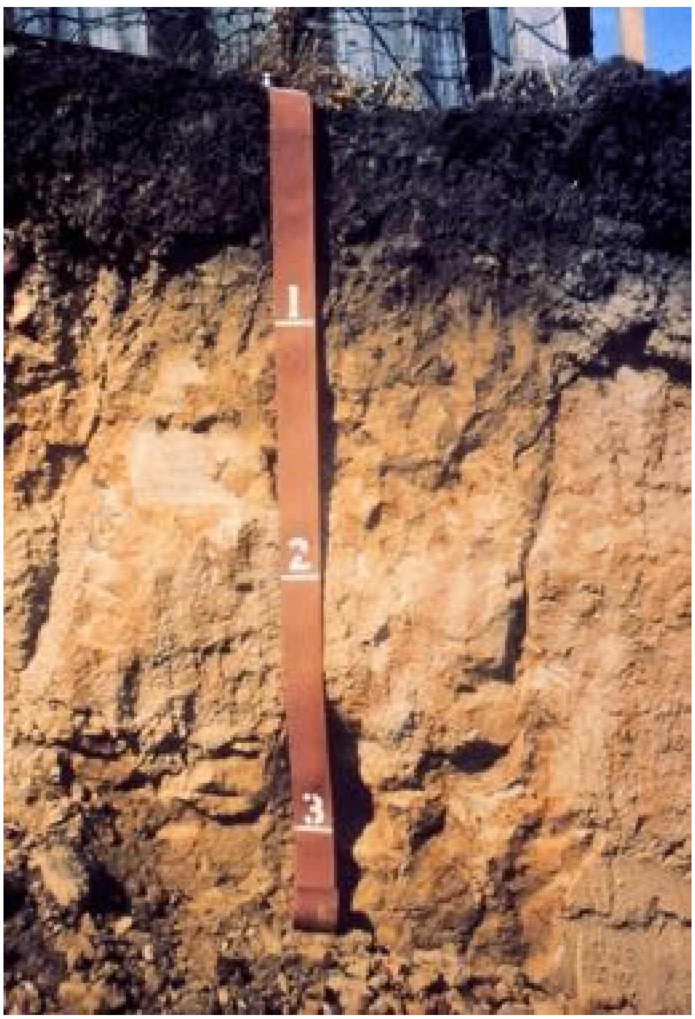


Photo 9.—A soil with an ochric epipedon about 15 cm thick. The dark colored ochric epipedon is too thin to be a mollic or umbric epipedon.

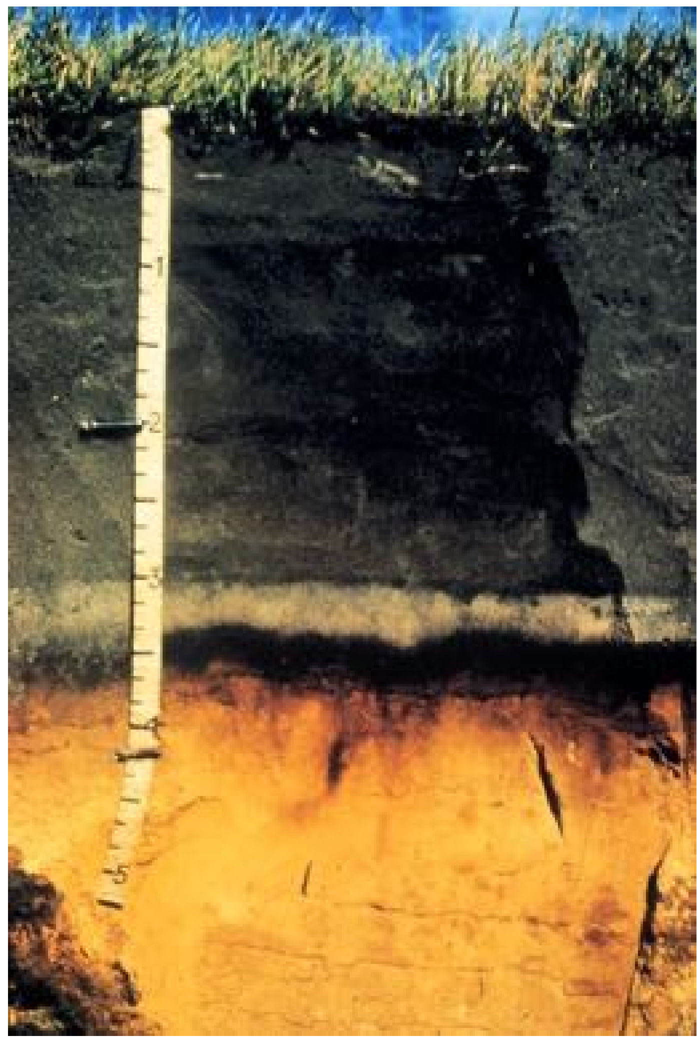


Photo 10.—A soil that has a plaggen epipedon about 90 cm (3 ft) thick. The sod presumably came from the heath. Variations caused by mixing of materials can be seen. This map unit has straight boundaries, and it is higher than the surrounding landscape. Plaggen epipedons are not known to occur in the United States but are common in parts of Western Europe.

Photo 11.—An umbric epipedon in an Xerept from Spain.

Photo 12.—An albic horizon in an Argialboll from North Dakota.

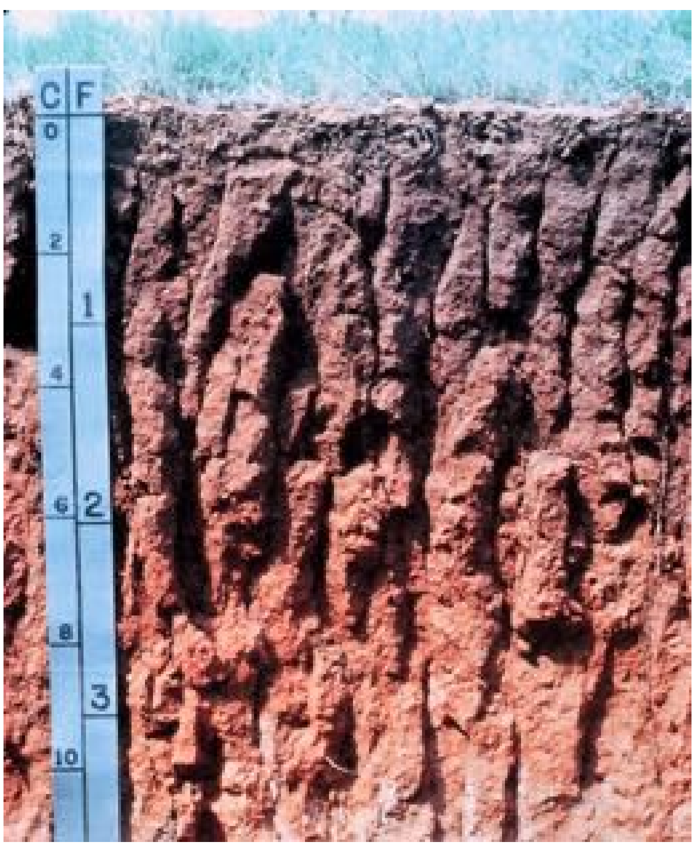


Photo 13.—An argillic horizon that begins at about 5 cm in a Haplustalf from Texas. This argillic horizon has strong prismatic structure.

Photo 14.—A prominent clay film in a pore and a faint clay film on the surface of a ped in an argillic horizon.

Photo 15.—Clay films and bridges on sand grains, which commonly occur in argillic horizons with associated eluvial horizons that have less than 15 percent clay.

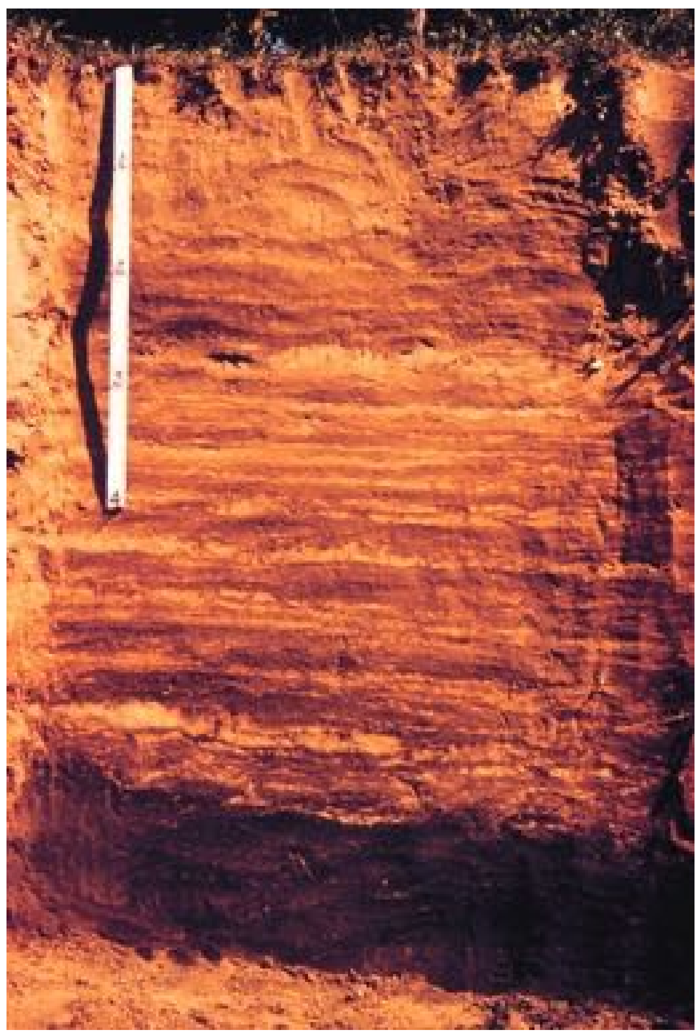


Photo 16.—An argillic horizon that consists of lamellae.

Photo 17.—A partially cemented Ustic Haplocalcid from New Mexico.

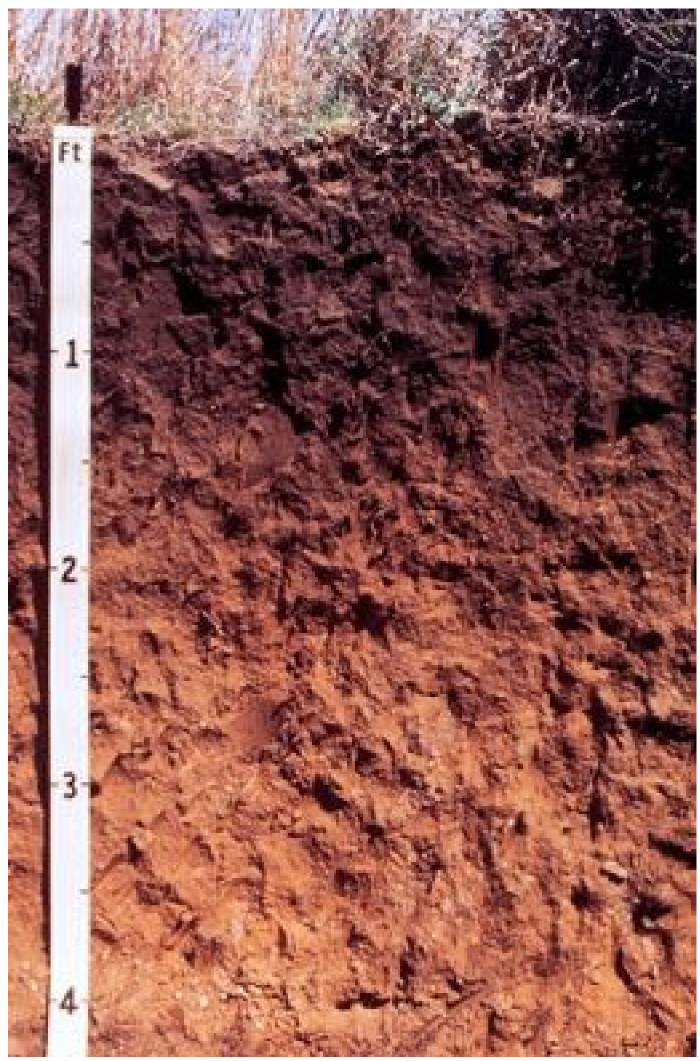


Photo 18.—A cambic horizon below a mollic epipedon in an Ustoll from Nebraska.

Photo 19.—A duripan underlain by cinders in a Durustoll from Arizona.

Photo 20.—Close-up of a calcareous duripan.

Photo 21.—A fragipan beginning at a depth of about 50 cm. Bleached seams are between the peds.

Photo 22.—A glossic horizon that has more than 15 percent albic material between the peds of a degrading argillic horizon.

Photo 23.—A gypsic horizon between depths of 26 and 165 cm in a Gypsid from New Mexico.

Photo 24.—A natric horizon with columnar structure in a Natrudoll from Argentina.

Photo 25.—A petrocalcic horizon that begins at a depth of about 63 cm in an Argic Petrocalcid from New Mexico.

Photo 26.—A petrogypsic horizon beginning at a depth of about 50 cm in a Petrogypsid from New Mexico.

Photo 27.—A salic horizon in an Aquisalid from Nevada.

Photo 28.—A spodic horizon in a Haplocryod from Alaska. This soil receives periodic deposits of volcanic ash.

Photo 29.—A pedon with andic soil properties between depths of about 48 and 100 cm. The material above 48 cm is from the 1980 eruption of Mount St. Helens and has not weathered sufficiently to meet the criteria for andic soil properties.

Photo 30.—Identifiable secondary carbonates that have engulfed a calcic horizon.

Photo 31.—Lamellae below an argillic horizon.

Photo 32.—Close-up of lamellae.

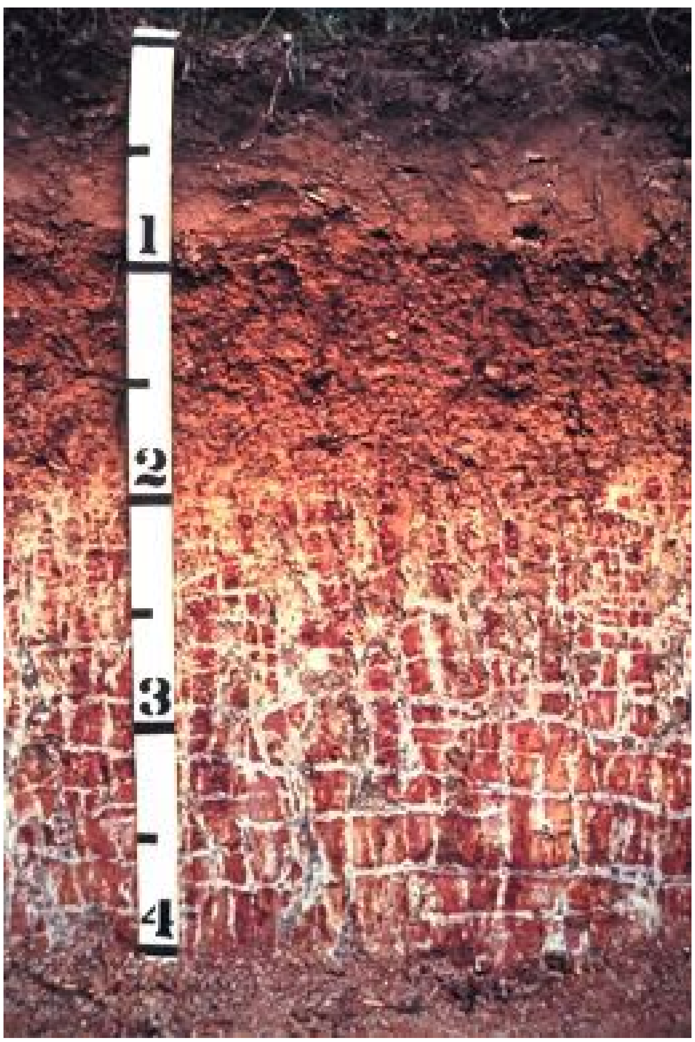


Photo 33.—Continuous plinthite in a Plinthic Paleudalf from Texas.

Photo 34.—Slickensides.

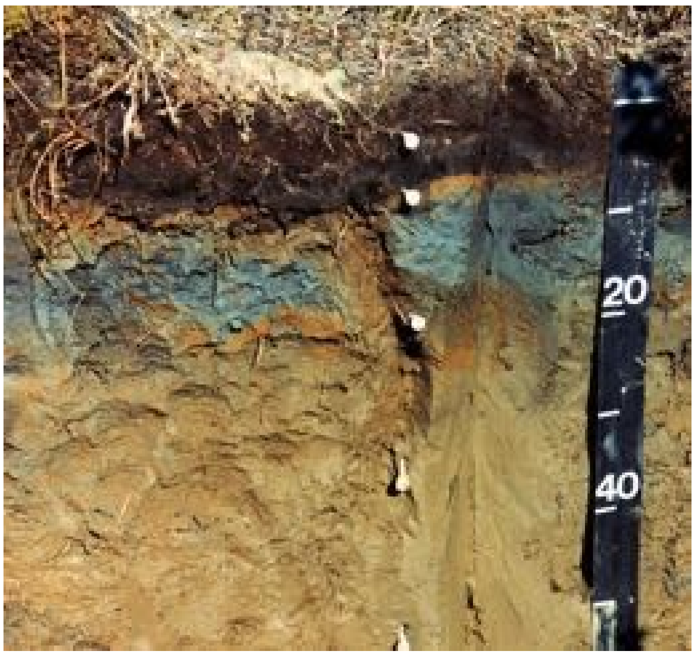


Photo 35.—A pedon with aquic conditions close to the surface.

Photo 36.—Peds from a gleyed horizon and the horizon directly below.

Photo 37.—A Turbel from the Yukon Territory with cryoturbation in the subsoil.

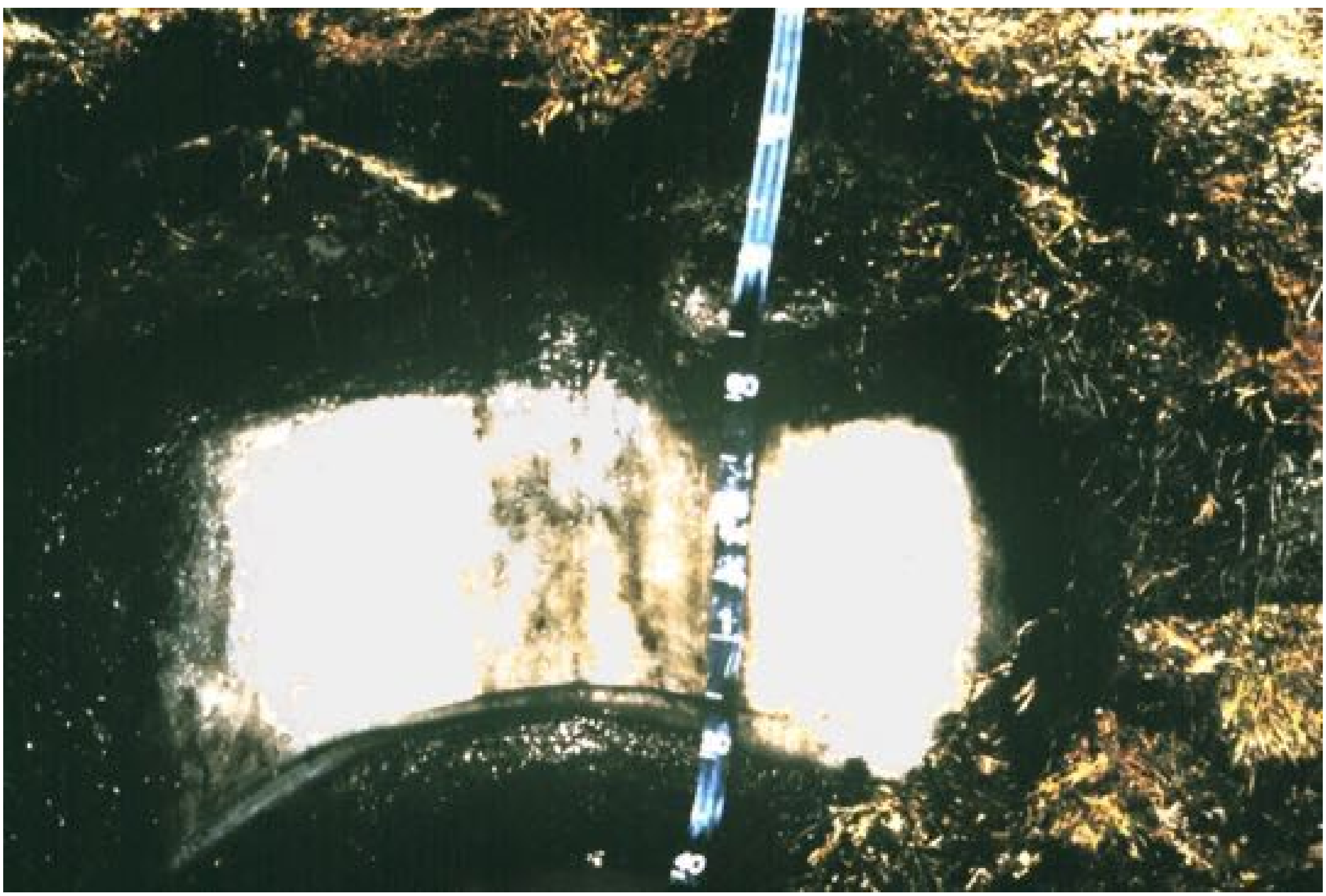


Photo 38.—A Glacistel from the Yukon Territory with a glacic layer beginning at a depth of about 50 cm.

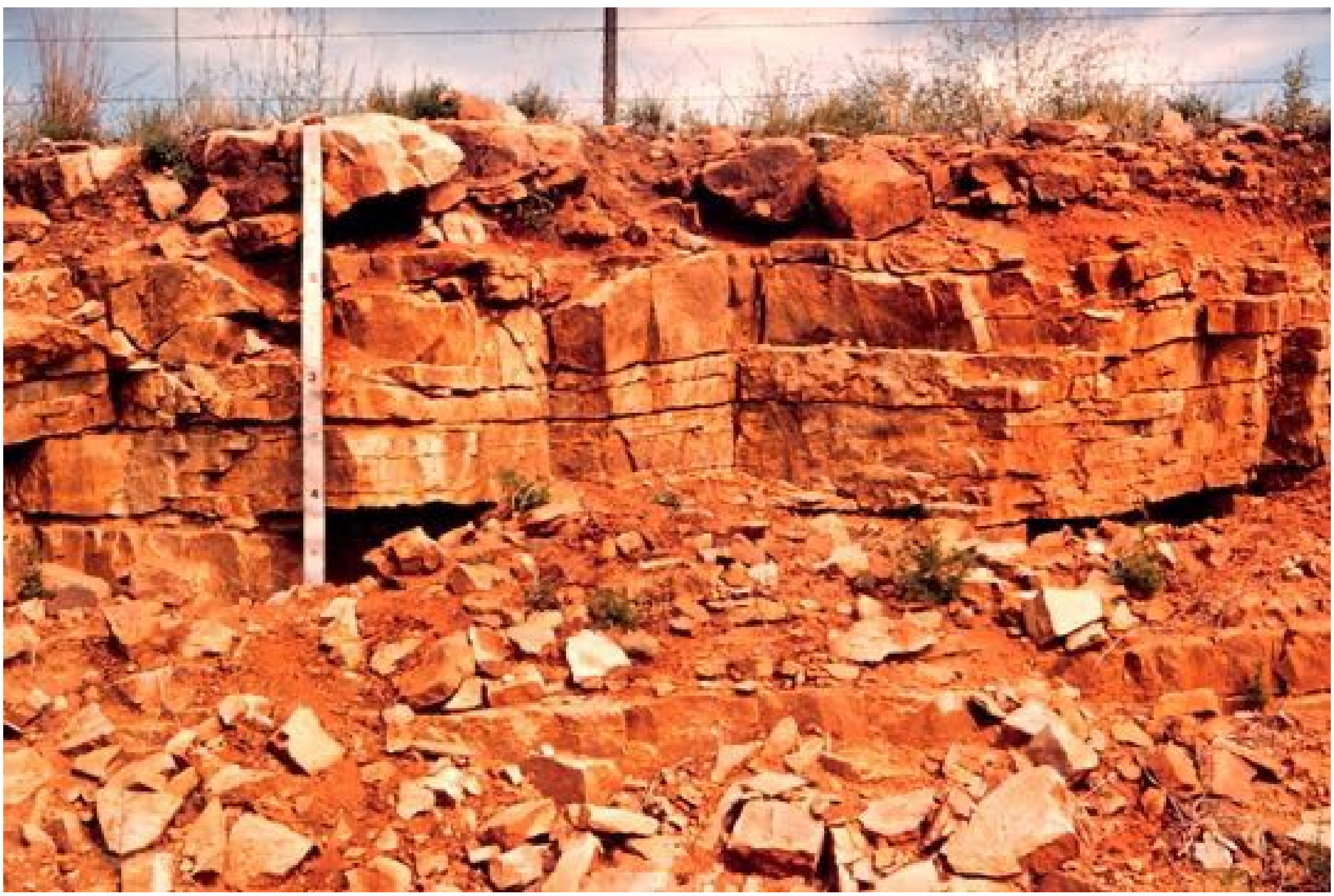


Photo 39.—Fractured lithic contact. Vertical fractures are greater than 10 cm. Sandstone is below the lithic contact.

Photo 40.—Differential weathering in grus from a soil in South Africa. The paralithic contact is highly irregular in this pedon.

When there are significantly higher quantities in an illuvial horizon than in an eluvial horizon, it is concluded that spodic materials are present.

Thickness of the Spodic Horizon

For a variety of reasons, some spodic horizons are thin or otherwise weakly developed. Some soils, particularly those that formed in calcareous parent materials in areas of cool, humid climates, have two horizons of accumulation, the upper of which contains an accumulation of amorphous materials, whereas the lower contains phyllosilicates. The two are separated by an eluvial horizon. This sequence of horizons is defined as a bisequum. In this situation, a spodic horizon has formed, or begun to form, in a clay-depleted eluvial horizon. Other spodic horizons are thin because they rest on a fragipan or on a densic, lithic, or paralithic contact. In areas of very cold, humid climates, any illuvial horizon is normally dominated by organic matter and amorphous sesquioxides and may be thin. Very thin horizons of accumulation are easily destroyed by plowing, trampling by livestock, or logging. To prevent such minor disturbances from changing the classification of a soil, a minimum depth to the lower boundary of the spodic horizon is required for the Spodosol order, depending on the soil temperature regime (defined below). If the soil temperature regime is mesic or warmer, the spodic horizon must extend to a depth of 25 cm from the mineral soil surface, unless the soil is less than 25 cm deep. For soils that have either a cryic or a pergelic soil temperature regime, or a frigid soil temperature regime and a spodic horizon with a coarse-loamy, loamy-skeletal, or finer particle-size class, depth limits are waived because in these soils there is less prospect of a serious disturbance of significant areas than in sandy and warmer soils. Depth limits also are waived for soils that have a duripan or fragipan or a petroferric, paralithic, densic, or lithic contact within 25 cm of the mineral soil surface. If these soils are disturbed, the whole soil is altered and the classification is likely to be affected.

Required Characteristics

A spodic horizon is normally a subsurface horizon underlying an O, A, Ap, or E horizon. It may, however, meet the definition of an umbric epipedon.

A spodic horizon must have 85 percent or more spodic materials (described below) in a layer 2.5 cm or more thick that is not part of any Ap horizon.

Other Diagnostic Soil Characteristics (Mineral Soils)

Diagnostic soil characteristics are features of the soil that are used in various places in the keys or in definitions of diagnostic horizons.

Abrupt Textural Change

An abrupt textural change is a specific kind of change that may occur between an ochric epipedon or an albic horizon and an argillic horizon. It is characterized by a considerable increase in clay content within a very short vertical distance in the zone of contact. If the clay content in the fine-earth fraction of the ochric epipedon or albic horizon is less than 20 percent, it doubles within a vertical distance of 7.5 cm or less. If the clay content in the fine-earth fraction of the ochric epipedon or the albic horizon is 20 percent or more, there is an increase of 20 percent or more (absolute) within a vertical distance of 7.5 cm or less (e.g., an increase from 22 to 42 percent) and the clay content in some part of the argillic horizon is 2 times or more the amount contained in the overlying horizon.

Normally, there is no transitional horizon between an ochric epipedon or an albic horizon and an argillic horizon, or the transitional horizon is too thin to be sampled. Some soils, however, have a glossic horizon or interfingering of albic materials (defined below) in parts of the argillic horizon. The upper boundary of such a horizon is irregular or even discontinuous. Sampling this mixture as a single horizon might create the impression of a relatively thick transitional horizon, whereas the thickness of the actual transition at the contact may be no more than 1 mm.

Albic Materials

Albic (L. *albus*, white) materials are soil materials with a color that is largely determined by the color of primary sand and silt particles rather than by the color of their coatings. This definition implies that clay and/or free iron oxides have been removed from the materials or that the oxides have been segregated to such an extent that the color of the materials is largely determined by the color of the primary particles.

Required Characteristics

Albic materials have *one* of the following colors:

1. Chroma of 2 or less; *and either*

   a. A color value, moist, of 3 and a color value, dry, of 6 or more; *or*

   b. A color value, moist, of 4 or more and a color value, dry, of 5 or more; *or*

2. Chroma of 3 or less; *and either*

   a. A color value, moist, of 6 or more; *or*

   b. A color value, dry, of 7 or more; *or*

3. Chroma that is controlled by the color of uncoated grains of silt or sand, hue of 5YR or redder, and the color values listed in item 1-a or 1-b above.

Relatively unaltered layers of light colored sand, volcanic ash, or other materials deposited by wind or water are not considered albic materials, although they may have the same color and apparent morphology. These deposits are parent materials that are not characterized by the removal of clay and/or free iron and do not overlie an illuvial horizon or other soil horizon, except for a buried soil. Light colored krotovinas or filled root channels should be considered albic materials only if they have no fine stratifications or lamellae, if any sealing along the krotovina walls has been destroyed, and if these intrusions have been leached of free iron oxides and/or clay after deposition.

Andic Soil Properties

Andic soil properties result mainly from the presence of significant amounts of allophane, imogolite, ferrihydrite, or aluminum-humus complexes in soils (photo 29). These materials, originally termed "amorphous" (but understood to contain allophane) in the 1975 edition of *Soil Taxonomy*, are commonly formed during the weathering of tephra and other parent materials with a significant content of volcanic glass. Although volcanic glass is or was a common component in many Andisols, it is not a requirement of the Andisol order. Some soils develop andic soil properties without the influence of volcanic glass.

Volcanic glass is a significant component of fresh tephra. In most environments the volcanic glass weathers to short-range-order minerals. The concept of Andisols includes weakly weathered soils with much volcanic glass as well as more strongly weathered soils rich in short-range-order minerals. Hence, the content of volcanic glass is one of the characteristics used in defining andic soil properties. Volcanic glass is defined as optically isotropic translucent glass or pumice of any color, including glassy aggregates and glass coatings on other mineral grains. Composite grains must have at least 50 percent (by volume) volcanic glass to be counted as volcanic glass. In most cases the method used to determine volcanic glass is not critical. When accurate measurement is required, however, the standard method, use of a polarizing microscope, is recommended.

Most horizons that have andic soil properties consist of mineral soil materials. Some consist of organic soil materials. A layer or horizon must have less than 25 percent organic carbon, however, before it is considered to have andic soil properties.

Required Characteristics

To be recognized as having andic soil properties, soil materials must contain less than 25 percent (by weight) organic carbon and meet *one or both* of the following requirements:

1. In the fine-earth fraction, *all* of the following:

   a. Aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling 2.0 percent or more; *and*

   b. A bulk density, measured at 33 kPa water retention, of 0.90 g/cm^3 or less; *and*

   c. A phosphate retention of 85 percent or more; *or*

2. In the fine-earth fraction, a phosphate retention of 25 percent or more, 30 percent or more particles 0.02 to 2.0 mm in size, and *one* of the following:

   a. Aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling 0.40 or more and, in the 0.02 to 2.0 mm fraction, 30 percent or more volcanic glass; *or*

   b. Aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling 2.0 or more and, in the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *or*

   c. Aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling between 0.40 and 2.0 and, in the 0.02 to 2.0 mm fraction, enough volcanic glass so that the glass percentage, when plotted against the value obtained by adding aluminum plus $^1/_2$ iron percentages in the fine-earth fraction, falls within the shaded area of diagram 1.

Anhydrous Conditions

Anhydrous conditions (Gr. *anydros*, waterless) refer to the active layer in soils of cold deserts and other areas with permafrost (often dry permafrost) and low precipitation (usually less than 50 mm water equivalent). Anhydrous soil conditions are similar to the aridic (torric) soil moisture regimes, except that the soil temperature is less than 0 ^{o}C.

Coefficient of Linear Extensibility (COLE)

The coefficient of linear extensibility (COLE) is the ratio of the difference between the moist length and dry length of a clod to its dry length. It is (Lm - Ld)/Ld, where Lm is the length at 33 kPa tension and Ld is the length when dry. COLE can be calculated from the differences in bulk density of the clod when moist and when dry. An estimate of COLE can be calculated in the field by measuring the distance between two pins in a clod of undisturbed soil at field capacity and again after the clod has dried. COLE does not apply if the shrinkage is irreversible.

Durinodes

Durinodes (L. *durus*, hard, and *nodus*, knot) are weakly cemented to indurated nodules with a diameter of 1 cm or more. The cement is SiO_2, presumably opal and microcrystalline forms of silica. Durinodes break down in hot concentrated KOH after treatment with HCl to remove

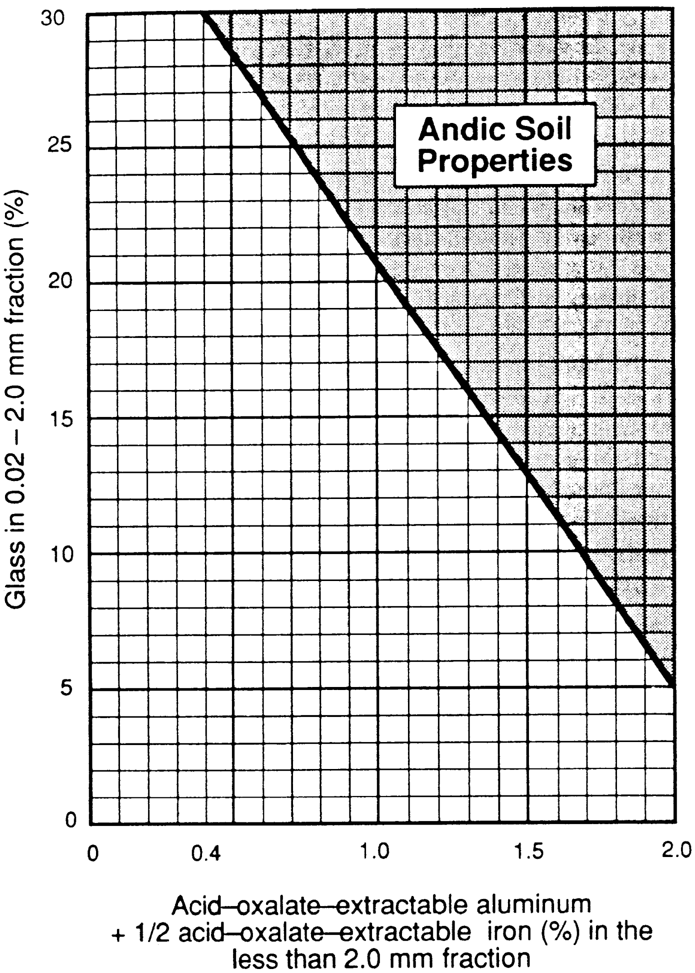


Diagram 1.—Soils that are plotted in the shaded area have andic soil properties. A soil has these properties if the fraction less than 2.0 mm in size has phosphate retention of more than 25 percent and the 0.02 to 2.0 mm fraction is at least 30 percent of the fraction less than 2.0 mm in size.

carbonates but do not break down with concentrated HCl alone. Dry durinodes do not slake appreciably in water, but prolonged soaking can result in spalling of very thin platelets. Durinodes are firm or firmer and brittle when wet, both before and after treatment with acid. Most durinodes are roughly concentric when viewed in cross section, and concentric stringers of opal are visible under a hand lens.

Fragic Soil Properties

Fragic soil properties are the essential properties of a fragipan. They have neither the layer thickness nor volume requirements for the fragipan. Fragic soil properties are in subsurface horizons, although they can be at or near the surface in truncated soils. Aggregates with fragic soil properties have a firm or firmer rupture-resistance class and a brittle manner of failure when soil water is at or near field capacity. Air-dry fragments of the natural fabric, 5 to 10 cm in diameter, slake when they are submerged in water. Aggregates with fragic soil properties show evidence of pedogenesis, including one or more of the following: oriented clay within the matrix or on faces of peds, redoximorphic features within the matrix or on faces of peds, strong or moderate soil structure, and coatings of albic materials or uncoated silt and sand grains on faces of peds or in seams. Peds with these properties are considered to have fragic soil properties regardless of whether or not the density and brittleness are pedogenic.

Soil aggregates with fragic soil properties must:

1. Show evidence of pedogenesis within the aggregates or, at a minimum, on the faces of the aggregates; *and*

2. Slake when air-dry fragments of the natural fabric, 5 to 10 cm in diameter, are submerged in water; *and*

3. Have a firm or firmer rupture-resistance class and a brittle manner of failure when soil water is at or near field capacity; *and*

4. Restrict the entry of roots into the matrix when soil water is at or near field capacity.

Identifiable Secondary Carbonates

The term "identifiable secondary carbonates" is used in the definitions of a number of taxa. It refers to translocated authigenic calcium carbonate that has been precipitated in place from the soil solution rather than inherited from a soil parent material, such as a calcareous loess or till (photo 30).

Identifiable secondary carbonates either may disrupt the soil structure or fabric, forming masses, nodules, concretions, or spheroidal aggregates (white eyes) that are soft and powdery when dry, or may be present as coatings in pores, on structural faces, or on the undersides of rock or pararock fragments. If present as coatings, the secondary carbonates cover a significant part of the surfaces. Commonly, they coat all of the surfaces to a thickness of 1 mm or more. If little calcium carbonate is present in the soil, however, the surfaces may be only partially coated. The coatings must be thick enough to be visible when moist. Some horizons are entirely engulfed by carbonates. The color of these horizons is largely determined by the carbonates. The carbonates in these horizons are within the concept of identifiable secondary carbonates.

The filaments commonly seen in a dry calcareous horizon are within the meaning of identifiable secondary carbonates if the filaments are thick enough to be visible when the soil is moist. Filaments commonly branch on structural faces.

Interfingering of Albic Materials

The term "interfingering of albic materials" refers to albic materials that penetrate 5 cm or more into an underlying argillic, kandic, or natric horizon along vertical and, to a lesser degree, horizontal faces of peds. There need not be a continuous overlying albic horizon. The albic materials constitute less than 15 percent of the layer that they penetrate, but they form continuous skeletans (ped coatings of clean silt or sand defined by Brewer, 1976) 1 mm or more thick on the vertical faces of peds, which means a total width of 2 mm or more between abutting peds. Because quartz is such a common constituent of silt and sand, these skeletans are usually light gray when moist and nearly white when dry, but their color is determined in large part by the color of the sand or silt fraction.

Required Characteristics

Interfingering of albic materials is recognized if albic materials:

1. Penetrate 5 cm or more into an underlying argillic or natric horizon; *and*

2. Are 2 mm or more thick between vertical faces of abutting peds; *and*

3. Constitute less than 15 percent (by volume) of the layer that they penetrate.

Lamellae

A lamella is an illuvial horizon less than 7.5 cm thick (photos 31 and 32). Each lamella contains an accumulation of oriented silicate clay on or bridging sand and silt grains (and rock fragments if any are present). A lamella has more silicate clay than the overlying eluvial horizon.

The significance of lamellae to soil classification is not in the single lamella but in the multiple number of lamellae, each with an overlying eluvial horizon in a single pedon. A single lamella may occur in a pedon, but more commonly there are several lamellae separated by eluvial horizons.

A lamella 0.5 cm or more thick can be part of a cambic horizon unless it is sandy (loamy fine sand or coarser). It can be part of an argillic horizon. A lamella is required to have an accumulation of oriented silicate clay, but no specific amount of clay is required. A single lamella is too thin to be either a cambic or an argillic horizon. A combination of lamellae 15 cm or more thick, however, can be either a cambic or an argillic horizon if all of the other criteria are met.

Identification

A lamella typically has (but is not required to have) a higher chroma, redder hue, or lower color value, or any combination of these, than the overlying eluvial horizon. Some lamellae have no color differences. All lamellae are required to have more silicate clay than the overlying eluvial horizon.

In a vertical cross section of a pedon, a lamella appears as a thin horizon and is often called a “band.” It actually is an undulating layer, and it is not always continuous. The upper and lower boundaries may be wavy, and the thickness may vary from one point to another.

Lamellae commonly occur in sandy and sandy-skeletal sediments and less commonly in coarse-loamy, loamy-skeletal, and coarse-silty sediments. The texture of the fine-earth fraction in lamellae is mostly loamy sand or sandy loam, but it is known to range from sand to sandy clay loam, silt loam, and clay loam. The content of rock fragments ranges from 0 to more than 65 percent. Lamellae commonly are single grained or granular, but in some pedons they are massive.

Laboratory data show that, in addition to silicate clay accumulations, silt (particularly fine silt), sesquioxides, and organic carbon accumulate in some lamellae. Where there is recharge of carbonates, there may also be accumulations of carbonates in lamellae.

Although lamellae most commonly occur in eolian and alluvial sediments, they have also been observed in coarse grained residuum, such as grus. It is likely that there were very thin layers with finer soil particles and smaller pore spaces than in the residuum either above or below them. These thin layers would then be similar to the bedding planes in the eolian or alluvial sediments. It is logical that lamellae in residuum form in the same way as described below.

Origin

Lamellae form in coarse textured sediments (coarse silt or coarser) of eolian or alluvial deposits that include very small amounts of silicate clay. Evidence indicates that they form initially in the bedding planes. The bedding planes, as used here, are very thin layers with finer soil particles and smaller pore spaces than the materials either above or below them. These were deposited during a lull in the wind or a reduction in the velocity of water. Before a wetting front can move through these bedding planes to the larger pores in the underlying strata, the finer pores must be nearly saturated. This pause in the percolation flow may be sufficient for plant roots to capture water leaving suspended clay. As a result, silicate clay suspended in the soil solution can be deposited in the pores and on the surfaces of the particles. This deposition further reduces the pore size. With the passing of each succeeding wetting front, the pore size is reduced even further and lamellae form.

The lamellae thicken as additional fine particles are deposited. It is thought that the lamellae may also begin to act as a filter at this point in their development.

In a close examination of pedons with a large number of lamellae, the lamellae nearer the soil surface generally have the least concentration of clay and have the faintest color contrast from the overlying eluvial horizon. Some sand grains are devoid of clay, and some have only thin coatings. These lamellae are generally more wavy and less continuous than those in the other parts of the lamellae zone (the zone in which lamellae form). The eluvial horizons overlying these lamellae are generally the thickest of those in the lamellae zone.

Lamellae in the middle part of the lamellae zone appear to have the highest concentration of clay at the upper edge of the lamellae, and the clay content decreases with increasing depth. The color contrast is greatest at the upper edge of the lamellae, adjacent to the overlying eluvial horizon. In the lower part of these lamellae, some sand grains are devoid of clay and some have only thin clay coatings. The lower part of these lamellae appear to be very similar to the lamellae closest to the soil surface. The lamellae in the middle part of the lamellae zone are wavy but commonly are not so wavy as those in the upper part of the lamellae zone.

The deepest lamellae are commonly very thin. They have a color contrast that is nearly as great as that at the upper edge of the lamellae in the middle part of the lamellae zone. The deepest lamellae are not very wavy and are commonly parallel with each other. The thickness of the overlying eluvial horizons varies more than that in the other parts of the lamellae zone.

These observations suggest that clay is being moved from the upper few lamellae to the lower lamellae. Also, in the lamellae in the middle part of the layer containing lamellae, clay is being stripped from the lower part of one lamella and is being redeposited in the top part of the next lower lamella. The lamellae thicken as clay is added to the top of the lamellae. At this point, a lamella begins to move away from the bedding plane from which it originated. The stripping of clay from the lower part of a lamella and the redeposition in the top part of the next lower lamella continue this movement upward and away from the bedding plane.

The movement upward of each lamella is not uniform throughout its extent. Consequently, lamellae are wavy rather than smooth, like the bedding planes from which they originated. Occasionally, some lamellae appear to be branched. This branching occurs where part of a lamella has moved up more rapidly than the overlying part of the next higher lamella and they become joined in this part. The branching is further evidence that lamellae form upward and that the movement is not uniform.

Required Characteristics

A lamella is an illuvial horizon less than 7.5 cm thick formed in unconsolidated regolith more than 50 cm thick. Each lamella contains an accumulation of oriented silicate clay on or bridging the sand and silt grains (and coarse fragments if any are present). Each lamella is required to have more silicate clay than the overlying eluvial horizon.

Lamellae occur in a vertical series of two or more, and each lamella must have an overlying eluvial horizon. (An eluvial horizon is not required above the uppermost lamella if the soil is truncated.)

Lamellae may meet the requirements for either a cambic or an argillic horizon. A combination of two or more lamellae 15 cm or more thick is a cambic horizon if the texture is very fine sand, loamy very fine sand, or finer. A combination of two or more lamellae meets the requirements for an argillic horizon if there is 15 cm or more cumulative thickness of lamellae that are 0.5 cm or more thick and that have a clay content of *either*:

1. 3 percent or more (absolute) higher than in the overlying eluvial horizon (e.g., 13 percent versus 10 percent) if any part of the eluvial horizon has less than 15 percent clay in the fine-earth fraction; *or*

2. 20 percent or more (relative) higher than in the overlying eluvial horizon (e.g., 24 percent versus 20 percent) if all parts of the eluvial horizon have more than 15 percent clay in the fine-earth fraction.

Linear Extensibility (LE)

Linear extensibility (LE) helps to predict the potential of a soil to shrink and swell. The LE of a soil layer is the product of the thickness, in cm, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons.

Lithologic Discontinuities

Lithologic discontinuities are significant changes in particle-size distribution or mineralogy that represent differences in lithology within a soil. A lithologic discontinuity can also denote an age difference. For information on using horizon designations for lithologic discontinuities, see the *Soil Survey Manual* (USDA, SCS, 1993).

Not everyone agrees on the degree of change required for a lithologic discontinuity. No attempt is made to quantify lithologic discontinuities. The discussion below is meant to serve as a guideline.

Several lines of field evidence can be used to evaluate lithologic discontinuities. In addition to mineralogical and textural differences that may require laboratory studies, certain observations can be made in the field. These include but are not limited to the following:

1. Abrupt textural contacts.—An abrupt change in particle-size distribution, which is not solely a change in clay content resulting from pedogenesis, can often be observed.

2. Contrasting sand sizes.—Significant changes in sand size can be detected. For exampe, if material containing mostly medium sand or finer sand abruptly overlies material containing mostly coarse sand and very coarse sand, one can assume that there are two different materials. Although the materials may be of the same mineralogy, the contrasting sand sizes result from differences in energy at the time of deposition by water and/or wind.

3. Bedrock lithology vs. rock fragment lithology in the soil.—If a soil with rock fragments overlies a lithic contact, one would expect the rock fragments to have a lithology similar to that of the material below the lithic contact. If many of the rock fragments do not have the same lithology as the underlying bedrock, the soil is not derived completely from the underlying bedrock.

4. Stone lines.—The occurrence of a horizontal line of rock fragments in the vertical sequence of a soil indicates that the soil may have developed in more than one kind of parent material. The material above the stone line is most likely transported, and the material below may be of different origin.

5. Inverse distribution of rock fragments.—A lithologic discontinuity is often indicated by an erratic distribution of rock fragments. The percentage of rock fragments decreases with increasing depth. This line of evidence is useful in areas of soils that have relatively unweathered rock fragments.

6. Rock fragment weathering rinds.—Horizons containing rock fragments with no rinds that overlie horizons containing rocks with rinds suggest that the upper material is in part depositional and not related to the lower part in time and perhaps in lithology.

7. Shape of rock fragments.—A soil with horizons containing angular rock fragments overlying horizons containing well rounded rock fragments may indicate a discontinuity. This line of evidence represents different mechanisms of transport (colluvial vs. alluvial) or even different transport distances.

8. Soil color.—Abrupt changes in color that are not the result of pedogenic processes can be used as indicators of discontinuity.

9. Micromorphological features.—Marked differences in the size and shape of resistant minerals in one horizon and not in another are indicators of differences in materials.

Use of Laboratory Data

Discontinuities are not always readily apparent in the field. In these cases laboratory data are necessary. Even with laboratory data, detecting discontinuities may be difficult. The decision is a qualitative or perhaps a partly quantitative judgment. General concepts of lithology as a function of depth might include:

1. Laboratory data—visual scan.—The array of laboratory data is assessed in an attempt to determine if a field-designated discontinuity is corroborated and if any data show evidence of a discontinuity not observed in the field. One must sort changes in lithology from changes caused by pedogenic processes. In most cases the quantities of sand and coarser fractions are not altered significantly by soil-forming processes. Therefore, an abrupt change in sand size or sand mineralogy is a clue to lithologic change. Gross soil mineralogy and the resistant mineral suite are other clues.

2. Data on a clay-free basis.—A common manipulation in assessing lithologic change is computation of sand and silt separates on a carbonate-free, clay-free basis (percent fraction, e.g., fine sand and very fine sand, divided by percent sand plus silt, times 100). Clay distribution is subject to pedogenic change and may either mask inherited lithologic differences or produce differences that are not inherited from lithology. The numerical array computed on a clay-free basis can be inspected visually or plotted as a function of depth.

Another aid used to assess lithologic changes is computation of the ratios of one sand separate to another. The ratios can be computed and examined as a numerical array, or they can be plotted. The ratios work well if sufficient quantities of the two fractions are available. Low quantities magnify changes in ratios, especially if the denominator is low.

n Value

The *n* value (Pons and Zonneveld, 1965) characterizes the relation between the percentage of water in a soil under field conditions and its percentages of inorganic clay and humus. The *n* value is helpful in predicting whether a soil can be grazed by livestock or can support other loads and in predicting what degree of subsidence would occur after drainage.

For mineral soil materials that are not thixotropic, the *n* value can be calculated by the following formula:

$$n = (A - 0.2R)/(L + 3H)$$

In this formula, A is the percentage of water in the soil in field condition, calculated on a dry-soil basis; R is the percentage of silt plus sand; L is the percentage of clay; and H is the percentage of organic matter (percent organic carbon multiplied by 1.724).

This formula is based on experience with soil materials that have humified organic matter and in which illite and other nonexpanding clay minerals are predominant. There are indications that the factor by which the organic matter is multiplied should exceed 3 if the organic matter is incompletely humified. The correction for the water held by the organic matter becomes an increasing source of uncertainty as the ratio of clay to organic matter becomes narrow. In this taxonomy, the *n* value is used only to characterize mineral soils.

Few data for calculations of the *n* value are available in the United States, but the critical *n* value of 0.7 can be approximated closely in the field by a simple test of squeezing a soil sample in the hand. If the soil flows between the fingers with difficulty, the *n* value is between 0.7 and 1.0 (slightly fluid manner of failure class); if the soil flows easily between the fingers, the *n* value is 1 or more (moderately fluid or very fluid manner of failure class).

Soils in which the moisture content is periodically reduced below field capacity seldom have an *n* value of 0.7 or more. Most of the soils that have been permanently saturated are likely to have a high *n* value. Consequently, high *n* values are primarily in soils of tidal marshes, swamps, and shallow lakes. The sediments in these areas have never been above the capillary fringe during drought cycles. A high calculated *n* value may also be characteristic of some soils that formed in volcanic ash in areas of a perhumid climate. These soils are thixotropic, and the field test is more reliable than the formula for estimating their bearing value.

Petroferric Contact

A petroferric (Gr. *petra*, rock, and L. *ferrum*, iron; implying ironstone) contact is a boundary between soil and a continuous layer of indurated material in which iron is an important cement and organic matter is either absent or present only in traces. The indurated layer must be continuous within the limits of each pedon, but it may be fractured if the average lateral distance between fractures is 10 cm or more. The fact that this ironstone layer contains little or no organic matter distinguishes it from a placic horizon and an indurated spodic horizon (ortstein), both of which contain organic matter.

The purpose in choosing a petroferric contact as a diagnostic feature distinct from a lithic contact is to identify the shallow layers of hard ironstone that may have been called hardened laterite and those that may have accumulated in a hard form. Petroferric contacts are extensive in tropical and subtropical regions. There may be shallow sandstone that is cemented by iron in any climatic region. The contact with such a layer is a lithic contact, not a petroferric contact.

Several features can aid in making the distinction between a lithic contact and a petroferric contact. First, a petroferric contact is roughly horizontal. Second, the material directly below a petroferric contact contains a high amount of iron (normally 30 percent or more Fe_2O_3). Third, the ironstone sheets below a petroferric contact are thin; their thickness ranges from a few centimeters to very few meters. Sandstone, on the other hand, may be thin or very thick, may be level-bedded or tilted, and may contain only a small percentage of Fe_2O_3. In the Tropics, the ironstone is generally more or less vesicular.

Plinthite

Plinthite (Gr. *plinthos*, brick) is an iron-rich, humus-poor mixture of clay with quartz and other minerals (photo 33). It commonly occurs as dark red redox concentrations that usually form platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on exposure to repeated wetting and drying, especially if it is also exposed to heat from the sun. The lower boundary of a zone in which plinthite occurs generally is diffuse or gradual, but it may be abrupt at a lithologic discontinuity.

Plinthite may occur as a constituent of a number of horizons, such as an epipedon, a cambic horizon, an argillic horizon, an oxic horizon, or a C horizon. It is one form of the material that has been called laterite. It normally forms in a horizon below the surface, but it may form at the surface in a seepy area at the base of a slope.

From a genetic viewpoint, plinthite forms by segregation of iron. In many places iron probably has been added from other horizons or from the higher adjacent soils. Generally, plinthite forms in a horizon that is saturated with water for some time during the year. Initially, iron is normally segregated in the form of soft, more or less clayey, red or dark red redox concentrations. These concentrations are not considered plinthite unless there has been enough segregation of iron to permit their irreversible hardening on exposure to repeated wetting and drying. Plinthite is firm or very firm when the soil moisture content is near field capacity and hard when the moisture content is below the wilting point. Plinthite does not harden irreversibly as a result of a single cycle of drying and rewetting. After a single drying, it will remoisten and then can be dispersed in large part if one shakes it in water with a dispersing agent.

In a moist soil, plinthite is soft enough to be cut with a spade. After irreversible hardening, it is no longer considered plinthite but is called ironstone. Indurated ironstone materials can be broken or shattered with a spade but cannot be dispersed if one shakes them in water with a dispersing agent.

A small amount of plinthite in the soil does not form a continuous phase; that is, the individual redox concentrations or aggregates are not connected with each other. If a large amount of plinthite is present, it may form a continuous phase. If a continuous layer becomes indurated, it is a massive ironstone layer that has irregular, somewhat tubular inclusions of yellowish, grayish, or white, clayey material. If the layer is exposed, these inclusions may be washed out, leaving an ironstone that has many coarse, tubular pores.

Much that has been called laterite is included in the meaning of plinthite. Doughy and concretionary laterite that has not hardened is an example. Hardened laterite, whether it is vesicular or pisolitic, is not included in the definition of plinthite.

Resistant Minerals

Several references are made to resistant minerals in this taxonomy. Obviously, the stability of a mineral in the soil is a partial function of the soil moisture regime. Where resistant minerals are referred to in the definitions of diagnostic horizons and of various taxa, a humid climate, past or present, is always assumed.

Resistant minerals are durable minerals in the 0.02 to 2.0 mm fraction. Quartz is the most common resistant mineral in soils. The less common ones include sphene, rutile, zircon, tourmaline, and beryl.

Slickensides

Slickensides are polished and grooved surfaces and generally have dimensions exceeding 5 cm (photo 34). They are produced when one soil mass slides past another. Some slickensides occur at the lower boundary of a slip surface where a mass of soil moves downward on a relatively steep slope. Slickensides result directly from the swelling of clay minerals and shear failure. They are very common in swelling clays that undergo marked changes in moisture content.

Spodic Materials

Spodic materials form in an illuvial horizon that normally underlies a histic, ochric, or umbric epipedon or an albic horizon. In most undisturbed areas, spodic materials underlie an albic horizon. They may occur within an umbric epipedon or an Ap horizon.

A horizon consisting of spodic materials normally has an optical-density-of-oxalate-extract (ODOE) value of 0.25 or more, and that value is commonly at least 2 times as high as the ODOE value in an overlying eluvial horizon. This increase in ODOE value indicates an accumulation of translocated organic materials in an illuvial horizon. Soils with spodic materials show evidence that organic materials and aluminum, with or without iron, have been moved from an eluvial horizon to an illuvial horizon.

Definition of Spodic Materials

Spodic materials are mineral soil materials that do not have all of the properties of an argillic or kandic horizon; are dominated by active amorphous materials that are illuvial and are composed of organic matter and aluminum, with or without iron; and have *both* of the following:

1. A pH value in water (1:1) of 5.9 or less and an organic-carbon content of 0.6 percent or more; *and*

2. *One or both* of the following:

a. An overlying albic horizon that extends horizontally through 50 percent or more of each pedon and, directly under the albic horizon, colors, moist (crushed and smoothed sample), as follows:

(1) Hue of 5YR or redder; *or*

(2) Hue of 7.5YR, color value of 5 or less, and chroma of 4 or less; *or*

(3) Hue of 10YR or neutral and a color value and chroma of 2 or less; *or*

(4) A color of 10YR 3/1; *or*

b. With or without an albic horizon and one of the colors listed above or hue of 7.5YR, color value, moist, of 5 or less, chroma of 5 or 6 (crushed and smoothed sample), and *one or more* of the following morphological or chemical properties:

(1) Cementation by organic matter and aluminum, with or without iron, in 50 percent or more of each pedon and a very firm or firmer rupture-resistance class in the cemented part; *or*

(2) 10 percent or more cracked coatings on sand grains; *or*

(3) Aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling 0.50 or more, and half that amount or less in an overlying umbric (or subhorizon of an umbric) epipedon, ochric epipedon, or albic horizon; *or*

(4) An optical-density-of-oxalate-extract (ODOE) value of 0.25 or more, and a value half as high or lower in an overlying umbric (or subhorizon of an umbric) epipedon, ochric epipedon, or albic horizon.

Weatherable Minerals

Several references are made to weatherable minerals in this taxonomy. Obviously, the stability of a mineral in a soil is a partial function of the soil moisture regime. Where weatherable minerals are referred to in the definitions of diagnostic horizons and of various taxa in this taxonomy, a humid climate, either present or past, is always assumed. The minerals that are included in the meaning of weatherable minerals are as follows:

1. Clay minerals: All 2:1 lattice clays, except for one that is currently considered to be an aluminum-interlayered chlorite. Sepiolite, talc, and glauconite are also included in this group of weatherable clay minerals, although they are not everywhere of clay size.

2. Silt- and sand-sized minerals (0.02 to 0.2 mm in diameter): Feldspars, feldspathoids, ferromagnesian minerals, glass, micas, zeolites, and apatite.

Obviously, this definition of the term "weatherable minerals" is restrictive. The intent is to include, in the definitions of diagnostic horizons and various taxa, only those weatherable minerals that are unstable in a humid climate compared to other minerals, such as quartz and 1:1 lattice clays, but that are more resistant to weathering than calcite.

Characteristics Diagnostic for Organic Soils

Following is a description of the characteristics that are used only with organic soils.

Kinds of Organic Soil Materials

Three different kinds of organic soil materials are distinguished in this taxonomy, based on the degree of decomposition of the plant materials from which the organic materials are derived. The three kinds are (1) fibric, (2) hemic, and (3) sapric. Because of the importance of fiber content in the definitions of these materials, fibers are defined before the kinds of organic soil materials.

Fibers

Fibers are pieces of plant tissue in organic soil materials (excluding live roots) that:

1. Are large enough to be retained on a 100-mesh sieve (openings 0.15 mm across) when the materials are screened; *and*

2. Show evidence of the cellular structure of the plants from which they are derived; *and*

3. Either are 2 cm or less in their smallest dimension or are decomposed enough to be crushed and shredded with the fingers.

Pieces of wood that are larger than 2 cm in cross section and are so undecomposed that they cannot be crushed and shredded with the fingers, such as large branches, logs, and stumps, are not considered fibers but are considered coarse fragments (comparable to gravel, stones, and boulders in mineral soils).

The degree of decomposition of organic materials is indicated by the content of fibers. If the organic materials are highly decomposed, fibers are nearly absent. If the organic materials are only slightly decomposed, more of the volume, exclusive of the coarse fragments, normally consists of fibers. If the organic materials are moderately decomposed, the fibers may be largely preserved but are easily broken down by rubbing between the thumb and fingers. The percentage of fibers that do not break down when rubbed gives the most realistic field estimate of the degree of decomposition. In addition, the bulk density (and hence the amount of subsidence after drainage) is more closely related to the content of fiber after rubbing than to the content of fiber before rubbing. A small volume of the wet material is rubbed between the thumb and fingers about 10 times with firm pressure. In the laboratory the material, after rubbing, is washed on a screen. In the field the rubbed material may be molded into a spherical or rod-shaped mass and broken for examination under a hand lens of 10 power or more to estimate the fiber content.

The definitions of fibric, hemic, and sapric soil materials that follow are based in part on the content of fibers after rubbing and in part on the solubility of the materials in sodium pyrophosphate.

Fibric Soil Materials

Fibric soil materials (L. *fibra*, fiber) are the least decomposed of all of the organic soil materials. They contain large amounts of fibers that are well preserved and can be linked to botanical origin. They have a low bulk density and a high water content when saturated. Fibric soil materials have a wide geographic distribution, and they occur in environments that are not conducive to processes of alteration and decomposition. Examples of such environments are the cool or cold, perhumid, boreal forest zones, where raised bogs and hill peats are dominated by *Sphagnum*; land-locked depressions that have *Hypnum* moss; and very flat, undrained areas that support a variety of reeds, sedges, and grasses. Wet flatlands occur in glaciated areas in the higher latitudes. Also, very wet flatlands are in some semitropical and tropical areas. An example is the sawgrass (sedge) bogs of the Everglades in Florida. Fibric materials commonly have a bulk density of less than 0.1; a fiber content (unrubbed) exceeding two-thirds of the volume; and a water content, when saturated, ranging from about 850 to more than 3,000 percent of the weight of ovendry material. Fibric materials commonly are light yellowish brown, dark brown, or reddish brown.

Fibric soil materials are organic soil materials that *either*:

1. Contain three-fourths or more (by volume) fibers after rubbing, excluding coarse fragments; *or*

2. Contain two-fifths or more (by volume) fibers after rubbing, excluding coarse fragments, and yield color values and chromas of 7/1, 7/2, 8/1, 8/2, or 8/3 (diagram 2) on white chromatographic or filter paper that is inserted into a paste made of the soil materials in a saturated sodium-pyrophosphate solution.

Hemic Soil Materials

Hemic soil materials (Gr. *hemi*, half; implying intermediate decomposition) are intermediate in their degree of decomposition between the less decomposed fibric and more decomposed sapric materials. Their morphological features give intermediate values for fiber content, bulk density, and water content. Hemic soil materials are partly altered both physically and biochemically. Their geographic distribution is widespread. Colors are commonly dark grayish brown to dark reddish brown. The fibers are largely destroyed when the wet organic material is rubbed. The bulk density commonly is between 0.07 and 0.18, the fiber content normally is between one-third and two-thirds of the volume before rubbing, and the maximum water content at saturation commonly ranges from about 450 to 850 percent. Hemic materials do not meet both the fiber content (after rubbing) and the sodium-pyrophosphate solubility requirements for either fibric or sapric materials (diagram 2).

Sapric Soil Materials

Sapric soil materials (Gr. *sapros*, rotten) are the most highly decomposed of the three kinds of organic soil materials. They have the smallest amount of plant fiber, the highest bulk density, and the lowest water content on a dry-weight basis at saturation. Sapric soil materials are commonly very dark gray to black. They are relatively stable; i.e., they change very little physically and chemically with time in comparison to other organic soil materials. Sapric materials have been exposed to aerobic decomposition either naturally or because of artificial

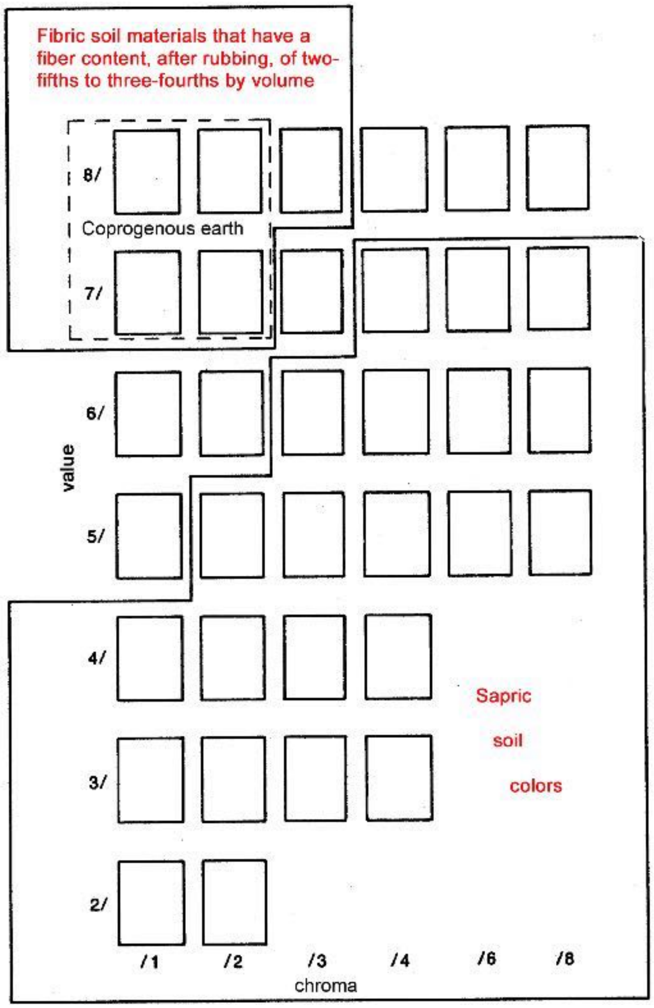


Diagram 2.—Value and chroma of pyrophosphate solution of fibric and sapric materials.

drainage. In undrained bogs sapric materials occur at the present surface or were previously at the surface and are now buried. The bulk density of these materials commonly is 0.2 or more, the fiber content averages less than one-third of the volume before rubbing, and the maximum water content at saturation normally is less than 450 percent on an ovendry basis.

Sapric materials have the following characteristics:

1. The fiber content, after rubbing, is less than one-sixth (by volume), excluding coarse fragments; *and*

2. The color of the sodium-pyrophosphate extract on white chromatographic or filter paper is below or to the right of a line drawn to exclude blocks 5/1, 6/2, and 7/3 (Munsell designations, diagram 2). If few or no fibers can be detected and the color of the pyrophosphate extract is to the left of or above this line, the possibility that the material is limnic must be considered.

Humilluvic Material

Humilluvic material, i.e., illuvial humus, accumulates in the lower parts of some organic soils that are acid and have been drained and cultivated. The humilluvic material has a C^{14} age that is not older than the overlying organic materials. It has very high solubility in sodium pyrophosphate and rewets very slowly after drying. Most commonly, it accumulates near a contact with a sandy mineral horizon.

To be recognized as a differentia in classification, the humilluvic material must constitute one-half or more (by volume) of a layer 2 cm or more thick. Because humilluvic materials are recognized in few soils, there are not enough data to develop a precise definition. Taxa with humilluvic material are recognized in Histosols but not Histels.

Limnic Materials

The presence or absence of limnic deposits is taken into account in the higher categories of Histosols but not Histels. The nature of such deposits is considered in the lower categories of Histosols. Limnic materials include both organic and inorganic materials that were either (1) deposited in water by precipitation or through the action of aquatic organisms, such as algae or diatoms, or (2) derived from underwater and floating aquatic plants and subsequently modified by aquatic animals. They include coprogenous earth (sedimentary peat), diatomaceous earth, and marl. Except for some of the coprogenous earths that contain 30 percent or more organic matter, most of these limnic materials are inorganic. Diatomite is highly siliceous; marl is mainly calcium carbonate. Limnic materials generally occur in the lower part of an organic soil and were formed during an open-water stage of bog development.

Coprogenous Earth

A layer of coprogenous earth (sedimentary peat) is a limnic layer that:

1. Contains many fecal pellets with diameters between a few hundredths and a few tenths of a millimeter; *and*

2. Has a color value, moist, of 4 or less; *and*

3. Either forms a slightly viscous water suspension and is nonplastic or slightly plastic but not sticky, or shrinks upon drying, forming clods that are difficult to rewet and often tend to crack along horizontal planes; *and*

4. Either yields a saturated sodium-pyrophosphate extract on

white chromatographic or filter paper that has a color value of 7 or more and chroma of 2 or less (diagram 2) or has a cation-exchange capacity of less than 240 cmol(+) per kg organic matter (measured by loss on ignition), or both.

Normally, layers of coprogenous earth contain almost no visible fragments of plants. These layers have a range in particle size and a C-N ratio (12 to 20) that are consistent with advanced decomposition. Yet, they have both a low and a narrow range in cation-exchange capacity (80 to 160 cmol(+) per kg of organic matter), which indicates little decomposition influenced by exposure to air. In places these layers have what appears to be platy structure. The individual plates are a little more than 0.5 mm thick and may be increments of annual deposition. Such structure certainly is not pedogenic. Olive or olive brown colors in organic layers of organic soils are characteristic of coprogenous earth layers. The most common colors are those with hue of 2.5Y or 5Y, value of 3 or 4, and chroma of 2.

Diatomaceous Earth

A layer of diatomaceous earth is a limnic layer that:

1. If not previously dried, has a matrix color value of 3, 4, or 5, which changes irreversibly on drying as a result of the irreversible shrinkage of organic-matter coatings on diatoms (identifiable by microscopic, 440 X, examination of dry samples); *and*

2. Either yields a saturated sodium-pyrophosphate extract on white chromatographic or filter paper that has a color value of 8 or more and chroma of 2 or less or has a cation-exchange capacity of less than 240 cmol(+) per kg organic matter (by loss on ignition), or both.

Layers of diatomaceous earth normally are more nearly mineral than organic in composition.

Marl

A layer of marl is a limnic layer that:

1. Has a color value, moist, of 5 or more; *and*

2. Reacts with dilute HCl to evolve CO_2.

The color of marl usually does not change irreversibly on drying because a layer of marl contains too little organic matter, even before it has been shrunk by drying, to coat the carbonate particles. Most of the samples of marl from the United States studied to date have an organic-matter content between 4 and 20 percent, inclusive, and, after treatment with dilute HCl, some disintegrated plant remains are evident.

Thickness of Organic Soil Materials (Control Section of Histosols and Histels)

The thickness of organic materials over limnic materials, mineral materials, water, or permafrost is used to define the Histosols and Histels.

For practical reasons, an arbitrary control section has been established for the classification of Histosols and Histels. Depending on the kinds of soil material in the surface layer, the control section has a thickness of either 130 cm or 160 cm from the soil surface if there is no densic, lithic, or paralithic contact, thick layer of water, or permafrost within the respective limit. The thicker control section is used if the surface layer to a depth of 60 cm either contains three-fourths or more fibers derived from *Sphagnum*, *Hypnum*, or other mosses or has a bulk density of less than 0.1. Layers of water, which may be between a few centimeters and many meters thick in these soils, are considered to be the lower boundary of the control section only if the water extends below a depth of 130 or 160 cm, respectively. A densic, lithic, or paralithic contact, if shallower than 130 or 160 cm, constitutes the lower boundary of the control section. In some soils the lower boundary is 25 cm below the upper limit of permafrost. An unconsolidated mineral substratum shallower than those limits does not change the lower boundary of the control section.

The control section of Histosols and Histels is divided somewhat arbitrarily into three tiers—surface, subsurface, and bottom tiers.

Surface Tier

The surface tier of a Histosol or Histel extends from the soil surface to a depth of 60 cm if either (1) the materials within that depth are fibric and three-fourths or more of the fiber volume is derived from *Sphagnum* or other mosses or (2) the materials have a bulk density of less than 0.1. Otherwise, the surface tier extends from the soil surface to a depth of 30 cm.

Some organic soils have a mineral surface layer less than 40 cm thick as a result of flooding, volcanic eruptions, additions of mineral materials to increase soil strength or reduce the hazard of frost, or other causes. If such a mineral layer is less than 30 cm thick, it constitutes the upper part of the surface tier; if it is 30 to 40 cm thick, it constitutes the whole surface tier and part of the subsurface tier.

Subsurface Tier

The subsurface tier is normally 60 cm thick. If the control section ends at a shallower depth (at a densic, lithic, or paralithic contact or a water layer or in permafrost), however, the subsurface tier extends from the lower boundary of the surface tier to the lower boundary of the control section. It includes any unconsolidated mineral layers that may be present within those depths.

Bottom Tier

The bottom tier is 40 cm thick unless the control section has its lower boundary at a shallower depth (at a densic, lithic, or paralithic contact or a water layer or in permafrost).

Thus, if the organic materials are thick, there are two possible thicknesses of the control section, depending on the presence or absence and the thickness of a surface mantle of fibric moss or other organic material that has a low bulk density (less than 0.1). If the fibric moss extends to a depth of 60 cm and is the dominant material within this depth (three-fourths or more of the volume), the control section is 160 cm thick. If the fibric moss is thin or absent, the control section extends to a depth of 130 cm.

Horizons and Characteristics Diagnostic for Both Mineral and Organic Soils

Following are descriptions of the horizons and characteristics diagnostic for both mineral and organic soils.

Aquic Conditions[2]

Soils with aquic (L. *aqua*, water) conditions are those that currently undergo continuous or periodic saturation and reduction. The presence of these conditions is indicated by redoximorphic features, except in Histosols and Histels, and can be verified by measuring saturation and reduction, except in artificially drained soils. Artificial drainage is defined here as the removal of free water from soils having aquic conditions by surface mounding, ditches, or subsurface tiles to the extent that water table levels are changed significantly in connection with specific types of land use. In the keys, artificially drained soils are included with soils that have aquic conditions.

Elements of aquic conditions are as follows:

1. Saturation is characterized by zero or positive pressure in the soil water and can generally be determined by observing free water in an unlined auger hole. Problems may arise, however, in clayey soils with peds, where an unlined auger hole may fill with water flowing along faces of peds while the soil matrix is and remains unsaturated (bypass flow). Such free water may incorrectly suggest the presence of a water table, while the actual water table occurs at greater depth. Use of well sealed piezometers or tensiometers is therefore recommended for measuring saturation. Problems may still occur, however, if water runs into piezometer slits near the bottom of the piezometer hole or if tensiometers with slowly reacting manometers are used. The first problem can be overcome by using piezometers with smaller slits and the second by using transducer tensiometry, which reacts faster than manometers. Soils are considered wet if they have pressure heads greater than -1 kPa. Only macropores, such as cracks between peds or channels, are then filled with air, while the soil matrix is usually still saturated. Obviously, exact measurements of the wet state can be obtained only with tensiometers. For operational purposes, the use of piezometers is recommended as a standard method.

The duration of saturation required for creating aquic conditions varies, depending on the soil environment, and is not specified.

Three types of saturation are defined:

a. *Endosaturation.*—The soil is saturated with water in all layers from the upper boundary of saturation to a depth of 200 cm or more from the mineral soil surface.

b. *Episaturation.*—The soil is saturated with water in one or more layers within 200 cm of the mineral soil surface and also has one or more unsaturated layers, with an upper boundary above a depth of 200 cm, below the saturated layer. The zone of saturation, i.e., the water table, is perched on top of a relatively impermeable layer.

c. *Anthric saturation.*—This term refers to a special kind of aquic conditions that occur in soils that are cultivated and irrigated (flood irrigation). Soils with anthraquic conditions must meet the requirements for aquic conditions and in addition have *both* of the following:

(1) A tilled surface layer and a directly underlying slowly permeable layer that has, for 3 months or more in normal years, *both*:

(a) Saturation and reduction; *and*

(b) Chroma of 2 or less in the matrix; *and*

(2) A subsurface horizon with *one or more* of the following:

(a) Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less in macropores; *or*

(b) Redox concentrations of iron; *or*

(c) 2 times or more the amount of iron (by dithionite citrate) contained in the tilled surface layer.

2. The degree of reduction in a soil can be characterized by the direct measurement of redox potentials. Direct measurements should take into account chemical equilibria as expressed by stability diagrams in standard soil textbooks.

[2] In 1992, the term "aquic conditions" was introduced and other changes were made throughout this taxonomy as a result of recommendations submitted to NRCS by the International Committee on Aquic Moisture Regime (ICOMAQ), which was established in 1982 and was chaired initially by Dr. Frank Moormann, then by Dr. Johan Bouma.

Reduction and oxidation processes are also a function of soil pH. Obtaining accurate measurements of the degree of reduction in a soil is difficult. In the context of this taxonomy, however, only a degree of reduction that results in reduced iron is considered, because it produces the visible redoximorphic features that are identified in the keys. A simple field test is available to determine if reduced iron ions are present. A freshly broken surface of a field-wet soil sample is treated with alpha,alpha-dipyridyl in neutral, 1-normal ammonium-acetate solution. The appearance of a strong red color on the freshly broken surface indicates the presence of reduced iron ions. A positive reaction to the alpha,alpha-dipyridyl field test for ferrous iron (Childs, 1981) may be used to confirm the existence of reducing conditions and is especially useful in situations where, despite saturation, normal morphological indicators of such conditions are either absent or obscured (as by the dark colors characteristic of melanic great groups). A negative reaction, however, does not imply that reducing conditions are always absent. It may only mean that the level of free iron in the soil is below the sensitivity limit of the test or that the soil is in an oxidized phase at the time of testing. Use of alpha,alpha-dipyridyl in a 10 percent acetic-acid solution is not recommended because the acid is likely to change soil conditions, for example, by dissolving $CaCO_3$.

The duration of reduction required for creating aquic conditions is not specified.

3. Redoximorphic features associated with wetness result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. The reduced iron and manganese ions are mobile and may be transported by water as it moves through the soil. Certain redox patterns occur as a function of the patterns in which the ion-carrying water moves through the soil and as a function of the location of aerated zones in the soil. Redox patterns are also affected by the fact that manganese is reduced more rapidly than iron, while iron oxidizes more rapidly upon aeration. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redox processes in a soil may result in redoximorphic features that are defined as follows:

a. *Redox concentrations.*—These are zones of apparent accumulation of Fe-Mn oxides, including:

(1) Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure. Boundaries commonly are diffuse if formed *in situ* and sharp after pedoturbation. Sharp boundaries may be relict features in some soils; *and*

(2) Masses, which are noncemented concentrations of substances within the soil matrix; *and*

(3) Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.

b. *Redox depletions.*—These are zones of low chroma (chromas less than those in the matrix) where either Fe-Mn oxides alone or both Fe-Mn oxides and clay have been stripped out, including:

(1) Iron depletions, i.e., zones that contain low amounts of Fe and Mn oxides but have a clay content similar to that of the adjacent matrix (often referred to as albans or neoalbans); *and*

(2) Clay depletions, i.e., zones that contain low amounts of Fe, Mn, and clay (often referred to as silt coatings or skeletans).

c. *Reduced matrix.*—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

d. In soils that have no visible redoximorphic features, a reaction to an alpha,alpha-dipyridyl solution satisfies the requirement for redoximorphic features.

Photo 35 shows a pedon from Alaska with aquic conditions close to the surface. When snow begins to melt in the spring, the subsoil remains frozen and perches water in the gleyed zone. Photo 36 shows peds from the gleyed horizon and the horizon directly below. The gleyed horizon has redoximorphic concentrations lining pores and redoximorphic depletions in the matrix. The horizon below has redoximorphic depletions lining pores and redoximorphic concentrations in the matrix.

Field experience indicates that it is not possible to define a specific set of redoximorphic features that is uniquely characteristic of all of the taxa in one particular category. Therefore, color patterns that are unique to specific taxa are referenced in the keys.

Anthraquic conditions are a variant of episaturation and are associated with controlled flooding (for such crops as wetland rice and cranberries), which causes reduction processes in the saturated, puddled surface soil and oxidation of reduced and mobilized iron and manganese in the unsaturated subsoil.

Cryoturbation

Cryoturbation (frost churning) is the mixing of the soil matrix within the pedon that results in irregular or broken horizons, involutions, accumulation of organic matter on the permafrost table, oriented rock fragments, and silt caps on rock fragments (photo 37).

Densic Contact

A densic contact (L. *densus*, thick) is a contact between soil and densic materials (defined below). It has no cracks, or the spacing of cracks that roots can enter is 10 cm or more.

Densic Materials

Densic materials are relatively unaltered materials (do not meet the requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) that have a noncemented rupture-resistance class. The bulk density or the organization is such that roots cannot enter, except in cracks. These are mostly earthy materials, such as till, volcanic mudflows, and some mechanically compacted materials, for example, mine spoils. Some noncemented rocks can be densic materials if they are dense or resistant enough to keep roots from entering, except in cracks.

Densic materials are noncemented and thus differ from paralithic materials and the material below a lithic contact, both of which are cemented.

Densic materials have, at their upper boundary, a densic contact if they have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. These materials can be used to differentiate soil series if the materials are within the series control section.

Gelic Materials

Gelic materials are mineral or organic soil materials that show evidence of cryoturbation (frost churning) and/or ice segregation in the active layer (seasonal thaw layer) and/or the upper part of the permafrost. Cryoturbation is manifested by irregular and broken horizons, involutions, accumulation of organic matter on top of and within the permafrost, oriented rock fragments, and silt-enriched layers. The characteristic structures associated with gelic materials include platy, blocky, or granular macrostructures; the structural results of sorting; and orbiculic, conglomeric, banded, or vesicular microfabrics. Ice segregation is manifested by ice lenses, vein ice, segregated ice crystals, and ice wedges. Cryopedogenic processes that lead to gelic materials are driven by the physical volume change of water to ice, moisture migration along a thermal gradient in the frozen system, or thermal contraction of the frozen material by continued rapid cooling.

Glacic Layer

A glacic layer is massive ice or ground ice in the form of ice lenses or wedges (photo 38). The layer is 30 cm or more thick and contains 75 percent or more visible ice.

Lithic Contact

A lithic contact is the boundary between soil and a coherent underlying material (photo 39). Except in Ruptic-Lithic subgroups, the underlying material must be virtually continuous within the limits of a pedon. Cracks that can be penetrated by roots are few, and their horizontal spacing is 10 cm or more. The underlying material must be sufficiently coherent when moist to make hand-digging with a spade impractical, although the material may be chipped or scraped with a spade. The material below a lithic contact must be in a strongly cemented or more cemented rupture-resistance class. Commonly, the material is indurated. The underlying material considered here does not include diagnostic soil horizons, such as a duripan or a petrocalcic horizon.

A lithic contact is diagnostic at the subgroup level if it is within 125 cm of the mineral soil surface in Oxisols and within 50 cm of the mineral soil surface in all other mineral soils. In organic soils the lithic contact must be within the control section to be recognized at the subgroup level.

Paralithic Contact

A paralithic (lithiclike) contact is a contact between soil and paralithic materials (defined below) where the paralithic materials have no cracks or the spacing of cracks that roots can enter is 10 cm or more (photo 40).

Paralithic Materials

Paralithic materials are relatively unaltered materials (do not meet the requirements for any other named diagnostic horizons or any other diagnostic soil characteristic) that have an extremely weakly cemented to moderately cemented rupture-resistance class. Cementation, bulk density, and the organization are such that roots cannot enter, except in cracks. Paralithic materials have, at their upper boundary, a paralithic contact if they have no cracks or if the spacing of cracks that roots can enter is 10 cm or more. Commonly, these materials are partially weathered bedrock or weakly consolidated bedrock, such as sandstone, siltstone, or shale. Paralithic materials can be used to differentiate soil series if the materials are within the series control section. Fragments of paralithic materials 2.0 mm or more in diameter are referred to as pararock fragments.

Permafrost

Permafrost is defined as a thermal condition in which a material (including soil material) remains below 0 °C for 2 or more years in succession. Those gelic materials having permafrost contain the unfrozen soil solution that drives cryopedogenic processes. Permafrost may be cemented by ice or, in the case of insufficient interstitial water, may be dry. The frozen layer has a variety of ice lenses, vein ice, segregated ice crystals, and ice wedges. The permafrost table is in dynamic equilibrium with the environment.

Soil Moisture Regimes

It has been conventional to identify three soil moisture regimes. In one, the soil is saturated. In another, the amount of water is enough to cause leaching. In the third, no leaching occurs. In the leaching regime, some water moves through the soil at some time during the year and moves on down to the moist substratum. In the nonleaching regime, water moves into the soil but is withdrawn by evapotranspiration, leaving precipitated carbonates and more soluble salts. Between these two regimes, there is another possible one in which there is alternation from year to year; leaching occurs in some years but not in all. For consideration of the losses of soluble materials or their accumulation in horizons with k, y, or z suffixes, these concepts are adequate. For the understanding of biological processes, they leave much to be desired. A soil can be subject to leaching during winter, when it is too cold for optimum biological activity, and it can be too dry during most of the summer for significant biological activity. The result is a relatively wide carbon-nitrogen ratio.

The term "soil moisture regime" refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year. Water held at a tension of 1500 kPa or more is not available to keep most mesophytic plants alive. The availability of water is also affected by dissolved salts. If a soil is saturated with water that is too salty to be available to most plants, it is considered salty rather than dry. Consequently, a horizon is considered dry when the moisture tension is 1500 kPa or more and is considered moist if water is held at a tension of less than 1500 kPa but more than zero. A soil may be continuously moist in some or all horizons either throughout the year or for some part of the year. It may be either moist in winter and dry in summer or the reverse. In the Northern Hemisphere, summer refers to June, July, and August and winter refers to December, January, and February.

Significance to Soil Classification

The moisture regime of a soil is an important property of the soil as well as a determinant of processes that can occur in the soil. During geologic time there have been significant changes in climate. Soils that could have formed only in a humid climate are now preserved in an arid climate in some areas. Such soils have relict features that reflect the former moisture regime and other features that reflect the present moisture regime.

The soil moisture regime is only partially a function of climate. Most deep, permeable soils under high and well distributed rainfall have water that is available to plants most of the time. Soils in areas of an arid climate, however, are not necessarily dry. They may be dry, moist, or saturated, depending on their position on the landscape, because they may receive water from sources other than the rain that falls on them. The extra water may be runoff from rainfall on an adjacent slope or on distant mountains, or it may come from melting snow, seepage, or even natural artesian sources. In the Northern Hemisphere, precipitation is more effective in soils on north aspects than in soils on south aspects. In some areas this difference is significant enough for there to be different soil moisture regimes on north and south aspects. Soils may also lose part or most of the water that falls on them, particularly if they are sloping and the surface horizon has few noncapillary pores. On any given landscape that has uniform climate, adjacent soils may have different moisture regimes.

Each of the moisture regimes in the history of a soil is a factor in the genesis of that soil and is the cause of many accessory characteristics. Most of the accessory characteristics, however, and those most important for interpretations are associated with the present moisture regime, even if the present regime differs widely from some of the earlier regimes. For example, before an argillic horizon forms, enough water has to pass through the soil to remove soluble materials, such as finely divided carbonates. If the leaching and formation of the argillic horizon took place under climatic conditions with more effective precipitation than that of today, the present argillic horizon is not necessarily free from carbonates or other soluble materials. Soils with soluble salts or carbonates above and within the argillic horizon have characteristics that reflect both past and present climates. The argillic horizon formed under a past climate, and the soluble salts and carbonates accumulated under the present climate. Both climates have left markers that can be observed in the soils today. The argillic horizon that formed under more effective moisture may have formed under precipitation similar to that of today but under cooler temperatures, or it may have formed under temperatures similar to those of today but under higher precipitation. There is no precise measure of past climates, and an accurate reconstruction of past climates is difficult. More importantly, the present climate determines use and management of the soil. It is a property of the soil. Furthermore, the moisture regimes of most soils are inferred from the present climate, and small-scale maps can be interpreted in terms of the many accessory characteristics that are common to most of the soils that have a common climate. These characteristics include the amount, nature, and distribution of organic matter, the base status of the soil, and the presence or absence of salts.

The most important of the soil interpretations are the potentials for growing different plants and the cultural practices required to grow them. Without soil climate as a criterion at some level in the taxonomic system, for example, Vertisols from Texas could be in the same taxonomic class as Vertisols from North Dakota.

Normal Years

In the discussions that follow and throughout the keys, the term “normal years” is used. A normal year is defined as a year that has plus or minus one standard deviation of the long-term mean annual precipitation. (Long-term refers to 30 years or more.) Also, the mean monthly precipitation during a normal year must be plus or minus one standard deviation of the long-term monthly precipitation for 8 of the 12 months. For the most part, normal years can be calculated from the mean annual precipitation. When catastrophic events occur during a year, however, the standard deviations of the monthly means should also be calculated. The term “normal years” replaces the terms “most years” and “6 out of 10 years,” which were used in the previous edition of *Soil Taxonomy* (USDA, SCS, 1975).

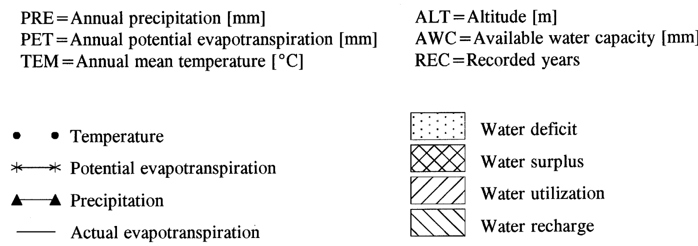
Estimation

The landscape position of every soil is subject to extremes in climate. While no 2 years have exactly the same weather conditions, the moisture status of the soil must be characterized by probability. Weather probabilities can be determined from long-term weather records and observations of how each soil responds to weather conditions as modified by its landscape position.

A number of methods have been devised to relate soil moisture to meteorological records. To date, all of these methods have some shortcomings, even for gently sloping soils that depend primarily on precipitation for their moisture. Dew and fog can add appreciable amounts of moisture to some soils, but quantitative data are rare.

The graphs in diagrams 3 to 16 are based on the average values for precipitation, temperature, and potential evapotranspiration. They give an oversimplified picture of the moisture regime of the whole soil rather than of the moisture control section. The data are based on the monthly climatological values of temperature and precipitation for the indicated number of years and the monthly potential evapotranspiration (PE) normals taken from the large Thornthwaite collection covering the world (Mather, 1964, 1965). No reduction from potential evapotranspiration was made.

The following legend helps to explain the graphs in diagrams 3 to 16. Numbers at the bottom of the graphs indicate months of the year.



In diagram 3 the area between the line that joins all of the precipitation normals and the one that joins all of the PE normals indicates the status of soil moisture. Beginning at the point where precipitation becomes greater than PE, the area to the right shows recharge, the amount of moisture stored in the soil. This area commonly extends to the extreme right of the diagram. The amount of recharge is limited either by the available water capacity (AWC) of the soil, in which case a vertical line delimits the area as surplus, or by the fact that PE again exceeds precipitation before the AWC has been filled. The point where PE exceeds precipitation is utilization. Utilization shows the amount of PE necessary to remove the water held at a tension of less than 1500 kPa. Excess PE, if any, before the time that recharge begins is called deficit and is delimited by a vertical line.

The discussion of recharge, surplus, utilization, and deficit in the preceding paragraph has implied the moisture regime of a cool, moist region in the Northern Hemisphere, but many other combinations of recharge, surplus, utilization, and deficit can occur, including all surplus and all deficit.

For definitions of taxa, it is recognized that the accretion of daily or monthly precipitation is depleted, linearly or nonlinearly, by daily or monthly potential evapotranspiration. An initial condition is set, and the sequence of subsequent water balances shows whether critical parts of the soil profile are likely to be moist, partly dry, or completely dry as the seasons advance. Depending on one’s purposes, an assumption of linear or of nonlinear depletion of soil moisture might be best. To represent the probable soil moisture regime, the estimate of evapotranspiration should be reduced as the soil dries. To represent irrigation needs, evapotranspiration at the full potential rate would give a better picture. Either procedure gives a crude picture of both.

Soil Moisture Control Section

The intent in defining the soil moisture control section is to facilitate estimation of soil moisture regimes from climatic data. The upper boundary of this control section is the depth to which a dry (tension of more than 1500 kPa, but not air-dry) soil will be moistened by 2.5 cm of water within 24 hours. The lower boundary is the depth to which a dry soil will be moistened by 7.5 cm of water within 48 hours. These depths do not include the depth of moistening along any cracks or animal burrows that are open to the surface.

The boundaries for the soil moisture control section correspond to the rooting depths for many crops; however, there are natural plant communities that have their roots either above or below the control section. Attempts are currently being made to improve the parameters of the soil moisture control section.

If 7.5 cm of water moistens the soil to a densic, lithic, paralithic, or petroferric contact or to a petrocalcic or petrogypsic horizon or a duripan, the contact or the upper boundary of the cemented horizon constitutes the lower boundary of the soil moisture control section. If a soil is moistened to one of these contacts or horizons by 2.5 cm of water, the soil moisture control section is the boundary or the contact itself. The control section of such a soil is considered moist if the contact or upper boundary of the cemented horizon has a thin film of water. If that upper boundary is dry, the control section is considered dry.

The concept of the soil moisture control section does not apply well to the cracking clays, because these clays remoisten from both the surface and the bases of the cracks. The soil moisture patterns of these soils are defined in terms of the pattern of cracking over time.

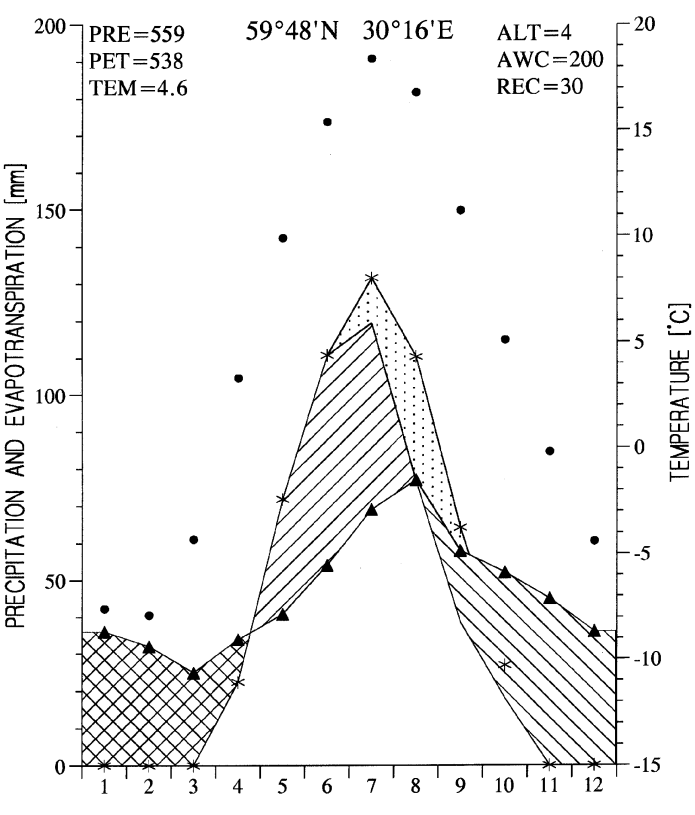


Diagram 3.—Udic, frigid; St. Petersburg, Russia (formerly Leningrad, U.S.S.R.).

Dry soils can remoisten unevenly for a variety of reasons other than microrelief or the presence of cracks or holes that are open at the surface. Water can be suspended by capillary forces in a dry sandy soil (Rode, 1965). When the suspended water exceeds a critical limit, it drains rapidly at some points into lower soil layers. Water can be suspended in a dry or moist soil if pore sizes increase with increasing depth, and similar leaks may occur. Uneven moistening may result from interception of rain by plants. Part of the rain reaches the soil by flowing down the stem of the plant. Some plants, such as mulga (*Acacia aneura*) in Australia, intercept virtually all of the rain falling on them. In this situation, the soil is moistened deeply around the stem but remains extremely dry under the canopy of the mulga. In areas between the plants, rain generally falls directly on the soil. Thus, within a very short distance, there are three contrasting moisture regimes. In one, the soil is deeply moistened; in the second, which surrounds the first, the soil receives virtually no moisture; and in the third, the soil is intermittently moist and dry.

If moistening occurs unevenly, the weighted average depth of moistening in a pedon is used for the limits of the moisture control section.

The moisture control section of a soil extends approximately (1) from 10 to 30 cm below the soil surface if the particle-size class of the soil is fine-loamy, coarse-silty, fine-silty, or clayey; (2) from 20 to 60 cm if the particle-size class is coarse-loamy; and (3) from 30 to 90 cm if the particle-size class is sandy. If the soil contains rock and pararock fragments that do not absorb and release water, the limits of the moisture control section are deeper. The limits of the soil moisture control section are affected not only by the particle-size class but also by differences in soil structure or pore-size distribution or by other factors that influence the movement and retention of water in the soil.

The classification of the soil series in the United States was determined in part by knowledge of the moisture regimes. The definitions of soil moisture regimes that follow were fitted to the boundaries. If future studies show that the classifications of the soils are not in agreement with these definitions, we are more likely to change the definitions than the classifications. Over time, changes in both will doubtless be made.

Classes of Soil Moisture Regimes

The soil moisture regimes are defined in terms of the level of ground water and in terms of the seasonal presence or absence of water held at a tension of less than 1500 kPa in the moisture control section. It is assumed in the definitions that the soil supports whatever vegetation it is capable of supporting, i.e., crops, grass, or native vegetation, and that the amount of stored moisture is not being increased by irrigation or fallowing. These cultural practices affect the soil moisture conditions as long as they are continued.

Aquic moisture regime.—The aquic (L. *aqua*, water) moisture regime is a reducing regime in a soil that is virtually free of dissolved oxygen because it is saturated by water. Some soils are saturated with water at times while dissolved oxygen is present, either because the water is moving or because the environment is unfavorable for micro-organisms (e.g., if the temperature is less than 1 °C); such a regime is not considered aquic.

It is not known how long a soil must be saturated before it is said to have an aquic moisture regime, but the duration must be at least a few days, because it is implicit in the concept that dissolved oxygen is virtually absent. Because dissolved oxygen is removed from ground water by respiration of micro-organisms, roots, and soil fauna, it is also implicit in the concept that the soil temperature is above biologic zero for some time while the soil is saturated. Biologic zero is defined as 5 °C in this taxonomy. In some of the very cold regions of the world, however, biological activity occurs at temperatures below 5 °C.

Very commonly, the level of ground water fluctuates with the seasons; it is highest in the rainy season or in fall, winter, or spring if cold weather virtually stops evapotranspiration. There are soils, however, in which the ground water is always at or very close to the surface. Examples are soils in tidal marshes or in closed, landlocked depressions fed by perennial streams. Such soils are considered to have a peraquic moisture regime. The distinction between the aquic moisture regime and the peraquic moisture regime is not closely defined because neither regime is used as a criterion for taxa above the series level. These terms can be used in descriptions of taxa. Some soils with an aquic moisture regime also have a xeric, ustic, or aridic (torric) regime.

Although the aquic and peraquic moisture regimes are not used as either criteria or formative elements for taxa, they are used in taxon descriptions as an aid in understanding genesis. The formative term "aqu" refers to aquic conditions, not an aquic moisture regime. Some soils included in the "Aqu" suborders may have aquic or peraquic moisture regimes.

Aridic and torric (L. *aridus*, dry, and L. *torridus*, hot and dry) moisture regimes.—These terms are used for the same moisture regime but in different categories of the taxonomy.

In the aridic (torric) moisture regime, the moisture control section is, in normal years:

1. Dry in all parts for more than half of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is above 5 °C; *and*

2. Moist in some or all parts for less than 90 consecutive days when the soil temperature at a depth of 50 cm is above 8 °C.

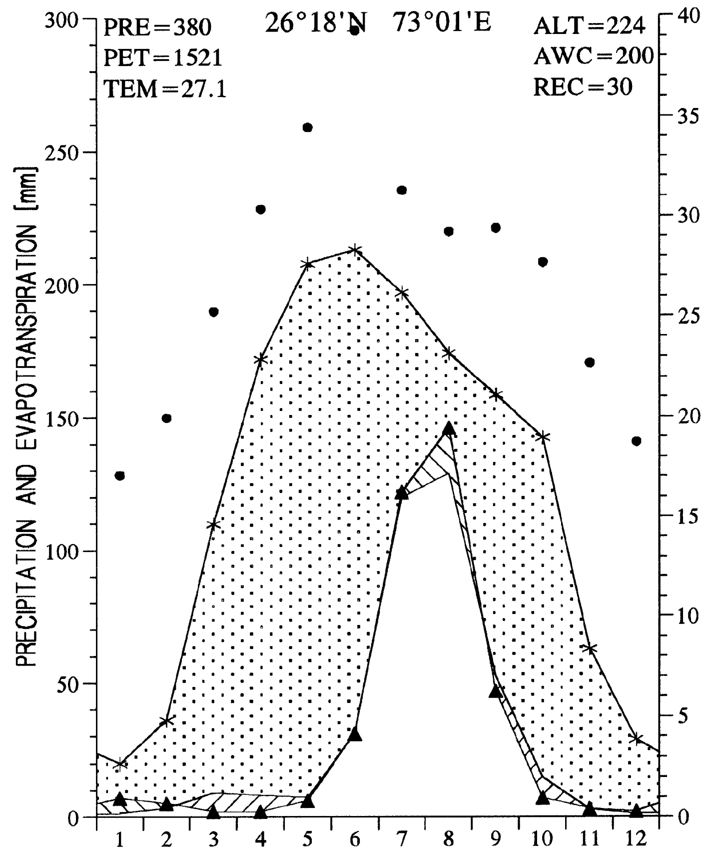


Diagram 4.—Aridic, hyperthermic; Jodhpur, India.

Soils that have an aridic (torric) moisture regime normally occur in areas of arid climates. A few are in areas of semiarid climates and either have physical properties that keep them dry, such as a crusty surface that virtually precludes the infiltration of water, or are on steep slopes where runoff is high. There is little or no leaching in this moisture regime, and soluble salts accumulate in the soils if there is a source.

Diagrams 4 to 7 illustrate climatic data in a region where the soils have an aridic (torric) moisture regime. Diagram 4 is an example of an area with an aridic soil moisture regime and a hyperthermic soil temperature regime. Diagram 5 is an example of an area with an aridic soil moisture regime and a thermic temperature regime. Diagram 6 is an example of an area with an aridic soil moisture regime and a mesic soil temperature regime. Diagram 7 is an example of an area with an aridic soil moisture regime that grades towards an ustic soil moisture regime.

The limits set for soil temperature exclude from these moisture regimes soils in the very cold and dry polar regions and in areas at high elevations. Such soils are considered to have anhydrous conditions (defined earlier).

Udic moisture regime.—The udic (L. *udus*, humid) moisture regime is one in which the soil moisture control section is not dry in any part for as long as 90 cumulative days in normal years. If the mean annual soil temperature is lower than 22 °C and if the mean winter and mean summer soil temperatures at a depth of 50 cm from the soil surface differ by 6 °C or more, the soil moisture control section, in normal years, is dry in all parts for less than 45 consecutive days

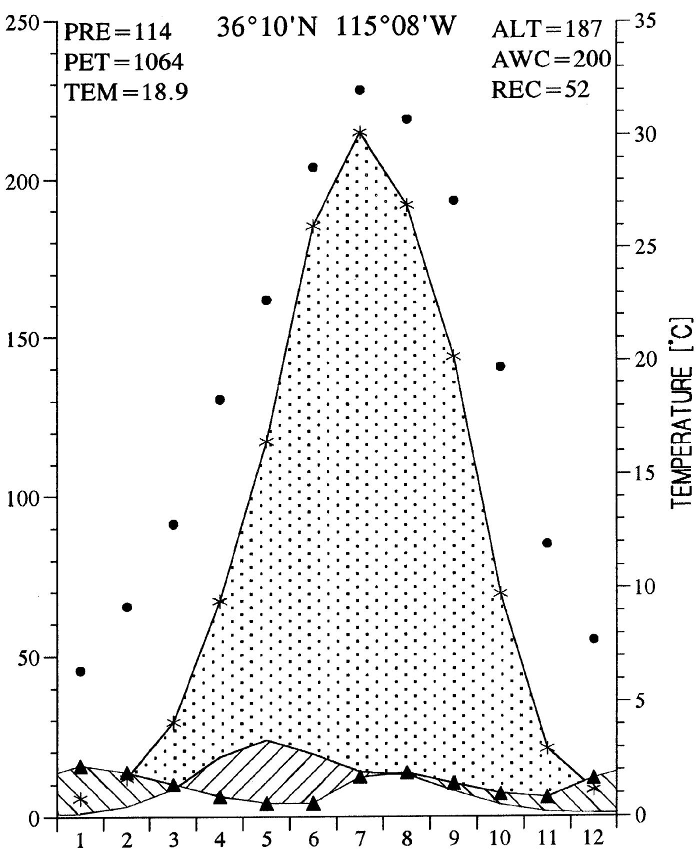


Diagram 5.—Aridic, thermic; Las Vegas, Nevada, United States.

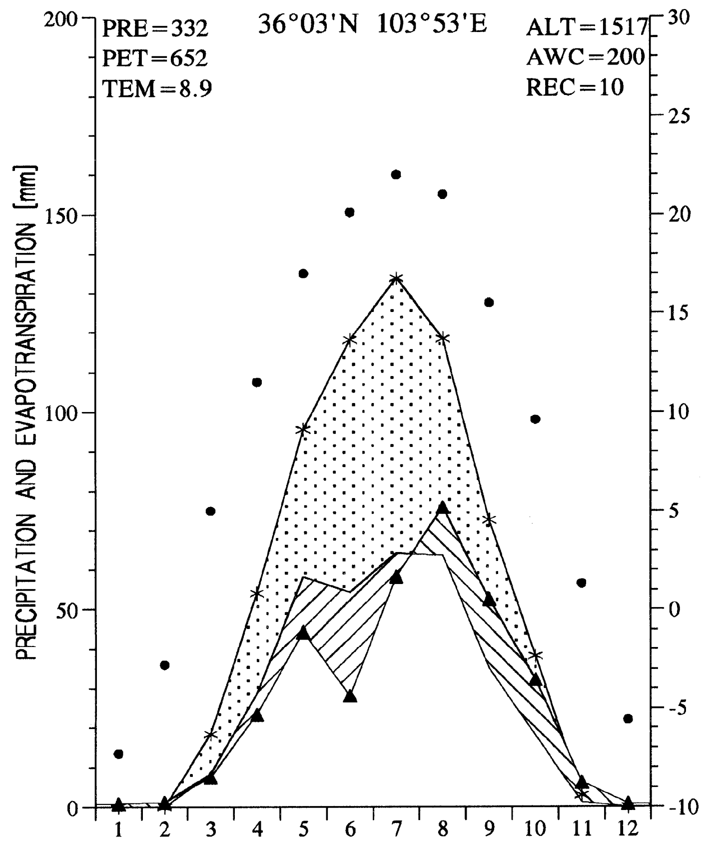


Diagram 6.—Aridic, mesic; Lanzhou, China.

in the 4 months following the summer solstice. In addition, the udic moisture regime requires, except for short periods, a three-phase system, solid-liquid-gas, in part or all of the soil moisture control section when the soil temperature is above 5 °C.

The udic moisture regime is common to the soils of humid climates that have well distributed rainfall; have enough rain in summer so that the amount of stored moisture plus rainfall is approximately equal to, or exceeds, the amount of evapotranspiration; or have adequate winter rains to recharge the soils and cool, foggy summers, as in coastal areas. Water moves downward through the soils at some time in normal years.

In climates where precipitation exceeds evapotranspiration in all months of normal years, the moisture tension rarely reaches 100 kPa in the soil moisture control section, although there are occasional brief periods when some stored moisture is used. The water moves through the soil in all months when

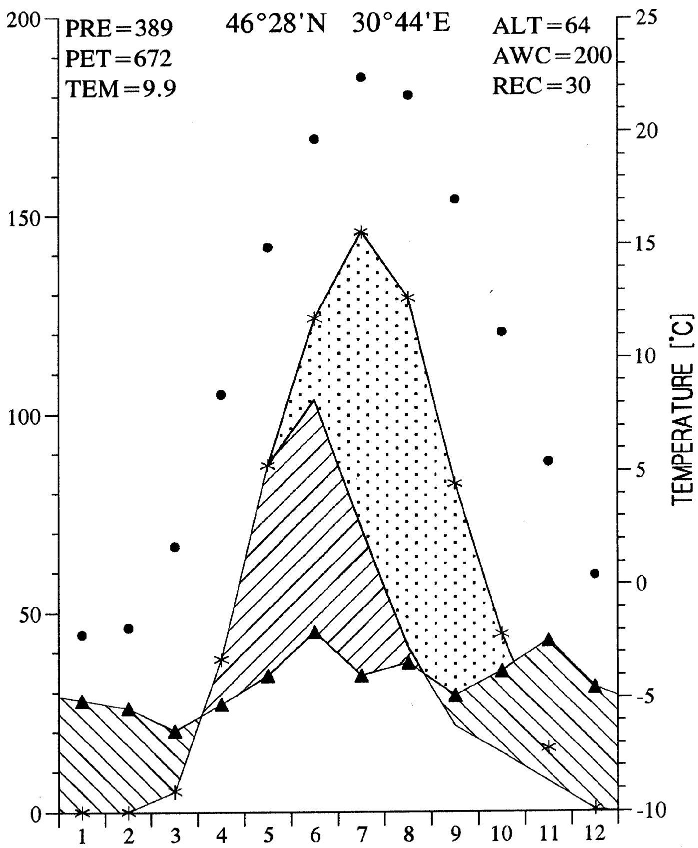


Diagram 7.—Aridic, mesic; Odessa, Ukraine.

it is not frozen. Such an extremely wet moisture regime is called perudic (L. *per*, throughout in time, and L. *udus*, humid). In the names of most taxa, the formative element "ud" is used to indicate either a udic or a perudic regime; the formative element "per" is used in selected taxa. The distinction between perudic and udic can always be made at the series level.

Diagram 8 illustrates an area with a udic soil moisture regime and an isohyperthermic soil temperature regime. Diagram 9 illustrates an area with a udic soil moisture regime and a thermic temperature regime. Diagrams 10 and 11 are examples of areas with a udic soil moisture regime and mesic and frigid temperature regimes, respectively.

Diagram 12 illustrates a perudic soil moisture regime. Note that the perudic regime shows a surplus every month of the year. Obviously, if calculations were made on a daily basis, there would be short periods of withdrawal.

Ustic moisture regime.—The ustic (L. *ustus*, burnt; implying dryness) moisture regime is intermediate between the aridic regime and the udic regime. Its concept is one of moisture that is limited but is present at a time when conditions are suitable for plant growth. The concept of the ustic moisture regime is not applied to soils that have permafrost or a cryic soil temperature regime (defined below).

If the mean annual soil temperature is 22 °C or higher or if the mean summer and winter soil temperatures differ by less than 6 °C at a depth of 50 cm below the soil surface, the soil moisture control section in areas of the ustic moisture regime is dry in some or all parts for 90 or more cumulative days in normal years. It is moist, however, in some part either for more than 180 cumulative days per year or for 90 or more consecutive days.

If the mean annual soil temperature is lower than 22 °C and

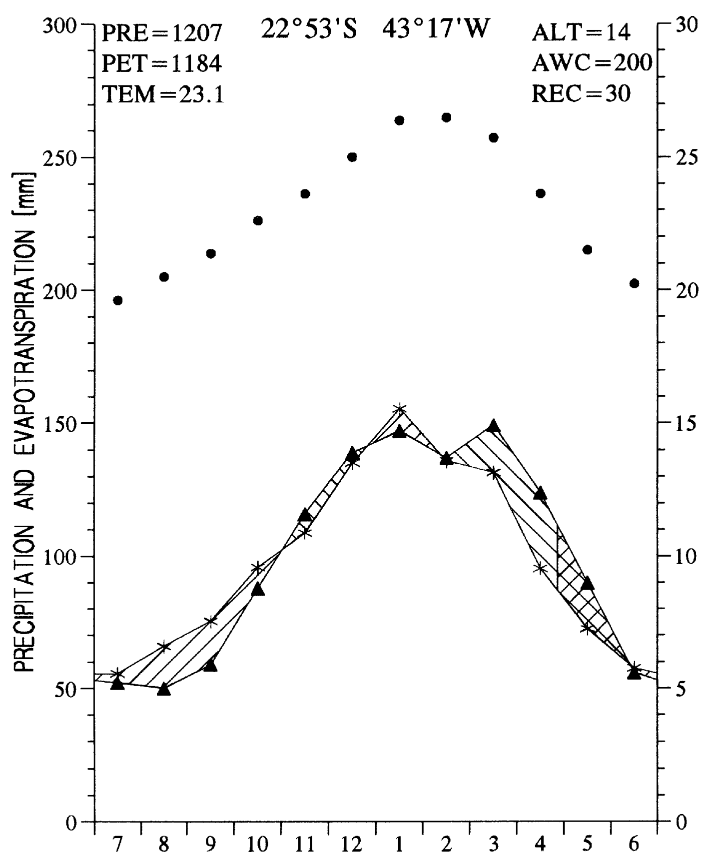


Diagram 8.—Udic, isohyperthermic; Rio de Janeiro, Brazil.

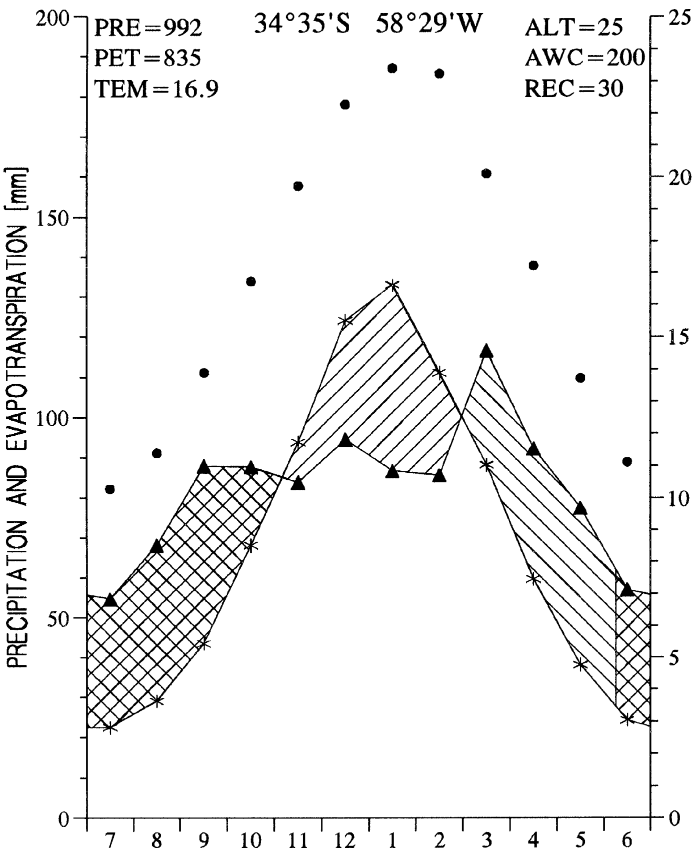


Diagram 9.—Udic, thermic; Buenos Aires, Argentina.

if the mean summer and winter soil temperatures differ by 6 °C or more at a depth of 50 cm from the soil surface, the soil moisture control section in areas of the ustic moisture regime is dry in some or all parts for 90 or more cumulative days in normal years, but it is not dry in all parts for more than half of the cumulative days when the soil temperature at a depth of 50 cm is higher than 5 °C. If in normal years the moisture control section is moist in all parts for 45 or more consecutive days in the 4 months following the winter solstice, the moisture control section is dry in all parts for less than 45 consecutive days in the 4 months following the summer solstice. Diagram 13 illustrates an area with an ustic soil moisture regime and a thermic soil temperature regime. Diagram 14 illustrates an area with an ustic soil moisture regime and a mesic soil temperature regime.

In tropical and subtropical regions that have a monsoon climate with either one or two dry seasons, summer and winter seasons have little meaning. In those regions the moisture regime is ustic if there is at least one rainy season of 3 months or more. In temperate regions of subhumid or semiarid climates, the rainy seasons are usually spring and summer or spring and fall, but never winter. Native plants are mostly annuals or plants that have a dormant period while the soil is dry.

Xeric moisture regime.—The xeric (Gr. *xeros*, dry) moisture regime is the typical moisture regime in areas of Mediterranean climates, where winters are moist and cool and summers are warm and dry. The moisture, which falls during the winter, when potential evapotranspiration is at a minimum, is particularly effective for leaching. In areas of a xeric moisture regime, the soil moisture control section, in normal years, is dry in all parts for 45 or more consecutive days in the 4 months following the summer solstice and moist in all parts for 45 or more consecutive days in the 4 months following the

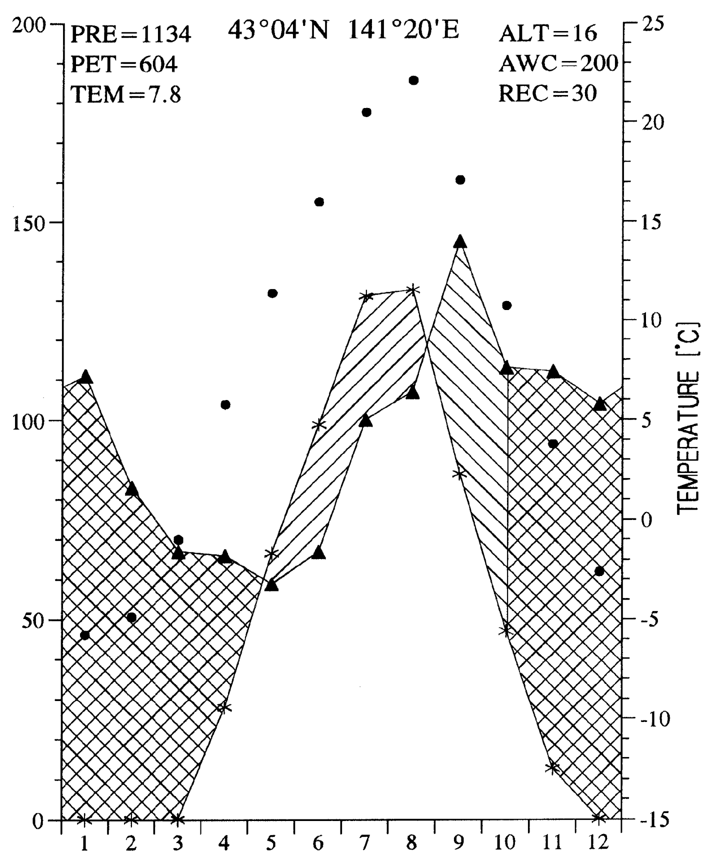


Diagram 10.—Udic, mesic; Sapporo, Japan.

winter solstice. Also, in normal years, the moisture control section is moist in some part for more than half of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is higher than 6 °C or for 90 or more consecutive days when the soil temperature at a depth of 50 cm is higher than 8 °C. The mean annual soil temperature is lower than 22 °C, and the mean summer and mean winter soil temperatures differ by 6 °C or more either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact if shallower.

Diagram 15 illustrates an area with a xeric soil moisture regime and a thermic soil temperature regime. Diagram 16 illustrates an area with a xeric soil moisture regime and a mesic soil temperature regime.

Soil Temperature Regimes

The temperature of a soil is one of its important properties. Within limits, temperature controls the possibilities for plant growth and for soil formation. Below the freezing point, there

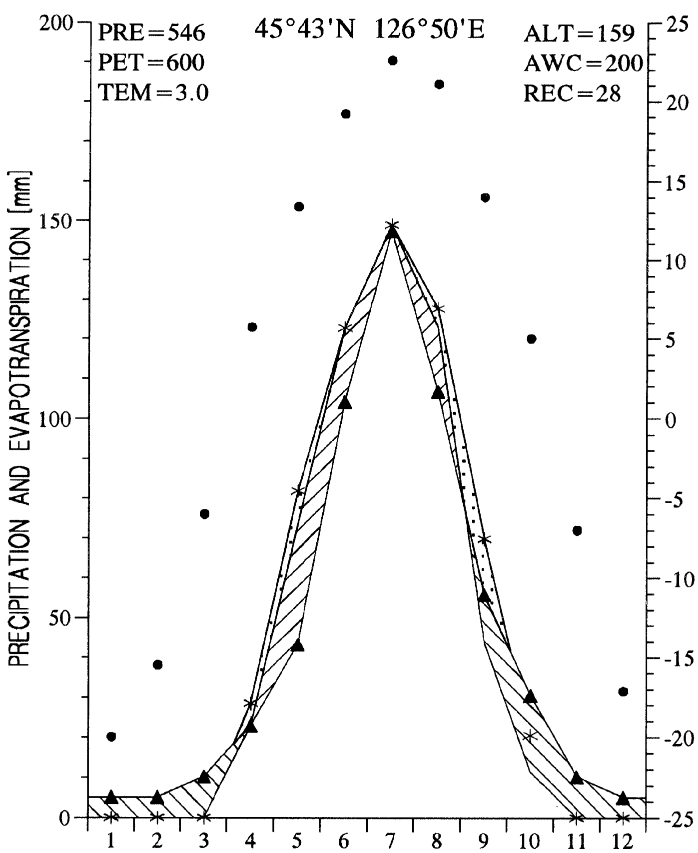


Diagram 11.—Udic, frigid; Harbin, China.

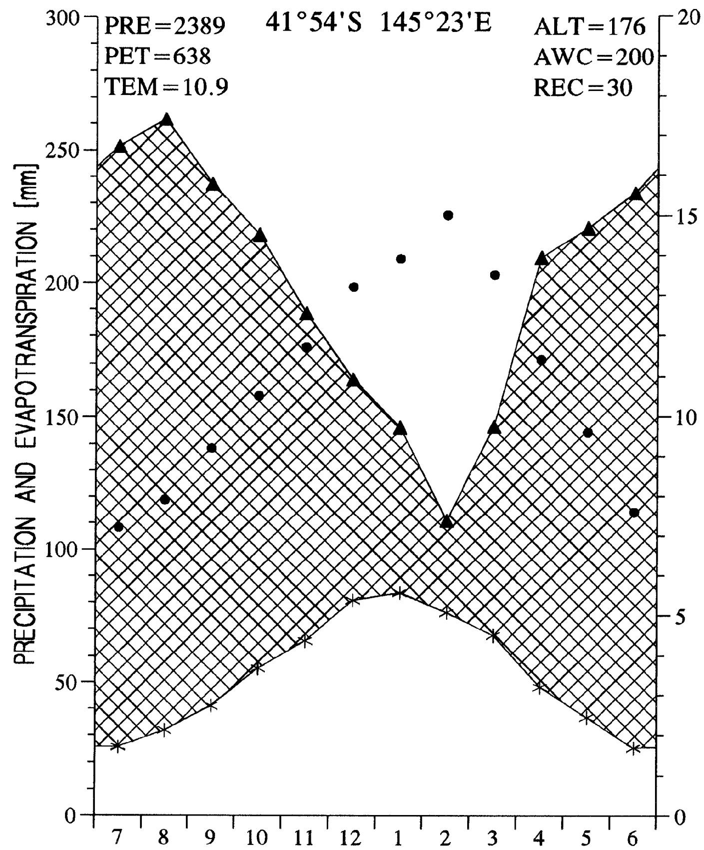


Diagram 12.—Perudic, mesic; Zeehan, Australia (Tasmania) .

is no biotic activity, water no longer moves as a liquid, and, unless there is frost heaving, time stands still for the soil. Between temperatures of 0 and 5 °C, root growth of most plant species and germination of most seeds are impossible. A horizon as cold as 5 °C is a thermal pan to the roots of most plants.

Biological processes in the soil are controlled in large measure by soil temperature and moisture. Each plant species has its own temperature requirements. In the Antarctic, for example, there is a microscopic plant that grows only at temperatures below 7 °C, temperatures at which most other plants are inactive. At the other extreme, germination of seeds of many tropical plant species requires a soil temperature of 24 °C or higher. Plant species have one or more soil temperature requirements that are met by the soils of their native environment. Similarly, soil fauna have temperature requirements for survival. Soil temperature, therefore, has an important influence on biological, chemical, and physical processes in the soil and on the adaptation of introduced plant species.

At any moment the temperature within a soil varies from horizon to horizon. The temperature near the surface fluctuates with the hours of the day and with the seasons of the year. The fluctuations may be very small or very large, depending on the environment. Because temperature is so variable, or perhaps because it is not preserved in samples, some pedologists have thought that it is not a property of a soil. One is inclined to notice the properties that differ among soils and to focus attention on them.

Each pedon has a characteristic temperature regime that can be measured and described. For most practical purposes, the temperature regime can be described by the mean annual soil temperature, the average seasonal fluctuations from that mean, and the mean warm or cold seasonal soil temperature gradient within the main root zone, which is the zone from a depth of 5 to 100 cm.

Mean Annual Soil Temperature

Each pedon has a mean annual temperature that is essentially the same in all horizons at all depths in the soil and at depths considerably below the soil. The measured mean annual soil temperature is seldom the same in successive

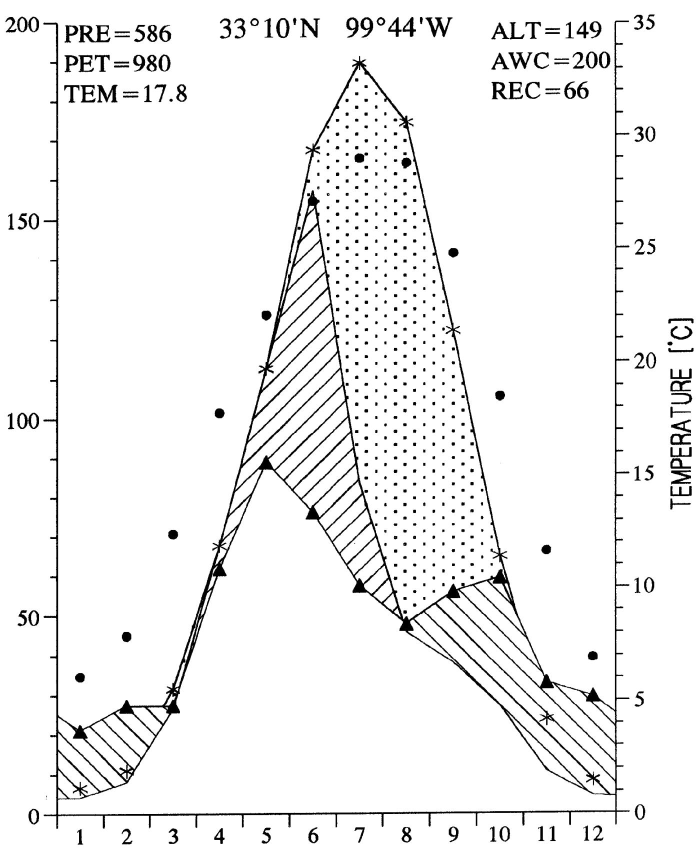


Diagram 13.—Ustic, thermic; Haskell, Texas, United States.

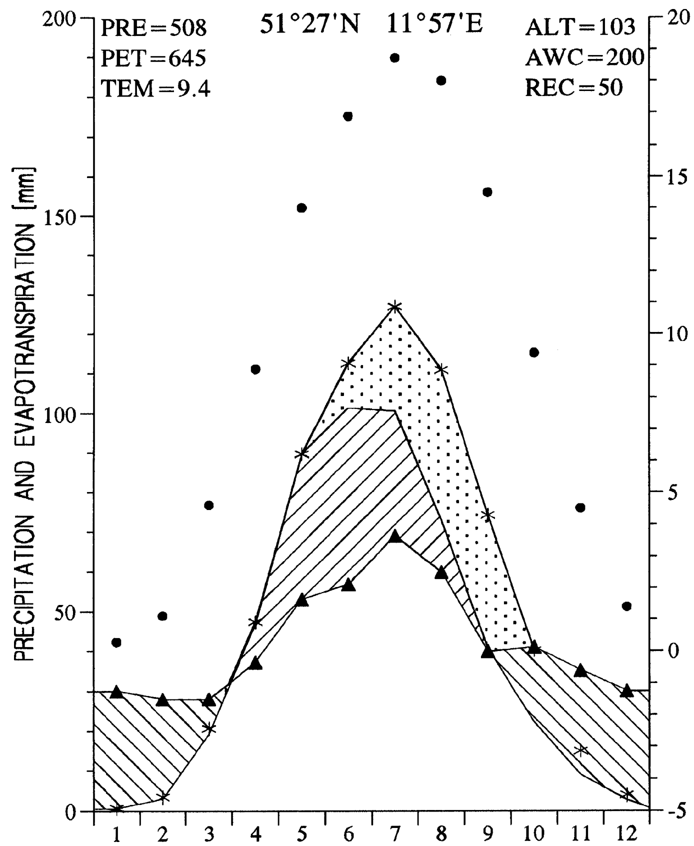


Diagram 14.—Ustic, mesic; Halle, Germany.

depths at a given location, but the differences are so small that it seems valid and useful to take a single value as the mean annual temperature of a soil.

The mean annual soil temperature is related most closely to the mean annual air temperature, but this relationship is affected to some extent by the amount and distribution of rain, the amount of snow, the protection provided by shade and by O horizons in forests, the slope aspect and gradient, and irrigation. Other factors, such as soil color, texture, and content of organic matter, have negligible effects (Smith et al., 1964).

Fluctuations of Soil Temperature

The mean annual temperature of a soil is not a single reading but the average of a series of readings. Near the surface, the readings may fluctuate from the mean fully as much as those of the air temperature, especially if there is no insulating cover. The fluctuations occur as daily and annual cycles, which in most places are made somewhat irregular by weather events. The fluctuations decrease with increasing depth and are ultimately damped out in the substrata in a zone

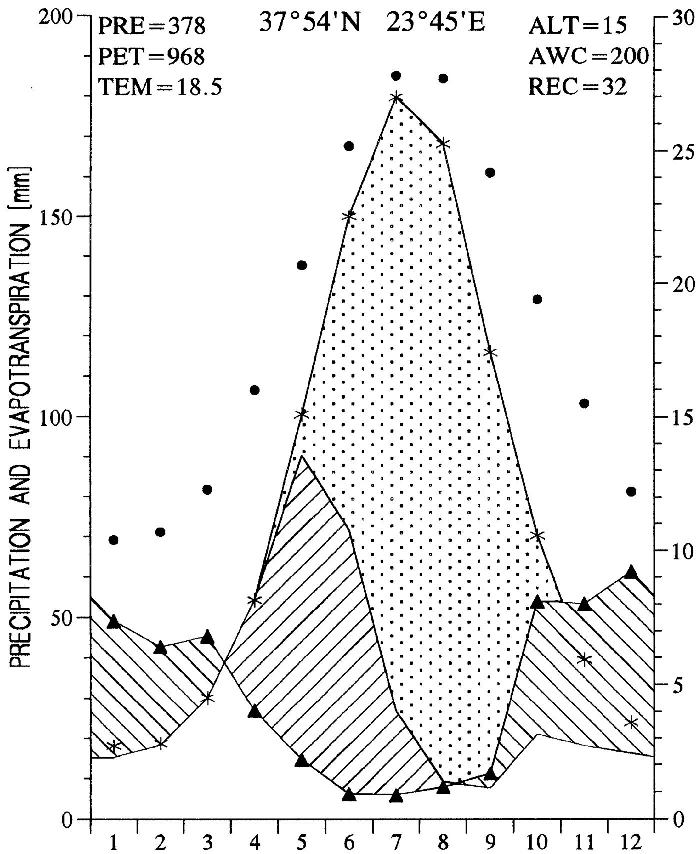


Diagram 15.—Xeric, thermic; Athens, Greece.

where the temperature is constant and is the same as the mean annual soil temperature.

Daily fluctuations.—Daily changes in air temperature have a significant effect on the temperature of soil horizons to a depth of about 50 cm. The fluctuations may be very large, particularly in soils of dry climates where the daily range in temperature of the upper 2.5 cm of the soils may approach 55 °C. At the other extreme, under melting snow, the temperature at the soil surface may be constant throughout the day. In a few places in high mountains very near the Equator, the soils have virtually constant temperature.

Daily fluctuations in soil temperature are affected by clouds, vegetation, length of day, soil color, slope, soil moisture, air circulation near the ground, and the temperature of any rain that falls. Moisture can be exceedingly important in reducing fluctuations in soil temperature. The specific heat of water is roughly 4 times that of a dry surface horizon, and the specific heat of a medium textured surface horizon at field capacity is roughly one-half more than that at the wilting point. Water increases the thermal conductivity of soils, and it can also absorb or liberate heat by freezing and thawing or by evaporating and condensing. All of these effects of soil water reduce fluctuations in soil temperature at the surface.

Fluctuations caused by changes in weather.—Soil temperatures also fluctuate during short periods of below-average or above-average air temperatures. The fluctuations caused by weather extend to a greater depth than those of the diurnal cycle. Periods of high or low temperature tend to last a few days to a week in most of the United States. Like weather patterns in general, however, they occur at irregular intervals.

The soil temperature at a depth of 50 cm shows almost no

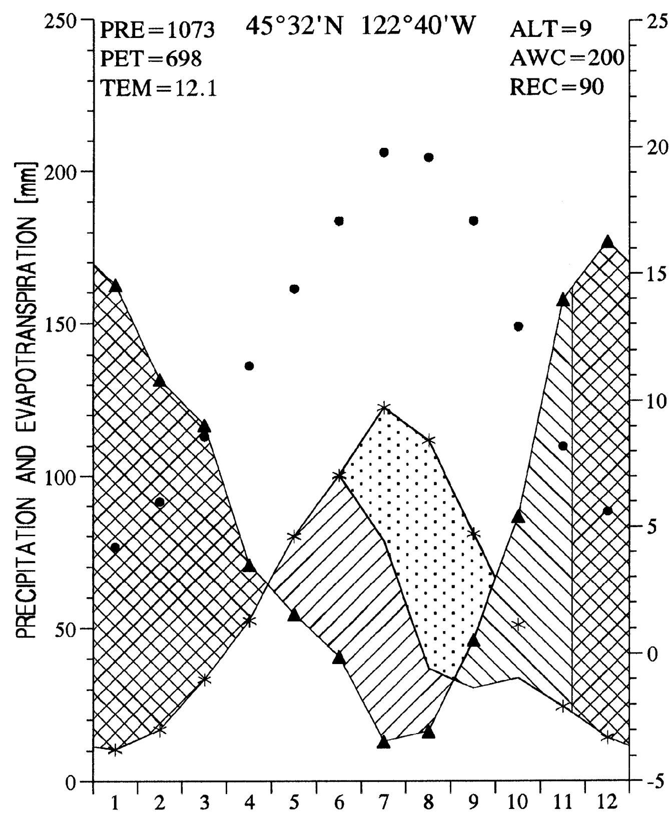


Diagram 16.—Xeric, mesic; Portland, Oregon, United States.

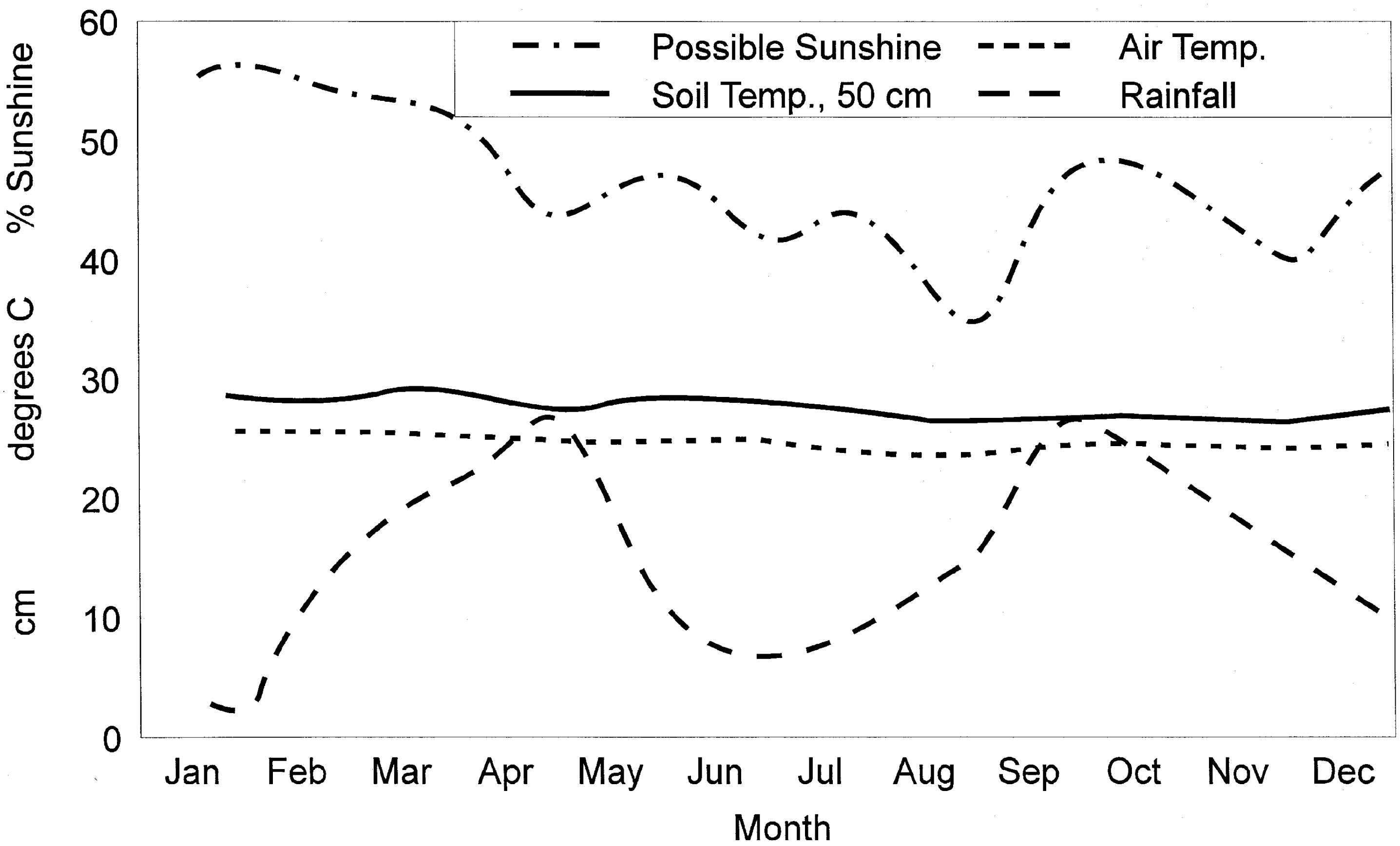


Diagram 17.—Mean monthly soil temperature at a depth of 50 cm for 1952 at Yangambi, Zaire, and the major factors that affect the soil temperature.

daily fluctuation, but it reflects short-time weather patterns. Data indicate that at shallow depths soil temperatures reflect daily fluctuations in temperature.

Cold or warm rains may bring about rapid and marked changes in the temperature of surface horizons. Generally, the direct effect of a rain on soil temperature is not measurable 48 hours after the rain ends.

Seasonal fluctuations and soil temperature gradients in the Tropics.—Seasonal fluctuations of soil temperature are generally small in the intertropical regions between the Tropic of Capricorn and the Tropic of Cancer. Mean annual soil temperatures vary with elevation, but seasonal temperatures vary primarily with clouds and rain. The warmest seasons may be the dry seasons, for the effects of clouds and rain may outweigh those of the angle of the sun's rays.

Diagram 17 shows the soil temperature, air temperature, rainfall, and percentage of possible sunshine at Yangambi, Zaire, at an elevation of about 365 m (I.N.E.A.C., 1953). These data indicate that the soil temperature is higher in winter than in summer. Actually, the soil temperature fluctuates with cloud cover and rain and appears to be most closely correlated with the amount of sunshine. In the Tropics, differences between summer and winter temperatures are small and may be in either direction. The average temperature over a 3-month season is virtually the same at all depths within the upper m of the soil.

As the temperate region is approached, near the Tropic of Cancer, for example, soil temperatures in summer are likely to be higher than those in winter, but the differences between the mean summer temperature and the mean winter temperature in the upper m of the soil are usually less than 6 °C.

Seasonal fluctuation and soil temperature gradients in midlatitudes.—Soil temperatures in the 48 conterminous States of the United States generally show marked seasonal

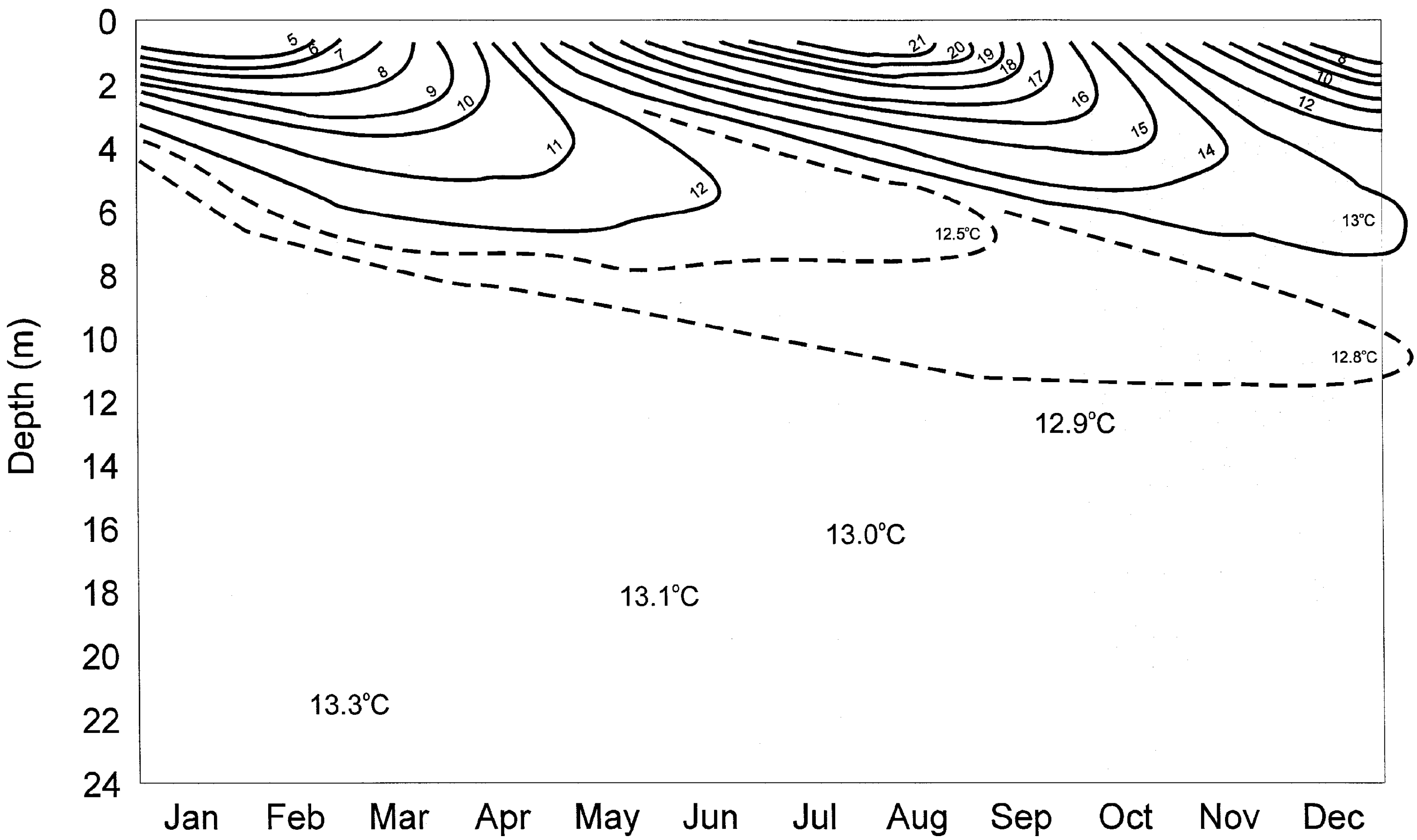


Diagram 18.—Mean monthly isotherms of ground temperature at Belgrade, Yugoslavia.

fluctuations. To illustrate seasonal changes under a midlatitude continental climate, such as that in much of the United States, a good record of soil temperatures from Belgrade, Yugoslavia (Chang, 1958b), has been selected. This record is shown graphically in diagram 18. The annual cooling and heating waves extend to a depth of 12 m, but the amplitude of variation at this depth is only 0.1 °C. At a depth of 14 m, the temperature is constant and is the same as the mean annual soil temperature. These records clearly show that seasonal temperature fluctuations penetrate deeply into the earth, well below the limit of soil.

The depth to the stratum that has constant temperature is not the same in all soils. It is reduced by shallow ground water because water has high specific heat. Records of well-water temperature in the 48 conterminous States of the United States show that, in the presence of ground water, the stratum of constant soil temperature occurs at a depth of about 9 m.

Chang (1958a) has estimated that, in the absence of ground water, seasonal fluctuations of soil temperature penetrate to a depth of 20 m in Alaska, 15 m in midlatitudes, and 10 m in the Tropics. In dry soils, thermal conductivity is low and, although seasonal fluctuations in temperature may be very large, the depth of penetration is no greater than in moist soils. At Jaipur, India (lat. 27° N.), the seasonal range in soil temperature at a depth of 6 m was 2.7 °C, but at a depth of 14 m, it was only 0.2 °C (Chang, 1958b).

The amplitude of seasonal fluctuations and the timing of periods of warm and cool soil temperature are primarily functions of latitude and climate. In midlatitudes the angle of the sun's rays is most important, but clouds, rain, irrigation water, snow cover, bodies of water, direction and angle of slope, and presence or absence of shallow ground water and of thick O horizons can all affect the amplitude of fluctuation. Seasonal fluctuations in midlatitudes are generally in excess of

6 °C. That is, the average summer soil temperature is more than 6 °C higher than the average winter soil temperature in the upper m of the soil.

Since the temperatures of soils at high elevations tend to resemble those of soils at high latitudes, the discussion in this section is confined to soils having mean annual temperatures of 8 °C or higher. The cold soils at high elevations in the midlatitudes are discussed with the soils of high latitudes.

Effect of depth.—In a given soil, the closer to the surface, the greater the amplitude of fluctuation. Seasonal variations of soil temperature are greatest at the surface and decrease with increasing depth until, at a depth of 9 m or more, they disappear (diagram 18). The mean summer, winter, and annual soil temperatures (Chang, 1958b) are plotted in diagram 19 as a function of depth together with air temperatures for Ames, Iowa, which is in the midlatitudes. If we disregard the upper few cm, the changes in the mean seasonal soil temperature with increasing depth are nearly linear, so nearly so that one must conclude that the mean seasonal temperature of soil to any depth within the main zone of rooting is very closely approximated by the mean temperature at the midpoint in depth. The temperature gradient is positive in winter and negative in summer. It is approximately 0.5 °C per 10 cm. The gradients seem very similar in most midlatitude soils where records are available, even in undrained peats.

Effect of vegetative cover.—In the humid midlatitudes, the plant cover can have an important influence on seasonal fluctuations of soil temperature. The differences among kinds of plant cover, such as grass, crops, and trees, in shading or insulating the soil are minor if O horizons are transient or absent.

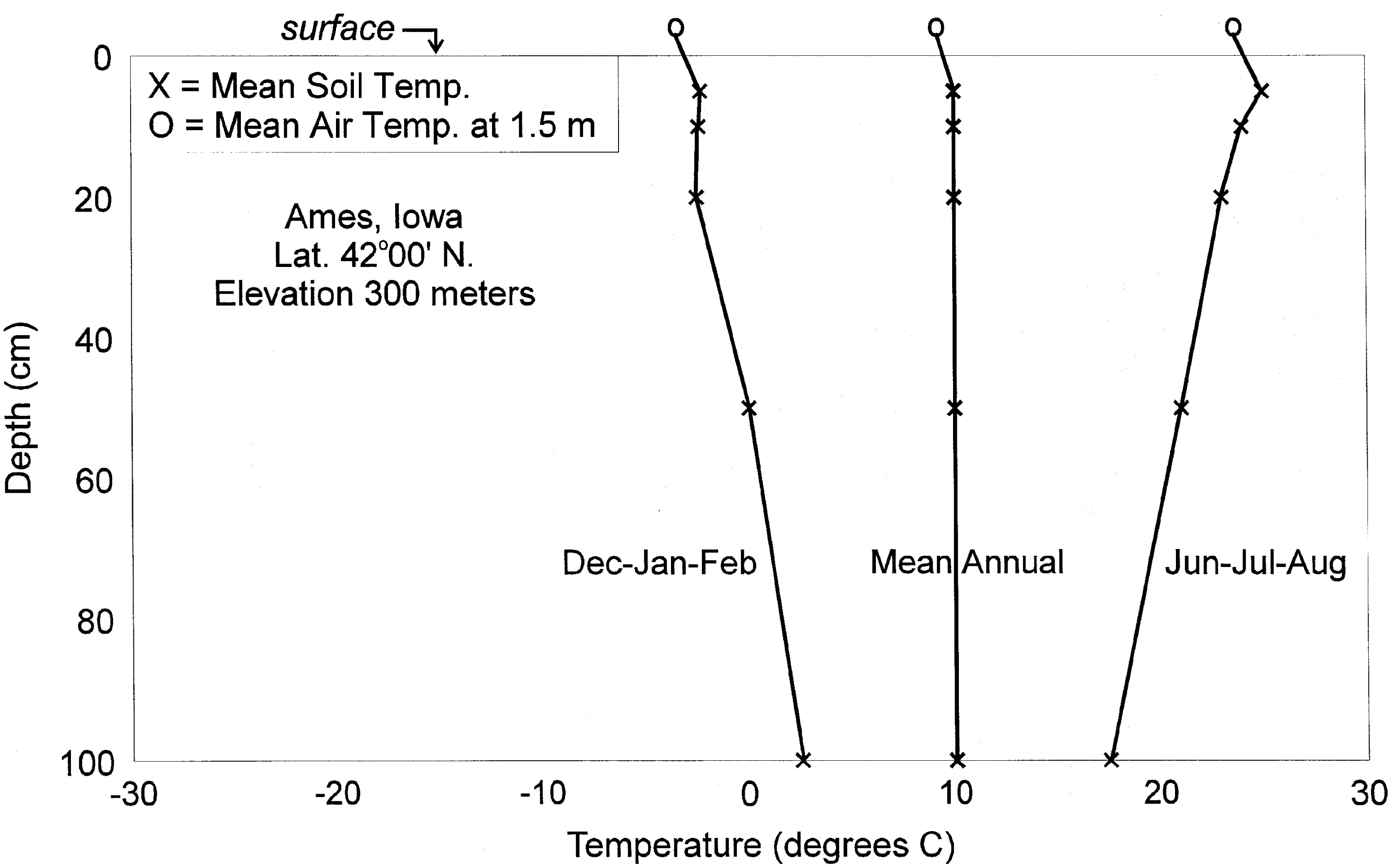


Diagram 19.—Soil temperature gradients with air temperatures for winter and summer in relation to mean annual temperatures at Ames, Iowa.

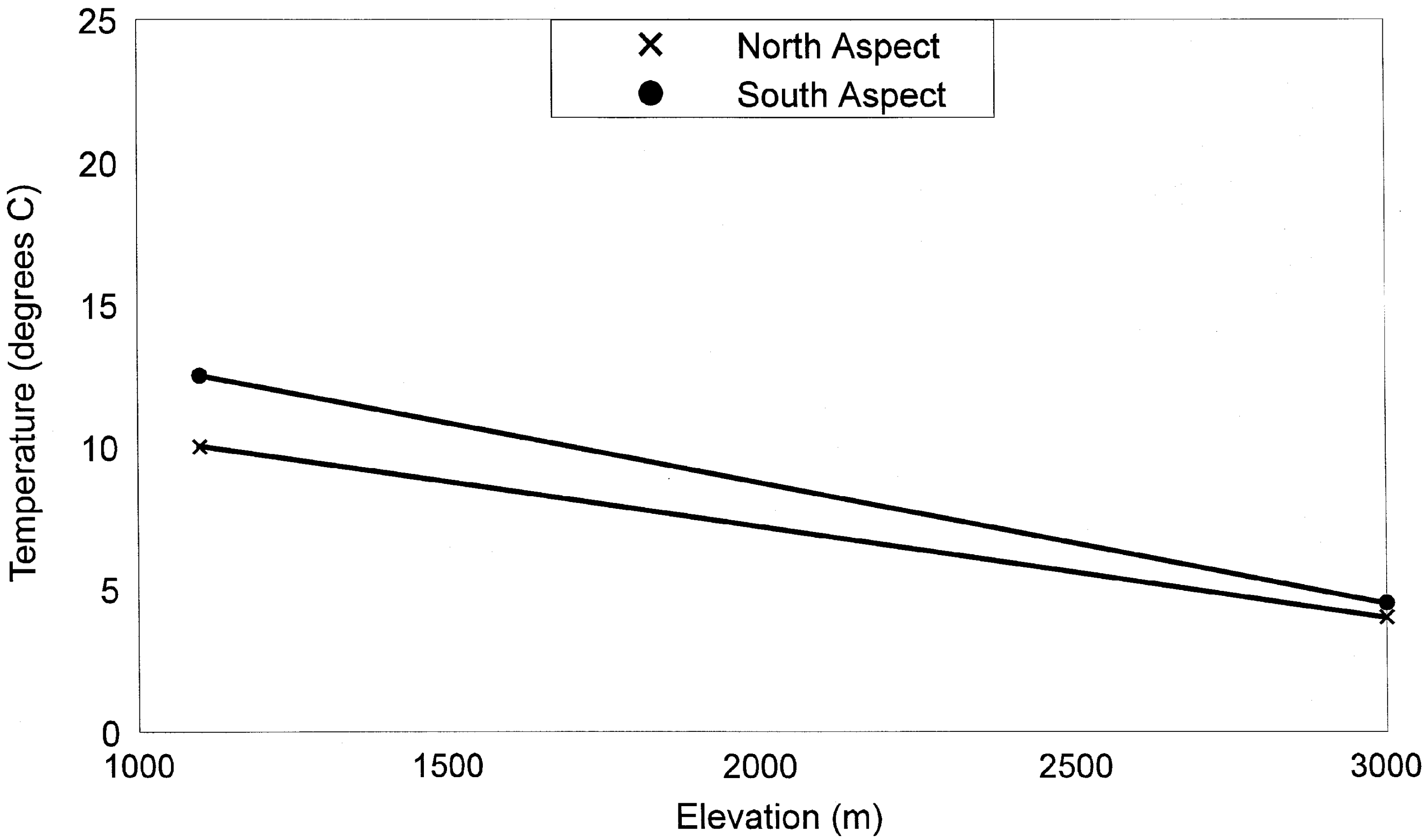


Diagram 20.—Relationship between soil temperature and elevation on south and north aspects.

Effect of irrigation.—Irrigation of dry soils can have a marked effect on the soil temperature in summer. Both evaporation and shade affect the temperature, but evaporation is probably the more important. The reduction may exceed 8 °C in places.

Effect of ground water.—Because of its large latent and specific heat, shallow ground water greatly affects seasonal fluctuations of soil temperature in midlatitudes. The principal effects occur during periods when the soil is freezing or thawing because the latent heat of the freezing of water is about 80 times the specific heat.

Effect of aspect and gradient of slope.—The aspect (direction) and gradient of slope may affect the deviation of the mean monthly soil temperatures from the annual mean. The effect in winter is large compared to that in summer. In the Northern Hemisphere, south-facing slopes have smaller seasonal fluctuations from the annual mean than north-facing slopes. The effects of aspect increase sharply in high latitudes. Diagram 20 shows the relationship between soil temperature and elevation on north and south aspects in the Great Basin of Nevada (Jensen et al., 1989).

Seasonal fluctuations in high latitudes.—Soils in high latitudes are cold, and the seasonal soil temperature fluctuations do not approximate a simple sine curve as do those in midlatitudes. Diagram 21 shows the mean monthly soil and air temperatures at Mustiala, Finland (Chang, 1958b). The air temperature follows a simple sine curve and is above the mean for only 5 months and below it for 7 months. The asymmetrical soil temperature fluctuations reflect the combined influence of snow as an insulator during winter and the relatively high insolation during summer months, when the sun is above the horizon all or most of the time

Diagram 22 shows the mean annual seasonal soil temperature at Mustiala, Finland, as a function of depth

(Chang, 1958b). The skewed seasonal fluctuations are indicated by the closeness of the lines that show winter temperature and mean annual temperature

In these latitudes, the soil temperature in summer is lower than the air temperature. The temperature gradients with increasing depth are similar to those in midlatitudes.

Effect of snow cover.—Diagram 23 shows the effect of snow cover on soil temperature at various depths (Molga, 1958). It indicates the difference in temperature between bare soil and soil covered with snow (snow-covered plot minus bare plot). From November through March, the snow-covered plot was warmer at all depths. The average temperature difference for the winter months, December through February, was 4 °C at a depth of 50 cm. In April, when the air temperature was rising and snow was melting, the bare soil warmed more rapidly and was warmer than the snow-covered plot to a depth of 40 cm.

The effect of snow on soil temperature is not limited to high latitudes and high altitudes. Snow cover is common but intermittent for the most part in midlatitudes where the mean annual soil temperature is less than 13 °C.

Effect of vegetative cover.—The cover of litter and of moss in areas of cold climates commonly is thicker than the cover in areas of warm climates. As the cover thickens, it reduces the amplitude of seasonal fluctuations of soil temperature because it insulates the soil during the entire year.

Diagram 24 shows the mean monthly soil temperatures for a cleared field versus a forested site at Delta Junction, Alaska (Shur et al., 1993). Without the shade from trees and insulation from litter and organic matter, the cleared field is colder in winter and warmer in summer.

Differences in the type of vegetation can result in variations in soil temperature. Diagram 25 illustrates differences between a climax spruce forest with a thick organic layer and a less insulated aspen forest in the Copper River area of Alaska (Moore and Ping, 1989).

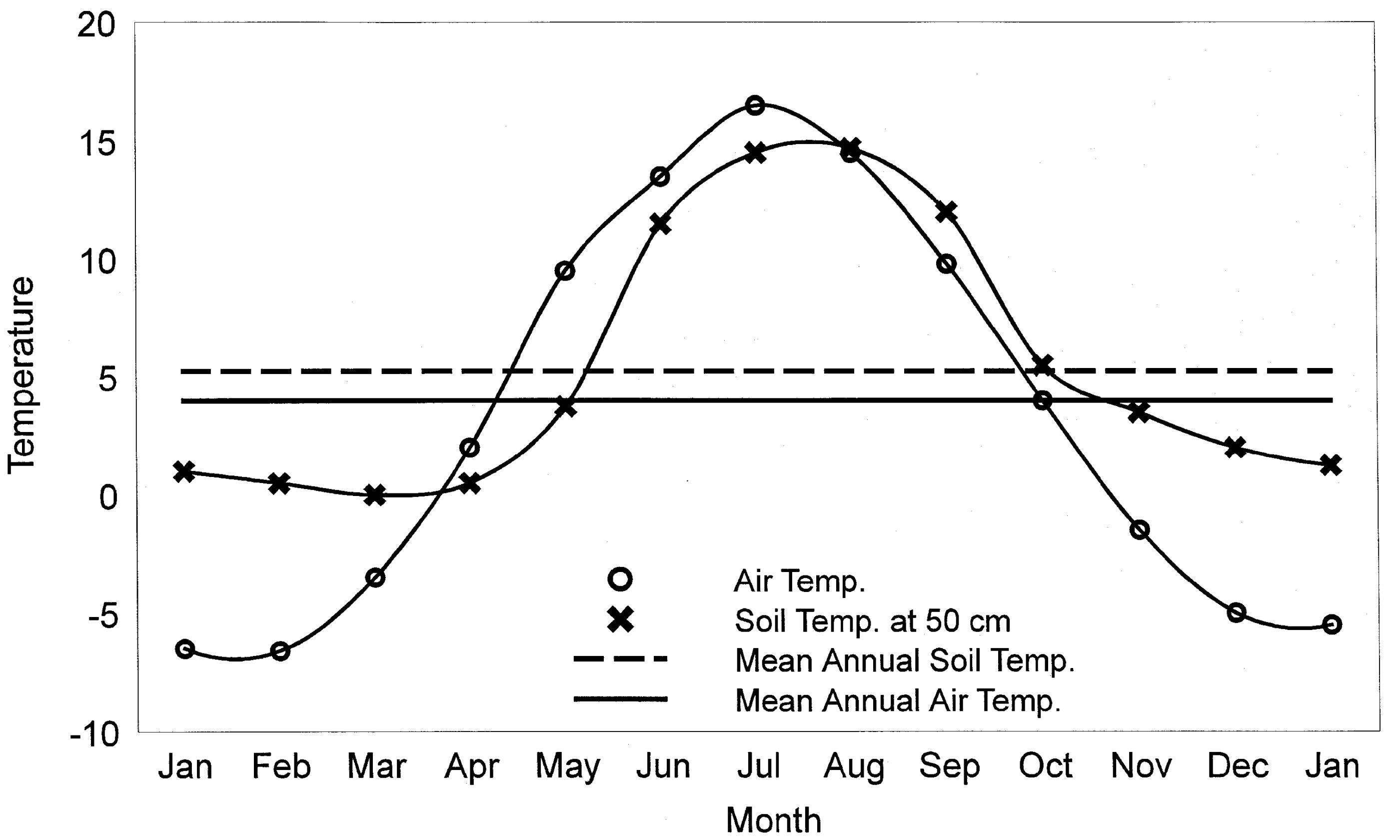


Diagram 21.—Mean monthly and annual soil and air temperatures at Mustiala, Finland.

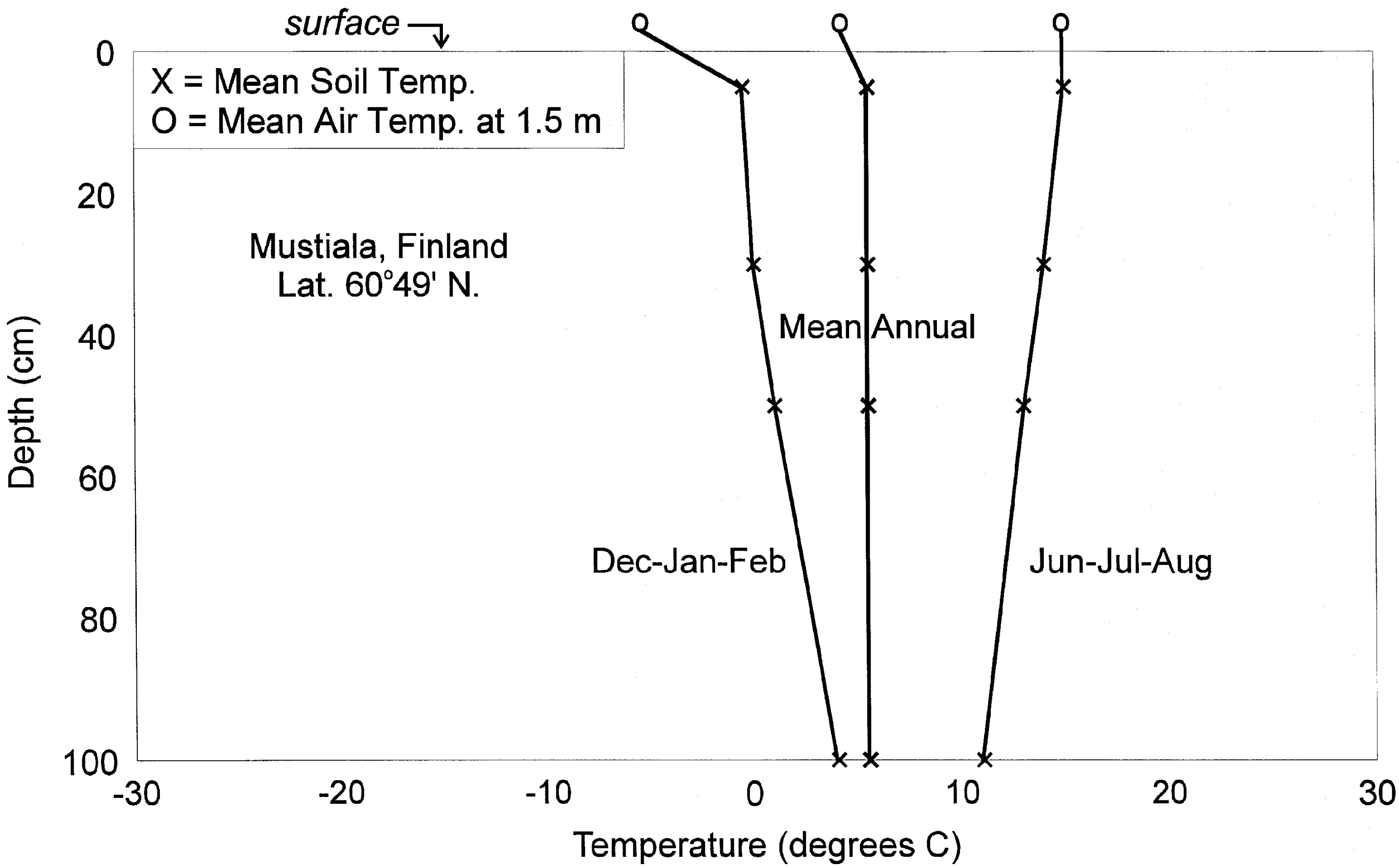


Diagram 22.—Soil temperature gradients with air temperatures for winter and summer in relation to mean annual temperatures at Mustiala, Finland.

Effect of ground water.—Because of its specific and latent heat, ground water reduces seasonal fluctuations of soil temperature. In diagram 26 the soil temperature at a depth of 50 cm is plotted for two soils at Flahult, Sweden (Chang, 1958b), where the mean annual soil temperature is about 6 °C. The soil in the wet bog was warmer in winter and cooler in summer than the sandy soil. The amplitude of fluctuations at a depth of 50 cm was 4 °C less in the wet bog than in the sandy soil.

Estimation of Soil Temperature

Soil temperature often can be estimated from climatological data with a precision that is adequate for the present needs of soil surveys. If we cannot make reasonably precise estimates, the measurement of soil temperature need not be a difficult or a time-consuming task.

Frequently, the mean annual soil temperature for much of the United States is estimated by adding 1 °C to the mean annual air temperature. The table "Mean Annual Soil Temperature (MAST) and Mean Annual Air Temperature (MAAT)" shows the mean annual soil temperature from various sites in the United States. It also shows the difference between the mean annual soil temperature and the mean annual air temperature at these sites. These data indicate that for some areas in the United States the mean annual soil temperature should be estimated by adding 2 or even 3 °C (rather than 1 °C) to the mean annual air temperature.

The mean summer soil temperature at a specific depth also can be estimated. To make this estimate, we can take the average summer temperatures of the upper 100 cm and correct for the temperature-depth gradient by adding or subtracting 0.6 °C for each 10 cm above or below a depth of 50 cm. The mean winter temperature of many midlatitude soils can be estimated from the difference between the mean annual temperatures and the mean summer temperatures because the differences are of the same magnitude but have opposite signs.

The cooling wave at Belgrade extends to a depth of 12 m, and at this depth the minimum temperature is reached about 10 months later than at a depth of 1 m (diagram 18). The amplitude of variation at a depth of 12 m is less than 0.1 °C. Thus, the mean annual temperature of a soil in midlatitudes can be determined at any time by a single reading at a depth of 13 m. A single reading at a depth of 10 m is within 0.1 °C of the mean annual soil temperature. A single reading at a depth of 6 m is within 1 °C of the mean annual temperature.

The mean annual temperature of soils underlain by deep regolith can therefore be very closely approximated at any season by measurement in a deep auger boring. In some areas an even simpler method of determining the mean annual soil temperature can be used. Dug wells generally range from 6 to 18 m in depth. If the water table stands between 9 and 18 m and water is drawn from the well frequently, the temperature of water in the well, which is in equilibrium with the soil temperature, gives the mean annual soil temperature within a margin of error of less than 1 °C. The well must be in use, so that water is moving into it from the ground. Unfortunately, this method is suited only to humid regions where ground water is shallow and is not frozen. Extensive records of well-water temperature have shown that the water temperature between depths of 9 and 18 m is essentially constant throughout the year.

If the soil is shallow and there are no wells, the mean annual soil temperature can be measured over the four seasons only by taking several readings at regular intervals of time. If the soil is expected to be frozen deeply at the time of one or

Mean Annual Soil Temperature (MAST) and Mean Annual Air Temperature (MAAT)

Site name	MAST (50 cm)	MAST minus MAAT
	°C	*°C*
Adams Ranch, New Mexico	14.67	2.94
Crescent City, Minnesota	7.30	1.39
Ellicott City, Maryland	12.23	1.14
Geneva, New York	9.60	1.20
Lind, Washington	11.12	1.70
Mandan, North Dakota	7.13	2.84
Molly Caren, Ohio	11.72	2.19
Nunn, Colorado	10.43	2.89
Prairie View, Texas	21.17	1.79
Rogers Farm, Nebraska	11.25	1.84
Tidewater, North Carolina	16.29	.72
Torrington, Wyoming	9.96	2.40
Wabeno, Wisconsin	6.14	2.10
Watkinsville, Georgia	17.20	2.14

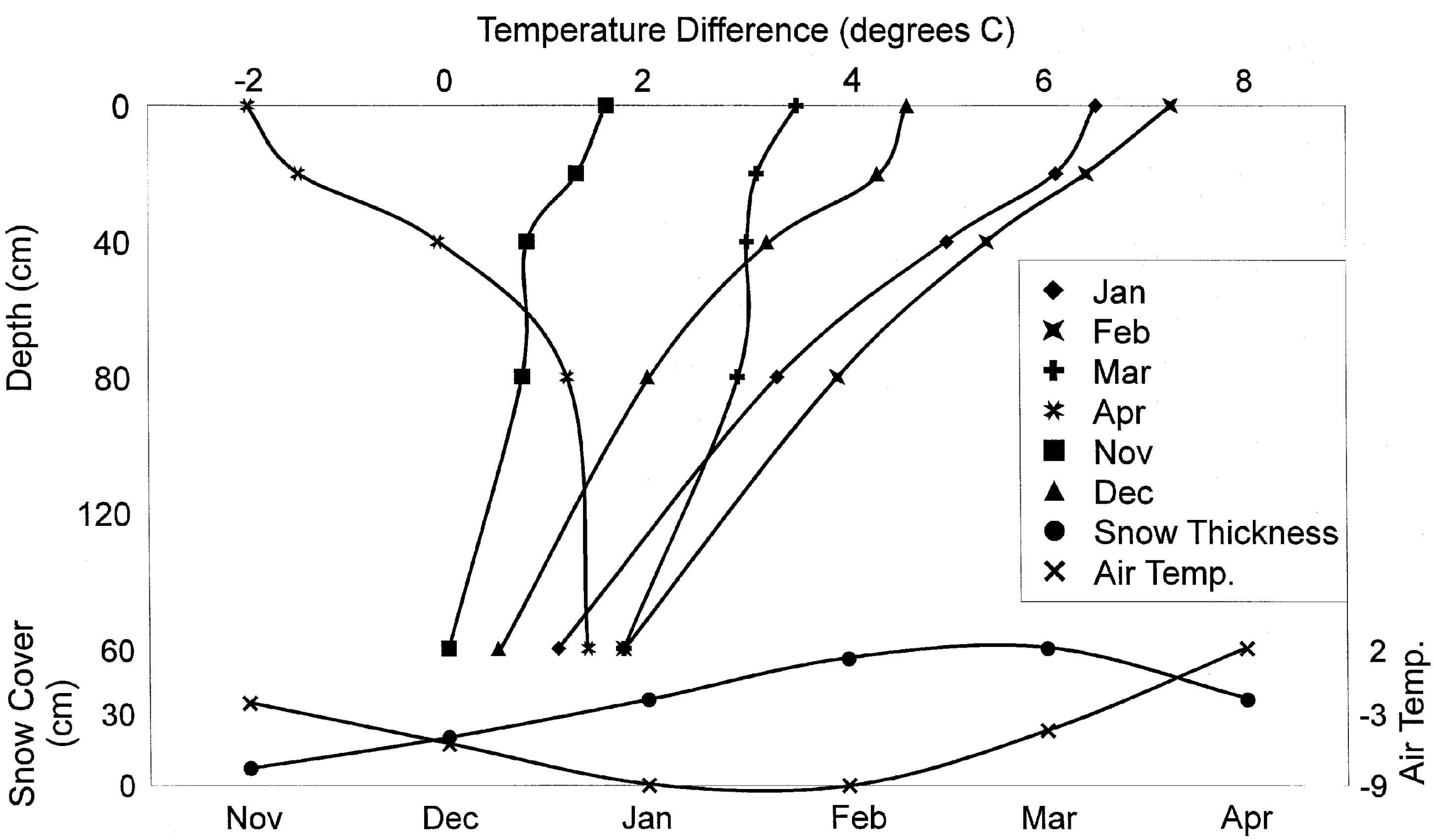


Diagram 23.—Monthly soil temperature differences between bare and snow-covered plots at Leningrad, U.S.S.R. (now St. Petersburg, Russia), and mean monthly air temperature and snow thickness.

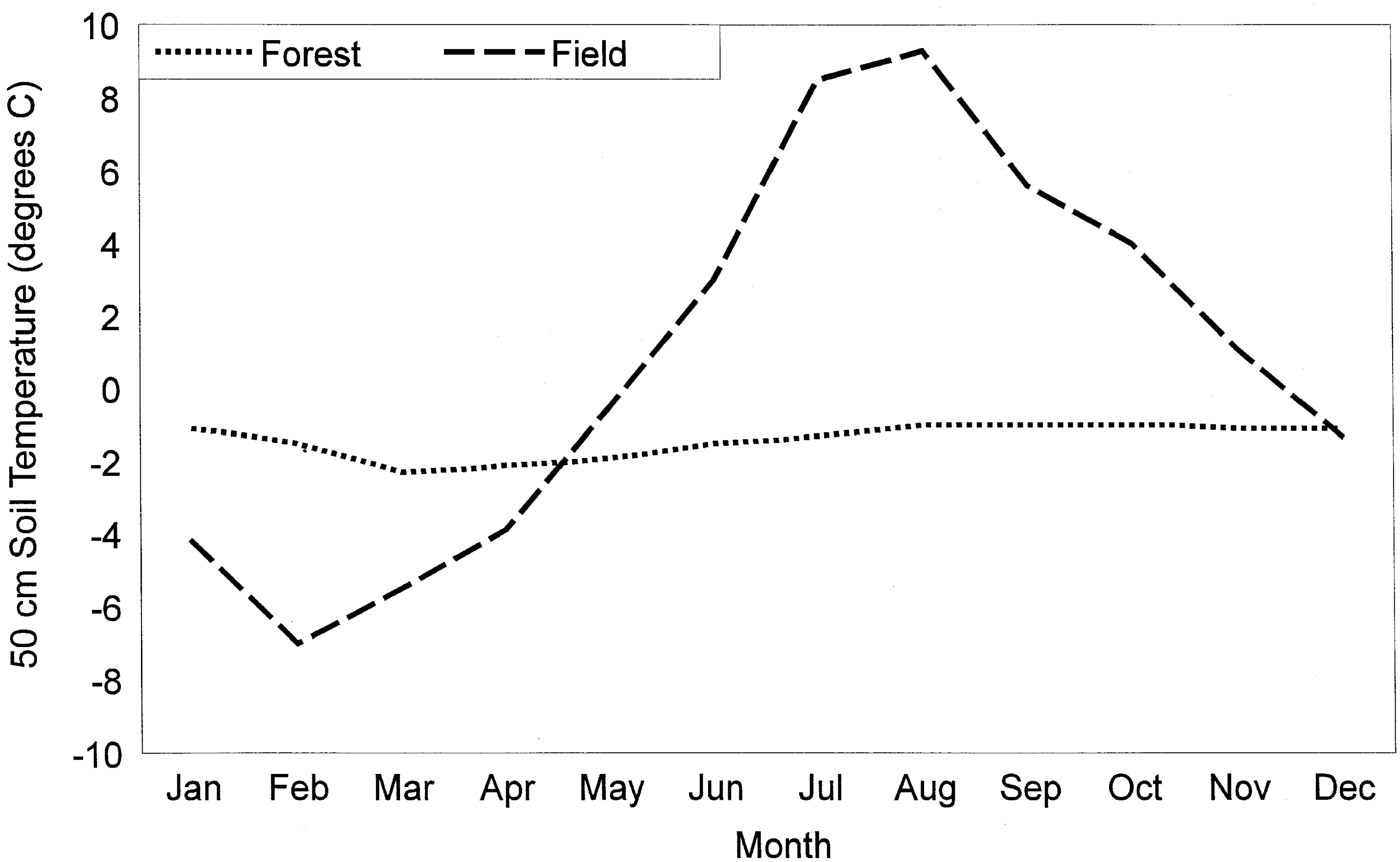


Diagram 24.—Mean monthly soil temperatures measured at 50 cm below the mineral soil surface during 1992 near Delta Junction, Alaska, United States.

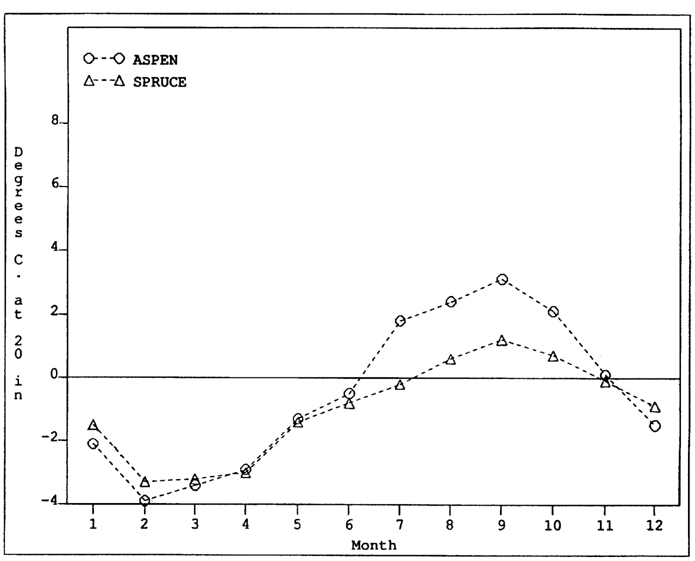


Diagram 25.—Relationship of mean annual soil temperature (MAST) and vegetative cover for the Copper River series. Sites are in close proximity on the same landform. The spruce site is in a late seral stage. The aspen site is in an early seral stage because of wildfire.

more readings, a special thermometer or a thermocouple can be buried. If the temperature of a soil is measured at a depth below the influence of the daily cycle of fluctuations, such as a depth of 50 cm, four readings equally spaced throughout the year give a very close approximation of the mean annual temperature. For example, the average of readings taken at a depth of 50 cm at Vauxhall, Alberta, on January 1, April 1, July 1, and October 1, 1962, differs from the average of two readings each day of the year by only 0.3 °C. Greater precision can be achieved by increasing either the number or the depth of the readings. The mean annual soil temperature computed for any one year will be close to the long-term mean annual temperature, that is, the normal temperature. At Ames, Iowa, for example, the standard deviation of the yearly mean for a 13-year record at a depth of 50 cm is only 0.6 °C.

Seasonal temperatures bear an almost linear relation to depth within the limits of depth that usually concern soil scientists. By selecting a suitable depth and measuring the temperature on the 15th of June, July, and August, we can derive the average soil temperature for the 3-month summer period. The margin of error will be small only if measurements are made at a depth below the daily temperature fluctuations, that is, at a depth of 50 cm or more. Measurements made at a depth of 50 cm give the average temperature in the upper m of the soil. A test of this method at Vauxhall, Alberta, shows that the average of three measurements taken at a depth of 50 cm on June 15, July 15, and August 15, 1962, is within 0.6 °C of the mean summer temperature computed from daily readings.

Greater precision can be achieved mainly by increasing the number of readings. Readings of soil temperature at depths as shallow as 50 cm should be deferred for at least 48 hours after a heavy rain.

Classes of Soil Temperature Regimes

Following is a description of the soil temperature regimes used in defining classes at various categoric levels in this taxonomy.

Cryic (Gr. *kryos*, coldness; meaning very cold soils).—Soils in this temperature regime have a mean annual temperature lower than 8 °C but do not have permafrost.

1. In mineral soils the mean summer soil temperature (June, July, and August in the Northern Hemisphere and December, January, and February in the Southern Hemisphere) either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower, is as follows:

a. If the soil is not saturated with water during some part of the summer and

(1) If there is no O horizon: lower than 15 °C; *or*

(2) If there is an O horizon: lower than 8 °C; *or*

b. If the soil is saturated with water during some part of the summer and

(1) If there is no O horizon: lower than 13 °C; *or*

(2) If there is an O horizon or a histic epipedon: lower than 6 °C.

2. In organic soils the mean annual soil temperature is lower than 6 °C.

Cryic soils that have an aquic moisture regime commonly are churned by frost.

Isofrigid soils could also have a cryic temperature regime. A few with organic materials in the upper part are exceptions.

The concepts of the soil temperature regimes described

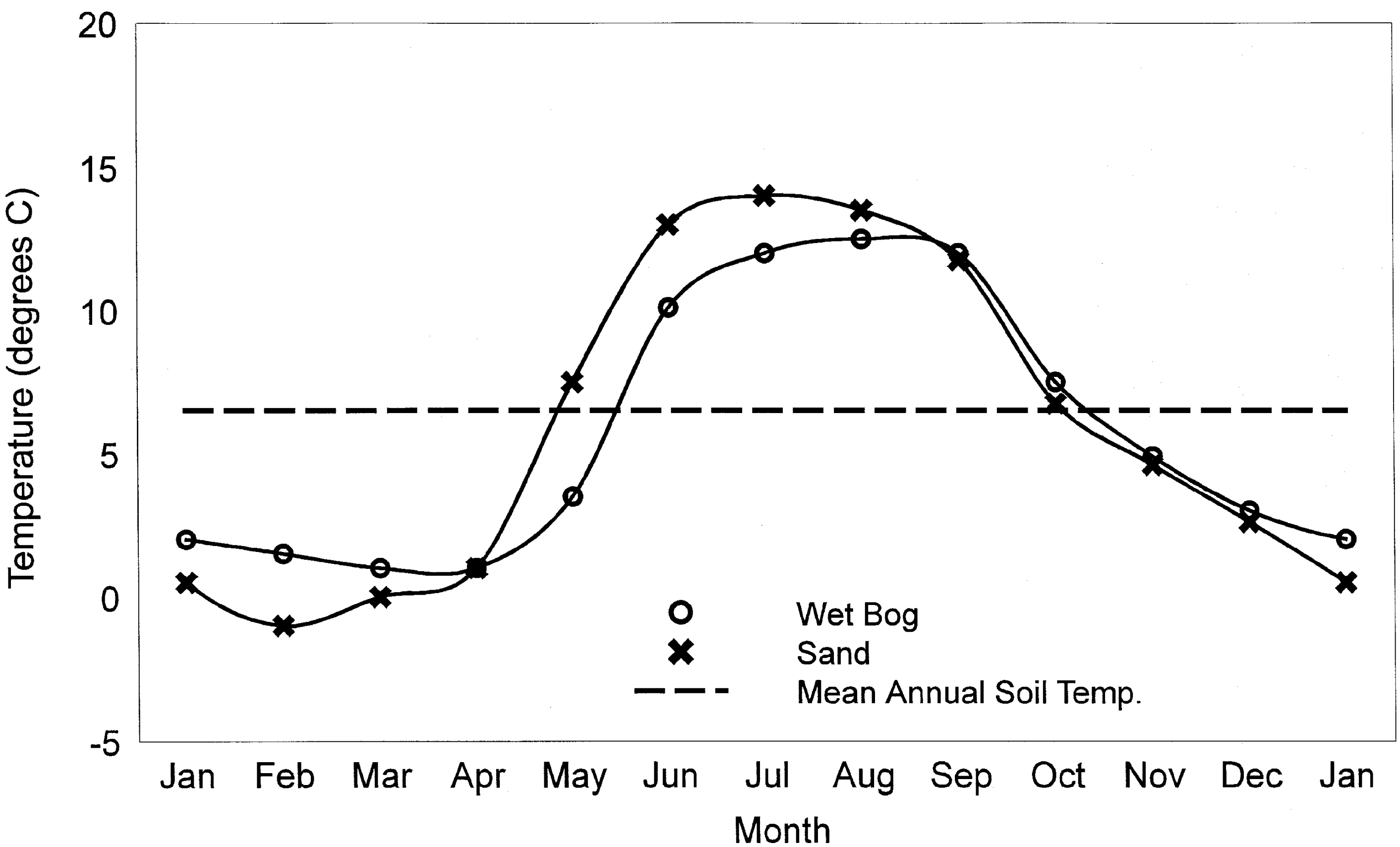


Diagram 26.—Mean monthly and mean annual soil temperatures in a soil in a wet bog and in a sandy soil at Flahult, Sweden.

below are used in defining classes of soils in the low categories.

Frigid.—A soil with a frigid temperature regime is warmer in summer than a soil with a cryic regime, but its mean annual temperature is lower than 8 °C and the difference between mean summer (June, July, and August) and mean winter (December, January, and February) soil temperatures is more than 6 °C either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Mesic.—The mean annual soil temperature is 8 °C or higher but lower than 15 °C, and the difference between mean summer and mean winter soil temperatures is more than 6 °C either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Thermic.—The mean annual soil temperature is 15 °C or higher but lower than 22 °C, and the difference between mean summer and mean winter soil temperatures is more than 6 °C either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

Hyperthermic.—The mean annual soil temperature is 22 °C or higher, and the difference between mean summer and mean winter soil temperatures is more than 6 °C either at a depth of 50 cm from the soil surface or at a densic, lithic, or paralithic contact, whichever is shallower.

If the name of a soil temperature regime has the prefix *iso*, the mean summer and mean winter soil temperatures differ by less than 6 °C at a depth of 50 cm or at a densic, lithic, or paralithic contact, whichever is shallower.

Isofrigid.—The mean annual soil temperature is lower than 8 °C.

Isomesic.—The mean annual soil temperature is 8 °C or higher but lower than 15 °C.

Isothermic.—The mean annual soil temperature is 15 °C or higher but lower than 22 °C.

Isohyperthermic.—The mean annual soil temperature is 22 °C or higher.

Sulfidic Materials

Sulfidic materials contain oxidizable sulfur compounds. They are mineral or organic soil materials that have a pH value of more than 3.5 and that, if incubated as a layer 1 cm thick under moist aerobic conditions (field capacity) at room temperature, show a drop in pH of 0.5 or more units to a pH value of 4.0 or less (1:1 by weight in water or in a minimum of water to permit measurement) within 8 weeks.

Sulfidic materials accumulate as a soil or sediment that is permanently saturated, generally with brackish water. The sulfates in the water are biologically reduced to sulfides as the materials accumulate. Sulfidic materials most commonly accumulate in coastal marshes near the mouth of rivers that carry noncalcareous sediments, but they may occur in freshwater marshes if there is sulfur in the water. Upland sulfidic materials may have accumulated in a similar manner in the geologic past.

If a soil containing sulfidic materials is drained or if sulfidic materials are otherwise exposed to aerobic conditions, the sulfides oxidize and form sulfuric acid. The pH value, which normally is near neutrality before drainage or exposure, may drop below 3. The acid may induce the formation of iron and aluminum sulfates. The iron sulfate, jarosite, may segregate, forming the yellow redoximorphic concentrations that commonly characterize a sulfuric horizon. The transition from sulfidic materials to a sulfuric horizon normally requires very few years and may occur within a few weeks. A sample of sulfidic materials, if air-dried slowly in shade for about 2 months with occasional remoistening, becomes extremely acid.

Sulfuric Horizon

Brackish water sediments frequently contain pyrite (rarely marcasite), which is an iron sulfide. Pyrite forms from the microbial decomposition of organic matter. Sulfur released from the organic matter combines with the iron to crystallize FeS. Characteristically, the pyrite crystals occur as nests or framboids composed of bipyramidal crystals of pyrite. In an oxidizing environment, pyrite oxidizes and the products of oxidation are jarosite and sulfuric acid. The jarosite may undergo slow hydrolysis, leading to further production of sulfuric acid. Iron is precipitated as a reddish ochre precipitate, commonly ferrihydrite, which later may crystallize as maghemite, goethite, and even hematite. If free aluminum is present, alunite may crystallize in addition to jarosite. The jarosite has a straw-yellow color and frequently lines pores in the soil. Jarosite concentrations are among the indicators of a sulfuric horizon.

In some soils, the hydrolysis of jarosite is rapid and the yellow redoximorphic concentrations may not be evident, even though the soils are extremely acid (pH less than 3.5) or the soil solution is high in soluble sulfur. The low pH and high amount of soluble sulfur are indicators of a sulfuric horizon. A soil can develop low pH values, however, from highly acidic materials from other sources. Therefore, low pH and sulfuric materials in the underlying layers also are indicators of a sulfuric horizon. A quick test of sulfidic materials is a rapid fall in pH on drying or after treatment with an oxidizing agent, such as hydrogen peroxide.

A sulfuric horizon forms as a result of drainage (most commonly artificial drainage) and oxidation of sulfide-rich or organic soil materials. It can form in areas where sulfidic materials have been exposed as a result of surface mining, dredging, or other earth-moving operations. A sulfuric horizon is detrimental to most plants.

Required Characteristics

The sulfuric (L. *sulfur*) horizon is 15 cm or more thick and is composed of either mineral or organic soil material that has a pH value of 3.5 or less (1:1 by weight in water or in a minimum of water to permit measurement) and shows evidence that the low pH value is caused by sulfuric acid. The evidence is *one or more* of the following:

1. Jarosite concentrations; *or*

2. Directly underlying sulfidic materials (defined above); *or*

3. 0.05 percent or more water-soluble sulfate.

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CHAPTER 5

Application of Soil Taxonomy to Soil Surveys

The fundamental purposes of a soil survey are to show the geographic distribution of soils and to make predictions about the soils (USDA, SCS, 1951 and 1993). To this end, a soil survey includes soil maps, map unit descriptions, soil series descriptions, taxonomic classifications, and interpretations for the use and management of the soils.

Soil surveys are made at several intensities and for many uses. The procedures, standards, and uses are described in the most recent revision of the *Soil Survey Manual* (USDA, SCS, 1993) and the most recent version of the National Soil Survey Handbook (USDA, NRCS, 1997). The applications of soil survey are numerous. They include interpretations for the growth of plants, such as crops, forage species, trees, and ornamental shrubs. They also include interpretations for urban, rural, and recreational development and for conservation and wildlife habitat planning.

Soil mapping and classification have evolved, and the conceptual framework for mapping and classifying soils has changed and will continue to change. Over the years soil science literature has documented numerous concepts and approaches to mapping, classifying, and interpreting soils at various scales. The purpose of this chapter is not to present the numerous concepts and approaches but to outline the application of widely used and accepted soil-landscape models and taxonomic models for mapping and labeling soil geographic order in soil surveys at scales of 1:12,000 to 1:100,000 and in soil surveys at scales smaller than 1:100,000.

Mapping and Labeling Soil Geographic Order at Large (1:12,000 to 1:31,680) and Intermediate (1:31,680 to 1:100,000) Scales

Mapping Soil Geographic Order

A landscape is a portion of the land surface that the eye can comprehend in a single view and is a collection of landforms (Ruhe, 1969). Understanding landscapes and landforms and their influence on soil distribution is critical in observing and mapping soil geographic order (Peterson, 1981; Ruhe, 1969). The tasks of a soil scientist who sets out to map soils and produce a soil survey are to perceive a meaningful soil geographic pattern at the landscape, landform, and landform component levels and to record that pattern in a form that can be retained and conveyed to others. The most common scales for a large-scale soil map range from 1:12,000 to 1:31,680 (USDA, SCS, 1993). With intensive field investigation of areas mapped within this scale range, soil geographic variation can be readily observed and recorded cartographically at the landscape, landform, and landform component levels. The minimum-size delineation is commonly between 0.6 and 4 ha (USDA, SCS, 1993).

Intermediate-scale soil maps range from 1:31,680 to 1:100,000 and are commonly associated with lower intensity field soil surveys (USDA, SCS, 1993). At this map scale and with the lower intensity of field investigation, soil geographic variation can be observed and recorded cartographically at the multiple landscape, landscape, or landform level. The minimum-size delineation for intermediate soil maps is commonly between 4 and 250 ha (USDA, SCS, 1993).

In mapping soils at any scale, it is necessary to assume that there is a pattern of order in the spatial distribution of soil characteristics. The soil genesis model, which defines soil as a function of parent material, climate, living organisms, relief, and time, provides a basis for predicting order. A soil surveyor quickly learns that the geographic distribution of soils is related to the five soil-forming factors. A soil surveyor observes and maps a geographic pattern of soils by grouping soils with similar genesis and by separating soils where there is a change in one or more of the soil-forming factors. Hudson (1990 and 1992) outlined the application of the catena concept (Milne, 1936) and the soil factor equation (Jenny, 1941) to soil survey as a general model of perceiving and mapping soil geographic order. Hudson (1992) has also summarized the soil-landscape paradigm that has guided field soil surveys in the United States for almost a century.

The Soil-Landscape Paradigm and Soil Survey

Soils are landscapes as well as profiles (USDA, SCS, 1951, pp. 5-8; USDA, SCS, 1993, pp. 9-11). In soil survey, a soil-landscape unit can be thought of as a landscape unit (landscape, landform, or landform component) further modified by one or more of the soil-forming factors. Within a soil-landscape unit, the five factors of soil formation interact in a distinctive manner. As a result, areas of a soil-landscape unit have a relatively homogeneous soil pattern. A soil surveyor perceives soil patterns by first conceptually dividing the landscape into soil-landscape units. The boundaries between dissimilar soil-landscape units are placed where one or more of the soil-forming factors change within a short lateral distance. The more rapid the change between one or more of the soil-forming factors, the more abrupt the boundary between the soil-landscape units and the easier it is for one to locate the boundary. The slower the change between one or more of the soil-forming factors, the more gradual the boundary between the soil-landscape units and the more difficult it is for one to locate the boundary. Generally, the closer the similarities between two landscape units, the more gradual the change between the landscape units and the more similar their associated soils tend to be. Conversely, very dissimilar landscape units tend to have abrupt boundaries between them and have very dissimilar soils.

Identifying soil-landscape units provides the basis for recognizing soils and then designing soil map units, which are the basic units for identifying soil geographic order in a soil survey. Soil-landscape units can be combined to form map units that encompass broader ranges of soils, or subdividing the soil-landscape units can identify the soils and soil distribution within a map unit in greater detail. The degree to which soil-landscape units are combined or subdivided to form soil map units is primarily a function of the complexity of the soil-landscape units, the detail required for the intended use of the soil survey, and the ability of the soil scientist to consistently identify the soils and map units through application of the available knowledge and tools and within the constraints of cost and time.

Labeling Soil Geographic Order With Soil Taxonomy

A soil delineation (soil map unit delineation) is an individual polygon identified on a soil map by a map unit symbol and/or name that defines a three-dimensional soil body of a specified area, shape, and location on the landscape (Soil Science Society of America, 1997). A map unit is an aggregate of all soil delineations in a soil survey area that have a defined set of similar soil characteristics (Van Wambeke and Forbes, 1986).

Once soil-landscape units and soil map units have been delineated, some means of labeling and representing the kinds of soil that occur in the map units is needed. The classification system described in *Soil Taxonomy* (USDA, SCS, 1975) has been used for many years in identifying and labeling soils that occur within soil-landscape units and soil map units. Following is a description of the application of the taxonomic system to soil survey.

A class is a group of individuals or other units similar in selected properties and distinguished from all other classes of the same population by differences in these properties. Taxon (*pl.* taxa) is a name used in classifications for a single class. It may be broadly or narrowly defined according to the category. A soil order is a taxon, as is a soil series, a family, or a great group (Smith, 1963). The taxa of this soil classification are conceptual and are defined as precisely as our present knowledge permits. They give us common standards for soil correlation, which includes the mapping, naming, and interpretation of soils. In practice, soil scientists map soil-landscape units. Properties of these soil-landscape units correspond to the concepts of the taxa. Relating the soil bodies (soil-landscape units or soil delineations) represented on maps to taxonomic classes at some level in a classification system is accomplished through soil correlation (Simonson, 1963).

In large- and intermediate-scale soil surveys, if the concept of a named series or other taxon corresponds to the properties of the soil expected in a soil-landscape unit or soil map unit, we normally use the name of that series or taxon to help identify the soil properties of the delineation. If there is no named series or taxon available and we believe that such a series or other taxon would be useful, we define and establish a new series or other taxon. Also, for the practical purposes of a soil survey, another classification is superimposed on the series or taxa to identify significant differences in slope, erosion, stoniness, or other characteristics. The assignment of taxonomic names, such as the name of a soil series, to label a map unit means that if we examine the soil-landscape unit or soil map unit, we expect most locations within the delineation to meet the criteria of the taxon or taxa (Holmgren, 1988). The designing, naming, and describing of soil map units, which are covered elsewhere (USDA, SCS, 1993; USDA, NRCS, 1997; Van Wambeke and Forbes, 1986), are all critical elements in the understanding of soil geographic patterns.

Soil Geographic Order and Soil Taxonomy in Soil Survey

It is commonly acknowledged that there is a disparity between the entity that soil surveyors map and the entity that they classify. Soil surveyors map soil bodies (soil-landscape units and soil map units). Soil taxonomy, however, effectively utilizes properties from samples taken within the soil-landscape units and soil map units to establish taxon boundaries and classify soils (Holmgren, 1988). Time and the fiscal constraints of a soil survey necessitate minimizing the number of samples taken. In the past, this disparity between sampling units and mapping units and the need for minimizing the sampling effort was rationalized with the pedon and polypedon. The pedon served as the sampling unit and was defined as a three-dimensional soil volume with an area of 1 to 10 m^2 and a depth that includes the entire solum (USDA, SCS, 1975). The polypedon was defined as a set of contiguous pedons (USDA, SCS, 1975). It was intended to be used to establish series level taxa and the map units delineated in the soil survey.

Applying the pedon and polypedon concepts to mapping and classification has been the subject of debate and a source of misunderstanding in soil survey for decades (Hudson, 1990 and 1992; Holmgren, 1988). Some notable problems are that in reality soil profiles rather than pedons (i.e., three-dimensional volumes) are really sampled and classified (Holmgren, 1988), that soil property variation prohibits the selection of one profile or a few profiles to represent variation within delineated soil bodies (Hudson, 1990), and that soil-landscape units and soil map units are composed of more than one polypedon (as defined by USDA, SCS, 1975) and contain soils with properties outside the ranges of established taxa. Application of the soil-landscape paradigm (Hudson, 1990 and 1992), however, can identify soil-landscape boundaries and soil map unit boundaries, and then, through careful selection of soil profiles that best represent soil conditions within soil-landscape and soil map unit delineations, the soil map units can be labeled and described and useful soil surveys can be produced.

Large- and intermediate-scale soil surveys can be used to provide general information about soil properties within each soil-landscape unit and soil map unit. These soil surveys, however, cannot be used in predicting exact soil properties at any particular location with statistical confidence, and soil properties may exceed the ranges defined for the taxa used to represent soil-landscape units and soil map units.

Recognizing Established Series and Establishing New Series in a Soil Survey Area at Scales of 1:12,000 to 1:100,000

The standards for establishing series, recognizing established series, and naming the map units within a soil survey area have changed in the past and can be expected to change in the future. The current standards are presented elsewhere (USDA, SCS, 1993; USDA, NRCS, 1997; Van Wambeke and Forbes, 1986), and the results of the various international classification committees are readily available. The factors that should be considered when recognizing established soil series, establishing new soil series, and naming the map units within a soil survey area are described in the following paragraphs.

The soil series is the basic taxonomic class in soil survey areas mapped at large and intermediate scales. As a taxonomic class, a series is a group of soils that have horizons similar in arrangement and in differentiating characteristics (USDA, SCS, 1993). When recognizing established series and establishing new series in the field, we must consider the scale and the degree of accuracy and precision at which we observe and plot boundaries between soil-landscape units and soil map units. We must also consider the ability of soil scientists to consistently observe, determine, and record soil similarities and differences in the field; the purpose of the soil survey; the nature of the variability of the soils within a delineation; the importance of the variations to planning; and the probable uses of the soils. An example of the application of series differentiae is given in chapter 21 of this publication.

The representation of soil distribution on a map is imperfect to varying degrees. In the field, at large and intermediate scales, soil scientists observe the boundaries between soil-landscape units and soil map units and then record the boundaries on an aerial photo or an appropriate map base. Inevitably, there are errors in the observation and placement of these lines, in the sampling and identification of soils at the boundaries, and in the sampling and identification of soils within the boundaries of soil-landscape units and soil map units.

Because series have narrow ranges in their properties, most soils within a soil-landscape unit or soil map unit can be sampled and identified with reasonable accuracy, even though the locations of some of the boundaries may be obscure or difficult to place. There commonly are areas in which a soil in a delineation does not fit an established series. In this case the range in characteristics of the existing series could be expanded, a new series could be established, or the soil could be handled as a taxadjunct (USDA, SCS, 1993; Van Wambeke and Forbes, 1986). There are also cases in which soils within a soil-landscape unit or soil map unit occur as areas too small or too intermingled to be delineated at the selected scale or in which differences between soils are subtle and cannot be consistently observed and mapped in the field. These cases can be handled within the definitions of kinds of soil map units, which include consociations, complexes, associations, and undifferentiated groups, and in the map unit descriptions (USDA, SCS, 1993; Van Wambeke and Forbes, 1986).

Labeling Soil Maps at Scales Smaller Than 1:100,000

As map scales become smaller, the degree of detail and precision of the soil map decreases. This decrease is reflected in the naming of map units and in the map unit descriptions. Small-scale or general soil maps of individual survey areas in published soil surveys in the United States commonly have scales that range from about 1:100,000 to 1:250,000. The map units delineated on these maps have been named as associations of series. These generalized maps usually are made by combining the delineations of detailed soil survey maps to form broader map units (USDA, SCS, 1993). These broader map units group similar map unit delineations and are commonly named for the two or three most dominant soil series or taxa. The map unit descriptions for these smaller scale maps should reflect the greater degree of map generalization.

State and regional soil maps commonly are produced at scales of 1:250,000 to 1:1,000,000. State and regional general soil maps can be produced by further generalizing county soil maps. These state and regional maps are typically at scales of about 1:500,000, and the map units delineated on these maps are associations of the dominant soil series or taxa on the county general soil maps.

Schematic soil maps commonly are at a scale of 1:1,000,000 or smaller (USDA, SCS, 1993). These maps can be compiled from information on more detailed soil maps, county and state general soil maps, and regional soil maps. Other sources of soil geographic information can also be used where little or no soil mapping information is available. At these small scales, map units commonly are associations or consociations of taxa at the higher categories, such as Oxisols, Udalfs, and Epiaquepts.

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CHAPTER 6
The Categories of Soil Taxonomy

A category of soil taxonomy is a set of classes that is defined approximately at the same level of generalization or abstraction and that includes all soils. There are six categories in soil taxonomy. In order of decreasing rank and increasing number of differentiae and classes, the categories are order, suborder, great group, subgroup, family, and series.

In one sense, soil taxonomy is a sorting process. In the highest category, one sorts all kinds of soil into a small number of classes. The number of classes is small enough for one to comprehend and remember them and to understand the distinctions among them. The sorting must make distinctions that are meaningful for our purposes. When all soils are sorted into a very few classes, such as the 12 orders, each order is very heterogeneous with respect to properties that are not considered in the sorting and that are not accessory to the properties that are considered. For some purposes, however, the order level may provide sufficient information. As one continues to classify a soil at lower and lower levels of soil taxonomy, more information is conveyed about the soil. This method of conveying information is one of the advantages of a multicategoric classification system.

Reducing the heterogeneity requires another sorting in the next lower category, the suborder. Again, the sorting must be meaningful, but the sorting in one order may have little meaning in another order. In soil taxonomy there are 64 suborders, a number larger than can be remembered conveniently along with all the properties of the suborders. If we focus on the suborders of a single order, however, we have, at the most, seven suborders to understand and remember. Each of the suborders in an order has the properties common to the order plus the properties used for sorting into that suborder. In each of the 64 suborders, there is still great heterogeneity, so we must sort again to obtain, at the next lower level, a set of meaningful great groups. There are more than 300 great groups, more than one can remember. One need focus, however, on only one suborder at a time.

The sorting process continues in the remaining categories down to the soil series. The soils in any one series are nearly homogeneous in that their range of properties is small and can be readily understood. Collectively, the thousands of soil series are far beyond our powers of comprehension, but they can be sorted category by category, and one seldom needs to comprehend more than a few of them at any one time.

Orders

There are 12 orders. They are differentiated by the presence or absence of diagnostic horizons or features that reflect soil-forming processes. If the soils in a given taxon are thought to have had significantly different genesis, the intent has been to sort out the differences in the next lower category.

Soil properties are the consequences of a variety of processes acting on parent materials over time. Distinctions among orders aid in understanding soils and remembering them on a grand scale. The processes that occur in soils must be orderly in relation to the soil-forming factors, which are climate and living organisms acting on parent materials over time, as conditioned by relief. These factors, in turn, have geographic order. The features of the soil-forming processes are clearly visible, but the details of the processes can only be inferred. The distinctions made in classifying soils cannot be based on the processes themselves because new knowledge is certain to change our ideas about the processes, but the features of the processes are facts that can be observed and measured and used as a basis for distinctions. Thus, the distinctions between orders are based on the markers left by processes that experience indicates are dominant forces in shaping the character of the soil. In this framework, the lack of features or the zero degree also is a logical criterion.

The 12 orders and the major properties that differentiate them illustrate the nature of this category. Complete definitions are given later in this publication.

These orders are not the only possible orders in the taxonomy. In fact, two new orders, Andisols and Gelisols, have been established since the first edition of *Soil Taxonomy*. The hierarchy is flexible, and other *ad hoc* orders may be defined to emphasize properties not considered in the 12 orders. The method of defining *ad hoc* orders is described in connection with nomenclature later in this publication.

Alfisols

The soils in this order have markers of processes that translocate silicate clays without excessive depletion of bases and without dominance of the processes that lead to the formation of a mollic epipedon. The unique properties of Alfisols are a combination of an ochric or umbric epipedon, an argillic or natric horizon, a medium to high supply of bases in the soils, and water available to mesophytic plants for more than half the year or more than 3 consecutive months during a warm season. Because these soils have water and bases, they are, as a whole, intensively used.

Andisols

The unique property of Andisols is a dominance of short-range-order minerals or Al-humus complexes that result from weathering and mineral transformation with a minimum of translocation. The characteristics common to most Andisols include a high phosphorus retention, available water capacity, and cation-exchange capacity. Most Andisols formed in volcanic ejecta or volcaniclastic materials. Andisols can form in almost any environment, however, as long as suitable temperature and adequate moisture are available to permit weathering and the formation of short-range-order minerals. The soils can have any diagnostic epipedon or subsurface horizon as long as the unique property of Andisols is in 60 percent of the upper 60 cm of the soils, disregarding O horizons that have 25 percent or more organic carbon.

Prior to 1989, the soils now classified as Andisols were included with Inceptisols, mainly as Andepts and Andaquepts, which were discontinued with the acceptance of Andisols as an order in soil taxonomy.

Aridisols

The unique properties common to Aridisols are a combination of a lack of water available to mesophytic plants for very extended periods, one or more pedogenic horizons, a surface horizon or horizons not significantly darkened by humus, and absence of deep, wide cracks (see Vertisols) and andic soil properties (see Andisols). Aridisols have no available water during most of the time that the soils are warm enough for plant growth (warmer than 5 °C [41 °F]), and they never have water continuously available for as long as 90 days when the soil temperature is above 8 °C (47 °F).

Aridisols are primarily soils of arid areas. They are in areas that preclude much entry of water into the soils at present, either under extremely scanty rainfall or under slight rainfall that for one reason or another does not enter the soils. The vegetation in many areas consists of scattered ephemeral grasses and forbs, cacti, and xerophytic shrubs. Some Aridisols furnish limited grazing. If irrigated, many of them are suitable for a wide variety of crops.

Entisols

The unique properties common to Entisols are dominance of mineral soil materials and absence of distinct pedogenic horizons. The absence of features of any major set of soil-forming processes is itself an important distinction. There can be no accessory characteristics. Entisols are soils in the sense that they support plants, but they may be in any climate and under any vegetation. The absence of pedogenic horizons may be the result of an inert parent material, such as quartz sand, in which horizons do not readily form; slowly soluble, hard rock, such as limestone, which leaves little residue; insufficient time for horizons to form, as in recent deposits of ash or alluvium; occurrence on slopes where the rate of erosion exceeds the rate of formation of pedogenic horizons; recent mixing of horizons by animals or by plowing to a depth of 1 or 2 m; or the spoils from deep excavations.

Gelisols

The unique property of Gelisols is the presence of permafrost and soil features and properties associated with freezing and thawing. These features include irregular or broken horizons and incorporation of organic materials in the lower horizons, especially along the top of the permafrost table. Freezing and thawing produce granular, platy, and vesicular structures in surface and subsurface horizons. The increases in soil volume on freezing are considered a major soil-forming process in Gelisols. These soils are confined to the higher latitudes or high elevations, but they make up about 13 percent of the soils in the world, second only to Aridisols.

Histosols

The unique properties of Histosols are a very high content of organic matter in the upper 80 cm (32 in) of the soils and no permafrost. The amount of organic matter is at least 20 to 30 percent in more than half of this thickness, or the horizon that is rich in organic matter rests on rock or rock rubble. Most Histosols are peats or mucks, which consist of more or less decomposed plant remains that accumulated in water, but some formed from forest litter or moss, or both, and are freely drained. The freely drained Histosols are described in chapter 14.

Inceptisols

Inceptisols have a wide range in characteristics and occur in a wide variety of climates. They can form in almost any environment, except for an arid environment, and the comparable differences in vegetation are great. Inceptisols can grade toward any other soil order and occur on a variety of landforms. The unique properties of Inceptisols are a combination of water available to plants for more than half the year or more than 3 consecutive months during a warm season and one or more pedogenic horizons of alteration or concentration with little accumulation of translocated materials other than carbonates or amorphous silica. In addition, Inceptisols do not have one or more of the unique properties of Mollisols, which are a thick, dark surface horizon and a high calcium supply, or the unique property of Andisols, which is the dominance of short-range-order minerals or Al-humus complexes.

Mollisols

The unique properties of Mollisols are a combination of a very dark brown to black surface horizon (mollic epipedon) that makes up more than one-third of the combined thickness of the A and B horizons or that is more than 25 cm thick and that has structure or is not hard or very hard when dry; a dominance of calcium among the extractable cations in the A and B horizons; a dominance of crystalline clay minerals of moderate or high cation-exchange capacity; and less than 30 percent clay in some horizon above 50 cm if the soils have deep, wide cracks (1 cm or more wide) above this depth at some season.

Mollisols characteristically form under grass in climates that have a moderate to pronounced seasonal moisture deficit. Some Mollisols, however, formed under a forest ecosystem, and a few formed in marshes or in marls in humid climates. Mollisols are extensive soils on the steppes of Europe, Asia, North America, and South America.

Oxisols

The unique properties of Oxisols are extreme weathering of most minerals other than quartz to kaolin and free oxides, very low activity of the clay fraction, and a loamy or clayey texture (sandy loam or finer).

Oxisols characteristically occur in tropical or subtropical regions, on land surfaces that have been stable for a long time. Generally, the surfaces are early Pleistocene or much older, but Oxisols can occur on relatively young surfaces when weathered soil material is redeposited. Oxisols developed in a humid climate. Because climates change, however, some are now in an arid environment.

Spodosols

Spodosols have markers in at least an upper sequum of dominant processes that translocate humus and aluminum, or humus, aluminum, and iron, as amorphous materials. The unique property of Spodosols is a B horizon consisting of an accumulation of black or reddish amorphous materials that have a high cation-exchange capacity. This horizon is the spodic horizon. In most undisturbed soils, an albic horizon overlies the B horizon. The spodic horizon has accessory characteristics of coarse texture, high pH-dependent charge, and few bases. Commonly, the cation-exchange capacity is related to the amount of organic carbon rather than to the clay.

Ultisols

Ultisols, like Alfisols, have markers of clay translocation, but they also have markers of intensive leaching that are absent in Alfisols. The unique properties common to Ultisols are an argillic horizon and a low supply of bases, particularly in the lower horizons.

The cation-exchange capacity in Ultisols is mostly moderate or low. The decrease in base saturation with increasing depth reflects cycling of bases by plants or additions in fertilizers. In soils that have not been cultivated, the highest base saturation is normally in the few centimeters directly beneath the surface. Like Alfisols, Ultisols have water, but they have few bases. Without applications of fertilizer, they can be used for shifting cultivation. Because they are commonly warm and moist, however, they can be made highly productive if fertilizer is applied.

Vertisols

These soils have markers of processes related to the failure of soil materials along shear planes (slickensides). Because the soil material moves, the diagnostic properties have many accessory properties. Among them are a high bulk density when the soils are dry, low or very low hydraulic conductivity when the soils are moist, an appreciable rise and fall of the soil surface as the soils become moist and then dry, and rapid drying as a result of open cracks. The unique properties common to Vertisols are a high content of clay, pronounced changes in volume with changes in moisture, cracks that open and close periodically, and evidence of soil movement in the form of slickensides and of wedge-shaped structural aggregates that are tilted at an angle from the horizontal. The development of eluvial/illuvial horizons in some Vertisols suggests that pedoturbation is not rapid enough to preclude long-term translocation processes.

Suborders

Sixty-four suborders currently are recognized. The differentiae for the suborders vary with the order but can be illustrated by examples from two orders. The Entisol order has five suborders that distinguish the major reasons for absence of horizon differentiation. One suborder includes soils that have aquic conditions. These are the soils in areas of marshy recent alluvium and the soils of coastal marshes that are saturated with water and have a blue or green hue close to the surface. This suborder segregates the wet varieties. A second suborder includes soils that are not wet and that consist of recent alluvium, which generally is stratified. This suborder segregates the very young soils that do not have horizons because there is continuing deposition of new sediments. A third suborder includes soils on recently eroded slopes. This suborder segregates soils that are kept young by removal of soil materials at a rate that is more rapid than that of horizon differentiation. A fourth suborder includes sands that may range from recent to old. If old, they either lack the building blocks for pedogenic horizons or do not have enough moisture. Although the reasons for absence of horizons in the sands vary, the sands have many common physical properties, such as a low capacity for moisture retention, high hydraulic conductivity, and susceptibility to soil blowing. The sorting of these differences is continued in the lower categories. The fifth suborder of Entisols includes soils in which horizons have been mixed by deep plowing or other human activities that have destroyed the pedogenic horizons as such but not the fragments of the horizons.

Alfisols has five suborders. As in Entisols, one suborder includes wet soils in which the colors are dominantly gray. A second suborder includes Alfisols that are cold and have a short growing season. A third suborder includes soils that have a udic moisture regime and rarely do not have water available for plants. A fourth suborder has an ustic moisture regime and has extended or frequent periods when the soils do not have water that is available to mesophytic plants in some or all horizons. The fifth suborder includes the Alfisols that have a xeric moisture regime. These soils are cool and moist in winter, but they are dry for extended periods in summer.

The differentiae used in defining the suborders of Alfisols include important properties that influence genesis and that are extremely important to plant growth. The differentiae in six of the other orders closely parallel those of Alfisols. In the remaining orders, differentiae were selected to reflect what seemed to be the most important variables within the orders.

Great Groups

There are more than 300 great groups. At as high a categoric level as possible, it is desirable to consider all the horizons and their nature collectively as well as the temperature and moisture regimes. The moisture and temperature regimes are causes of properties, and they also are properties of the whole soil rather than of specific horizons. At the order and suborder levels, only a few of the most important horizons could be considered because there are few taxa in those categories. At the great group level, the assemblage of horizons and the most significant properties of the whole soil are considered. Although the definition of a great group may involve only a few differentiae, the accessory properties are many times that number.

Differentiae in the great group category segregate soils that have the following properties in common:

Close similarities in kind, arrangement, and degree of expression of horizons.—Exceptions are made for some thin surface horizons that would be mixed by plowing or lost by erosion and for horizons that indicate transitions to other great groups. For example, an argillic horizon that underlies the spodic horizon is permitted in the Spodosol order because that combination is considered to represent a kind of transition between Spodosols on the one hand and Alfisols and Ultisols on the other. Emphasis is placed on the upper sequum in the great group category because it is thought to reflect the current processes and is more critical to plant growth than the deeper horizons.

Similarities in base status.—If the base status varies widely within a suborder, the range is narrowed at the great group level.

The suborders of Alfisols were defined on the basis of moisture regimes. In addition to the argillic horizon that is common to all Alfisols, other kinds of horizons may occur. A fragipan or duripan restricts root development and water movement, which in turn affect current processes of soil formation. These horizons are used as one basis for defining great groups. The argillic horizon may have a fine texture and may be abruptly separated from an overlying albic horizon. This combination also affects root development and water movement, inducing shallow perched ground water and intermittent reducing conditions in the soils. The horizons may be thick as a result of very long periods of development. They may be undergoing destruction, and the soils may have developed a glossic horizon. These features also are used as differentiae for great groups.

In contrast to Alfisols, emphasis in the Entisols was placed on soil moisture and temperature regimes when the great groups were differentiated. Because the various suborders occur in all parts of the world, they have extreme ranges in moisture and temperature regimes, and those regimes affect pedogenesis as well as use and management of the soils.

Subgroups

There are more than 2,400 subgroups. Through the categories of order, suborder, and great group, emphasis has been placed on features or processes that appear to dominate the course or degree of soil development. In addition to these dominant features, many soils have properties that, although apparently subordinate, are still markers of important sets of processes. Some of these appear to be features of processes that are dominant in some other great group, suborder, or order. In a particular soil, however, they only modify the traits of other processes. For example, some soils have aquic conditions and have, throughout their depth, gray colors with reddish or brownish redox concentrations. Other soils have aquic conditions only in their lower horizons, and in those horizons the dominant colors may be shades of brown, red, or yellow with some gray redox depletions. The effects of ground water are apparent in both sets of soils, but they have less importance in the latter set.

Other properties are features of processes that are not used as criteria of any taxon above the subgroup level. For example, a Mollisol at the foot of a slope, where there has been a slow accumulation of materials washed from the higher parts of the slope, may have a greatly overthickened mollic epipedon.

Thus, there are three kinds of subgroups:

Typic subgroups.—These are not necessarily the most extensive subgroups, nor do they necessarily represent the central concept of the great group. In some taxa typic subgroups simply represent the soils that do not have the characteristics defined for the other subgroups.

Intergrades or transitional forms to other orders, suborders, or great groups.—The properties may be the result of processes that cause one kind of soil to develop from or toward another kind of soil or otherwise to have intermediate properties between those of two or three great groups. The properties used to define the intergrades may be:

1. Horizons in addition to those definitive of the great group, including an argillic horizon that underlies a spodic

horizon and a buried horizon, such as a thick layer of organic materials that is buried by a thin mineral soil; *or*

2. Intermittent horizons, such as those described in the section of chapter 1 that deals with the pedon; *or*

3. Properties of one or more other great groups that are expressed in part of the soils but are subordinate to the properties of the great group of which the subgroup is a member. One example of different depths of saturation and reduction was given earlier. Another example might be an Alfisol that has an ochric epipedon a little too thin or a little too light in color to be a mollic epipedon. This feature could result from an invasion of grassland by forest or the reverse, from the coexistence of both grass and forest, or from the erosion caused by human activities.

Extragrades.—These subgroups have some properties that are not representative of the great group but that do not indicate transitions to any other known kind of soil. One example of an overthickened mollic epipedon was given earlier. Other examples are soils that are very shallow over rock (Lithic) or soils that have high amounts of organic carbon (Humic).

Families

In this category, the intent has been to group the soils within a subgroup having similar physical and chemical properties that affect their responses to management and manipulation for use. In some cases soil properties are used in this category without regard to their significance as indicators of soil-forming processes.

The following are defined primarily to provide groupings of mineral soils with restricted ranges in:

1. Particle-size classes in horizons of major biologic activity below plow depth;

2. Mineralogy classes in the same horizons that are considered in naming particle-size classes;

3. Cation-exchange activity classes of certain particle-size and mineralogy classes in the same horizons that are considered in naming particle-size classes;

4. Calcareous and reaction classes in horizons directly below plow depth;

5. Soil temperature classes;

6. Thickness of the soil penetrable by roots; *and*

7. Classes of coatings, cracks, and rupture resistance used in defining some families to produce the needed homogeneity.

These properties carry important interpretive information, including aeration and the movement and retention of water, both of which affect the growth of plants and engineering uses. The differentiae are described in more detail in chapter 21.

Series

The series is the lowest category in this system. More than 19,000 series have been recognized in the United States. The differentiae used for series generally are the same as those used for classes in other categories, but the range permitted for one or more properties is narrower than the range permitted in a family or in some other higher category. For several properties, a series may have virtually the full range that is permitted in a family, but for one or more properties, the range is restricted. The purpose of the series category, like that of the family, is mainly pragmatic, and the taxa in the series category are closely allied to interpretive uses of the system.

Two kinds of distinctions, therefore, are made among series. First, the distinctions among families and among classes of all higher categories also are distinctions among series. A series cannot range across the limits between two families or between two classes of any higher category. Second, distinctions among similar series within a family are restrictions in one or more but not necessarily all of the ranges in properties of the family. Taken collectively, the number of the latter kind of distinctions is too large to be comprehended readily. One can only state the basis for separating individual series. Diagnostic horizons and features provide a framework for differentiating series, but series differentiae need not be limited to the defined diagnostic horizons and features.

The differentiae for series in the same family are expected to meet three tests. The first is that properties serving as differentiae can be observed or can be inferred with reasonable assurance. The second is that the differentiae must create soil series having a unique range of properties that is significantly greater than the normal margin of errors made by qualified pedologists when they measure, observe, or estimate the properties. The third is that the differentiae must reflect a property of the soils. This significance can be reflected in the nature or degree of expression of one or more horizons. The nature of horizons includes mineralogy, structure, rupture-resistance class, texture of the subhorizons, and moisture and temperature regimes. If color is accessory to some other property, it too is included. Degree of horizon expression includes thickness, contrast between horizons or subhorizons, and the nature of boundaries. If horizons are absent, the nature of the whole zone of major biologic activity is considered. The series control section is defined in chapter 21.

Important differences, shown by experience or research to condition or influence the nature of the statements that we can make about the behavior of the soil, should be considered as series differentiae.

A number of soil properties condition the statements made about a soil or its use but are not series differentiae. A steep slope or stones on the surface may be very important to the use of a soil in mechanized farming, but they may have virtually no importance to the growth of a forest, although they can hinder timber harvesting. If it is assumed that these soil characteristics are not reflected in the nature of the soil, or in the nature or degree of expression of horizons explained earlier, then they may be used as one of the bases of phases of soil series. The phases provide for a utilitarian classification that can be superimposed on soil taxonomy at any categoric level to permit more precise interpretations and predictions of the consequence of the various alternative uses of the soil.

The primary use of soil series in the classification system is to relate the map units represented on detailed soil maps to the taxa and to the interpretations that may follow. Map units are named for one or more soil series. Map units are real things, but series are conceptual. The Miami series, for example, cannot be seen or touched, but the map units that are identified as physical entities expressing the concept of the Miami series can be seen and touched.

The names of soil series have several meanings that must be kept in mind. First, the Miami series is a taxonomic class, a concept of a narrowly defined kind of soil. Second, one may examine a pedon and say, “This is Miami,” meaning that the properties in the pedon are those of the Miami series and that the pedon is a proper example. Third, “Miami” is used as part of the name of a map unit in an area that is shown on a soil map if the Miami series is dominant in that area. An example of such a map unit is Miami silt loam, 2 to 6 percent slopes. These are three common meanings of “Miami,” or of any series name, and all are proper. It is essential, however, to keep in mind that a series, as used in this taxonomy, is conceptual; the meaning is not identical with the meaning intended on soil maps because an area of Miami soil has inclusions of soils of other series. Inclusions of Miami soil also are permitted in areas named for other series. The application of this taxonomy to soil surveys is described in chapter 5.

CHAPTER 7

Nomenclature[1]

The nomenclature of soil taxonomy is based on the following premises: Each taxon requires a name if it is to be used in speech; a good name is short, easy to pronounce, and distinctive in meaning; a name is connotative, that is, capable of mnemonic attachment to the concept of the thing itself (Heller, 1963); and it is useful if the name of a taxon indicates its position in the classification, if similarities in important properties are reflected by similarities in names, if the mnemonic attachments hold in many languages, and if the name fits into many languages without translation.

The name of each taxon above the category of series indicates its class in all categories of which it is a member. The name of a soil series indicates only the category of series. Thus, a series name may be recognized as a series, but it does not indicate the order, suborder, great group, subgroup, or family.

The table "Example of Names of Taxa" shows the names of taxa in each category from order to series for two soil series. Because the assigned names are connotative and because most formative elements carry the same meaning in any combination, a name can convey a great deal of information about a soil.

Recognition of Names

Orders

The names of orders can be recognized as such because the name of each order ends in *sol* (L. *solum*, soil) with the connecting vowel *o* for Greek roots and *i* for other roots, as is indicated in the table "Formative Elements in Names of Soil Orders." Each name of an order contains a formative element that begins with the vowel directly preceding the connecting vowel and ends with the last consonant preceding the connecting vowel. In the order name "Entisol," the formative element is *ent*. In the name "Aridisol," it is *id*. These formative elements are used as endings for the names of suborders, great groups, and subgroups. Thus, the names of all taxa higher than the series that are members of the Entisol order end in *ent* and can be recognized as belonging to that order. Names ending in *id* are the names of taxa belonging to the Aridisol order.

[1] This chapter was developed with the assistance of the late Prof. A.L. Leemans, Classic Language Department, State University of Ghent, and the late Prof. John L. Heller, Department of the Classics, University of Illinois.

Suborders

The names of suborders have exactly two syllables. The first syllable connotes something about the diagnostic properties of the soils. The second is the formative element from the name of the order. The 28 formative elements shown in the table "Formative Elements in Names of Suborders" are used with the 12 formative elements from names of the orders to make the names of 64 suborders. The suborder of Entisols that has aquic conditions throughout is called Aquents (L. *aqua*, water, plus *ent* from Entisol). The formative element *aqu* is used with this meaning in 9 of the 12 orders. The suborder of Entisols that consists of very young sediments is called Fluvents (L. *fluvius*, river, plus *ent* from Entisol).

Great Groups

The name of a great group consists of the name of a suborder and a prefix that consists of one or two formative elements suggesting something about the diagnostic properties. The formative elements are shown in the table "Formative Elements in Names of Great Groups." The names of great groups, therefore, have three or four syllables and end with the name of a suborder. Fluvents that have a cryic temperature regime are called Cryofluvents (Gr. *kryos*, icy cold, plus fluvent). Fluvents that have a torric moisture regime are called Torrifluvents (L. *toridus*, hot and dry).

Subgroups

The name of a subgroup consists of the name of a great group modified by one or more adjectives. In some instances, the adjective *Typic* represents what is thought to typify the great group. In other instances, Typic subgroups simply do not have any of the characteristics used to define the other subgroups in a great group. Each Typic subgroup has, in clearly expressed form, all the diagnostic properties of the order, suborder, and great group to which it belongs. Typic subgroups also have no additional properties indicating a transition to another great group. A Typic subgroup is not necessarily the most extensive subgroup of a great group.

Example of Names of Taxa

Order	Suborder	Great Group	Subgroup	Family	Series
Entisols	Fluvents	Torrifluvents	Typic Torrifluvents	Fine-loamy, mixed, superactive, calcareous, mesic.	Jocity, Youngston.

Formative Elements in Names of Soil Orders

Name of order	Formative element in name	Derivation of formative element	Pronunciation of formative element
Alfisols	Alf	Meaningless syllable	Pedalfer.
Andisols	And	Modified from ando	Ando.
Aridisols	Id	L. *aridus*, dry	Arid.
Entisols	Ent	Meaningless syllable	Recent.
Gelisols	El	L. *gelare*, to freeze	Jell.
Histosols	Ist	Gr. *histos*, tissue	Histology.
Inceptisols	Ept	L. *inceptum*, beginning	Inception.
Mollisols	Oll	L. *mollis*, soft	Mollify.
Oxisols	Ox	F. *oxide*, oxide	Oxide.
Spodosols	Od	Gr. *spodos*, wood ash	Odd.
Ultisols	Ult	L. *ultimus*, last	Ultimate.
Vertisols	Ert	L. *verto*, turn	Invert.

Intergrade subgroups are those that belong to one great group but have some properties of another order, suborder, or great group. They are named by use of the adjectival form of the name of the appropriate taxon as a modifier of the great group name. Thus, the Torrifluvents that have some of the properties of Vertisols or the properties closely associated with Vertisols are called Vertic Torrifluvents. Vertic Torrifluvents have some of the properties of Vertisols superimposed on the complete set of diagnostic properties of Torrifluvents.

Extragrade subgroups are those that have important properties that are not representative of the great group but that do not indicate transitions to any other known kind of soil. They are named by modifying the great group name with an adjective that connotes something about the nature of the aberrant properties. Thus, a Cryorthent that has bedrock that is at least strongly cemented within 50 cm of the mineral soil surface is called a Lithic Cryorthent (lithic, Gr. *lithos*, stone). This subgroup is listed as an example in the table "Names of Orders, Suborders, Great Groups, and Subgroups."

Families

The names of families are polynomial. Each consists of the name of a subgroup and descriptive terms, generally three or more, that indicate the particle-size class (or combinations thereof if strongly contrasting), the mineralogy (26 classes), the cation-exchange activity (4 classes), the calcareous and reaction class (4 classes), the temperature (8 classes), and, in a few families, depth of the soil (3 classes), rupture resistance (2 classes), and classes of coatings and classes of cracks (3 classes). The names of most families have three to five descriptive terms that modify the subgroup name, but a few have only one or two and a few have as many as six. The example given in the table "Example of Names of Taxa" is a family of fine-loamy (particle-size class), mixed (mineralogy), superactive (cation-exchange activity), calcareous (calcareous and reaction), mesic (soil temperature) Typic Torrifluvents.

Series

The names of series as a rule are abstract place names. The name generally is taken from a place near the one where the series was first recognized. It may be the name of a town, a county, or some local feature. Some series have coined names. Many of the series names have been carried over from earlier classifications. Some have been in use since 1900. The name of a series carries no meaning to people who have no other source of information about the soils in the series.

Formative Elements in Names of Suborders

Formative element	Derivation	Connotation
Alb	L. *albus*, white	Presence of an albic horizon.
Anthr	Modified from Gr. *anthropos*, human	Modified by humans.
Aqu	L. *aqua*, water	Aquic conditions.
Ar	L. *arare*, to plow	Mixed horizon.
Arg	Modified from argillic horizon; L. *argilla*, white clay	Presence of an argillic horizon.
Calc	L. *calcis*, lime	Presence of a calcic horizon.
Camb	L. *cambiare*, to exchange	Presence of a cambic horizon.
Cry	Gr. *kryos*, icy cold	Cold.
Dur	L. *durus*, hard	Presence of a duripan.
Fibr	L. *fibra*, fiber	Least decomposed stage.
Fluv	L. *fluvius*, river	Flood plain.
Fol	L. *folia*, leaves	Mass of leaves.
Gyps	L. *gypsum*, gypsum	Presence of a gypsic horizon.
Hem	Gr. *hemi*, half	Intermediate stage of decomposition.
Hist	Gr. *histos*, tissue	Presence of organic materials.
Hum	L. *humus*, earth	Presence of organic matter.
Orth	Gr. *orthos*, true	The common ones.
Per	L. *per*, throughout in time	Perudic moisture regime.
Psamm	Gr. *psammos*, sand	Sandy texture.
Rend	Modified from Rendzina	High carbonate content.
Sal	L. base of *sal*, salt	Presence of a salic horizon.
Sapr	Gr. *saprose*, rotten	Most decomposed stage.
Torr	L. *torridus*, hot and dry	Torric moisture regime.
Turb	L. *turbidus*, disturbed	Presence of cryoturbation.
Ud	L. *udus*, humid	Udic moisture regime.
Ust	L. *ustus*, burnt	Ustic moisture regime.
Vitr	L. *vitrum*, glass	Presence of glass.
Xer	Gr. *xeros*, dry	Xeric moisture regime.

Meanings in the Names

The Jocity and Youngston series shown in the table "Example of Names of Taxa" are two members of the fine-loamy, mixed, superactive, calcareous, mesic family of Typic Torrifluvents. The meaning of each of these terms is defined as follows:

Fine-loamy means that from a depth of 25 to 100 cm there is no marked contrast in particle-size class, the content of clay is between 18 and 35 percent, 15 percent or more of the material is coarser than 0.1 mm in diameter (fine sand to very coarse sand plus gravel), but less than 35 percent of the material, by volume, is rock fragments 2.0 mm or more in diameter (less than about 50 percent by weight). The average texture, then, is likely to be loam, clay loam, or sandy clay loam.

Mixed indicates a mixed mineralogy, that is, there is less than 40 percent any one mineral other than quartz in the fraction between 0.02 and 2.0 mm in diameter, less than 20 percent (by weight) glauconitic pellets in the fine-earth fraction, a total of 5 percent or less iron plus gibbsite (by weight) in the fine-earth fraction, and a fine-earth fraction that has at least one of the following: free carbonates, pH of a suspension of 1 g soil in 50 ml 1 M NaF of 8.4 or less after 2 minutes, or a ratio of 1500 kPa water to measured clay of 0.6 or less.

Superactive means that the cation-exchange capacity divided by the percent clay is 0.60 or more.

Calcareous means that the soils have free carbonates in all parts from a depth of 25 to 50 cm and that, in this setting, they probably are calcareous throughout.

Mesic indicates a mesic temperature regime, that is, the mean annual soil temperature is between 8 and 15 ^{o}C (47 and 59 ^{o}F) and the soil temperature fluctuates more than 8 ^{o}C between summer and winter. In other words, the soils are somewhere in the midlatitudes, summer is warm or hot, and winter is cool or cold.

No term for soil depth is included in the family name of

Formative Elements in Names of Great Groups

Formative element	Derivation	Connotation
Acr	Modified from Gr. *arkos*, at the end	Extreme weathering.
Al	Modified from aluminum	High aluminum, low iron.
Alb	L. *albus*, white	Presence of an albic horizon.
Anhy	Gr. *anydros*, waterless	Very dry.
Anthr	Modified from Gr. *anthropos*, human	An anthropic epipedon.
Aqu	L. *aqua*, water	Aquic conditions.
Argi	Modified from argillic horizon; L. *argilla*, white clay	Presence of an argillic horizon.
Calci, calc	L. *calcis*, lime	A calcic horizon.
Cry	Gr. *kryos*, icy cold	Cold.
Dur	L. *durus*, hard	A duripan.
Dystr, dys	Modified from Gr. *dys*, ill; dystrophic, infertile	Low base saturation.
Endo	Gr. *endon*, *endo*, within	Implying a ground water table.
Epi	Gr. *epi*, on, above	Implying a perched water table.
Eutr	Modified from Gr. *eu*, good; eutrophic, fertile	High base saturation.
Ferr	L. *ferrum*, iron	Presence of iron.
Fibr	L. *fibra*, fiber	Least decomposed stage.
Fluv	L. *fluvius*, river	Flood plain.
Fol	L. *folia*, leaf	Mass of leaves.
Fragi	Modified from L. *fragilis*, brittle	Presence of a fragipan.
Fragloss	Compound of fra(g) and gloss	See the formative elements “frag” and “gloss.”
Fulv	L. *fulvus*, dull brownish yellow	Dark brown color, presence of organic carbon.
Glac	L. *glacialis*, icy	Ice lenses or wedges.
Gyps	L. *gypsum*, gypsum	Presence of a gypsic horizon.
Gloss	Gr. *glossa*, tongue	Presence of a glossic horizon.
Hal	Gr. *hals*, salt	Salty.
Hapl	Gr. *haplous*, simple	Minimum horizon development.
Hem	Gr. *hemi*, half	Intermediate stage of decomposition.
Hist	Gr. *histos*, tissue	Presence of organic materials.
Hum	L. *humus*, earth	Presence of organic matter.
Hydr	Gr. *hydor*, water	Presence of water.
Kand, kan	Modified from kandite	1:1 layer silicate clays.
Luv	Gr. *louo*, to wash	Illuvial.
Melan	Gr. *melasanos*, black	Black, presence of organic carbon.
Moll	L. *mollis*, soft	Presence of a mollic epipedon.
Natr	Modified from *natrium*, sodium	Presence of a natric horizon.
Pale	Gr. *paleos*, old	Excessive development.
Petr	Gr. comb. form of *petra*, rock	A cemented horizon.
Plac	Gr. base of *plax*, flat stone	Presence of a thin pan.
Plagg	Modified from Ger. *plaggen*, sod	Presence of a plaggen epipedon.
Plinth	Gr. *plinthos*, brick	Presence of plinthite.
Psamm	Gr. *psammos*, sand	Sandy texture.
Quartz	Ger. *quarz*, quartz	High quartz content.
Rhod	Gr. base of *rhodon*, rose	Dark red color.
Sal	L. base of *sal*, salt	Presence of a salic horizon.
Sapr	Gr. *saprose*, rotten	Most decomposed stage.
Somb	F. *sombre*, dark	Presence of a sombric horizon.
Sphagn	Gr. *sphagnos*, bog	Presence of sphagnum.
Sulf	L. *sulfur*, sulfur	Presence of sulfides or their oxidation products.
Torr	L. *torridus*, hot and dry	Torric moisture regime.

Formative Elements in Names of Great Groups--Continued

Formative element	Derivation	Connotation
Ud	L. *udus*, humid	Udic moisture regime.
Umbr	L. *umbra*, shade	Presence of an umbric epipedon.
Ust	L. *ustus*, burnt	Ustic moisture regime.
Verm	L. base of *vermes*, worms	Wormy or mixed by animals.
Vitr	L. *vitrum*, glass	Presence of glass.
Xer	Gr. *xeros*, dry	Xeric moisture regime.

these Typic Torrifluvents, indicating that the soils are 50 cm or more deep.

The meaning of *Typic* varies with the great group. *Torri* indicates a torric (dry) moisture regime. *Fluv* indicates that the sediments are probably alluvial rather than eolian because fresh eolian sediments may be sandy, silty, or clayey but are rarely fine-loamy. *Ent*, the final syllable, indicates that the soils are Entisols. As such, they have no fragipan, duripan, permafrost, or cambic, argillic, calcic, petrocalcic, gypsic, oxic, petrogypsic, placic, salic, or spodic horizon within 100 cm of the mineral soil surface; have no sulfuric horizon within 150 cm of the mineral soil surface; and have no histic, mollic, plaggen, or umbric epipedon.

The terms describing these Typic Torrifluvents allow us to visualize soils on flood plains or alluvial fans in an arid, temperate climate. Although the soils may be a bit salty, they cannot be extremely salty. They probably have stratification but have no severe limitation for irrigation. Under irrigation, iron chlorosis may be a problem in sensitive plants. Unless irrigated, the soils can be used only for limited grazing.

Forming Names

Names of Orders, Suborders, and Great Groups

The names of the orders, suborders, and great groups that are currently recognized are shown in the table “Names of Orders, Suborders, Great Groups, and Subgroups.” The formative elements used in these names are shown in the tables “Formative Elements in Names of Soil Orders,” “Formative Elements in Names of Suborders,” and “Formative Elements in Names of Great Groups.”

Names of Subgroups

The name of a subgroup consists of the name of a great group modified by one or more adjectives. As was explained earlier, the adjective *Typic* is used for the subgroup that is thought to typify the central concept of the great group or for soils that fail to meet the criteria of the other subgroups defined for a great group.

Intergrade subgroups that have, in addition to the properties of their great group, some properties of another taxon carry the name of the other taxon in the form of an adjective. The names of orders, suborders, or great groups or any of the prior (first) formative elements of those names may be used in the form of an adjective in subgroup names. A few soils may have aberrant properties of two great groups that belong in different orders or suborders. For these, it is necessary to use two names of taxa as adjectives in the subgroup name.

The names of extragrade subgroups include one or more special descriptive adjectives that modify the name of the great group and connote the nature of aberrant properties.

Names of Intergrades Toward Other Great Groups in the Same Suborder

If the aberrant property of a soil is one that is characteristic of another great group in the same suborder, only the distinctive formative element of the great group name is used to indicate the aberrant property. Thus, a Typic Argidurid is defined in part as having an indurated or very strongly cemented duripan. If the only aberrant feature of an Argidic Argidurid is that the duripan is strongly cemented or less cemented throughout, the soil is considered to intergrade toward Argids. The name, however, is Argidic Argidurids, not Haplargidic Argidurids. Only the prior (first) formative element is used in adjectival form if the two great groups are in the same suborder.

Names of Intergrades Toward a Great Group in the Same Order but in a Different Suborder

Two kinds of names have been chosen to indicate intergrades toward a great group in the same order but in a different suborder. If the only aberrant features are color and moisture regime and hue is too yellow or chroma is too high or too low for the Typic subgroup, the adjectives *Aeric* and *Aquic* are used.

If an Epiaquult has chroma too high for the Typic subgroup but has no other aberrant feature, it is assigned to an Aeric

Names of Orders, Suborders, Great Groups, and Subgroups

Order	Suborder	Great Group	Subgroup
Alfisols	Aqualfs	Cryaqualfs	Typic.
		Plinthaqualfs	Typic.
		Duraqualfs	Typic.
		Natraqualfs	Vertic, Vermic, Albic Glossic, Albic, Glossic, Mollic, Typic.
		Fragiaqualfs	Vermic, Aeric, Plinthic, Humic, Typic.
		Kandiaqualfs	Arenic, Grossarenic, Plinthic, Aeric Umbric, Aeric, Umbric, Typic.
		Vermaqualfs	Natric, Typic.
		Albaqualfs	Arenic, Aeric Vertic, Chromic Vertic, Vertic, Udollic, Aeric, Aquandic, Mollic, Umbric, Typic.
		Glossaqualfs	Histic, Arenic, Aeric Fragic, Fragic, Aeric, Mollic, Typic.
		Epiaqualfs	Aeric Chromic Vertic, Aeric Vertic, Chromic Vertic, Vertic, Aquandic, Aeric Fragic, Fragic, Arenic, Grossarenic, Aeric Umbric, Udollic, Aeric, Mollic, Umbric, Typic.
		Endoaqualfs	Aquandic, Chromic Vertic, Vertic, Aeric Fragic, Fragic, Arenic, Grossarenic, Udollic, Aeric Umbric, Aeric, Mollic, Umbric, Typic.
	Cryalfs	Palecryalfs	Andic, Vitrandic, Aquic, Oxyaquic, Xeric, Ustic, Mollic, Umbric, Typic.
		Glossocryalfs	Lithic, Vertic, Andic, Vitrandic, Aquic, Oxyaquic, Fragic, Xerollic, Umbric Xeric, Ustollic, Xeric, Ustic, Mollic, Umbric, Eutric, Typic.
		Haplocryalfs	Lithic, Vertic, Andic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Vitrandic,
			Aquic,
			Oxyaquic,
			Lamellic,
			Psammentic,
			Inceptic,
			Xerollic,
			Umbric Xeric,
			Ustollic,
			Xeric,
			Ustic,
			Mollic,
			Umbric,
			Eutric,
			Typic.
	Ustalfs	Durustalfs	Typic.
		Plinthustalfs	Typic.
		Natrustalfs	Salidic,
			Leptic Torrertic,
			Torrertic,
			Aquertic,
			Aridic Leptic,
			Vertic,
			Aquic Arenic,
			Aquic,
			Arenic,
			Petrocalcic,
			Leptic,
			Haplargdic,
			Aridic,
			Mollic,
			Typic.
		Kandiustalfs	Grossarenic,
			Aquic Arenic,
			Plinthic,
			Aquic,
			Arenic Aridic,
			Arenic,
			Aridic,
			Udic,
			Rhodic,
			Typic.
		Kanhaplustalfs ..	Lithic,
			Aquic,
			Aridic,
			Udic,
			Rhodic,
			Typic.
		Paleustalfs..........	Aquertic,
			Oxyaquic Vertic,
			Udertic,
			Vertic,
			Aquic Arenic,
			Aquic,
			Oxyaquic,
			Lamellic,
			Psammentic,
			Arenic Aridic,
			Grossarenic,
			Arenic,
			Plinthic,
			Petrocalcic,
			Calcidic,
			Aridic,
			Kandic,
			Rhodic,
			Ultic,
			Udic,
			Typic.
		Rhodustalfs.......	Lithic,
			Kanhaplic,
			Udic,
			Typic.
		Haplustalfs	Lithic,
			Aquertic,
			Oxyaquic Vertic,
			Torrertic,
			Udertic,
			Vertic,
			Aquic Arenic,
			Aquultic,
			Aquic,
			Oxyaquic,
			Vitrandic,
			Lamellic,
			Psammentic,
			Arenic Aridic,
			Arenic,
			Calcidic,
			Aridic,
			Kanhaplic,
			Inceptic,
			Calcic Udic,
			Ultic,
			Calcic,
			Udic,
			Typic.
	Xeralfs	Durixeralfs	Natric,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Durixeralfs (continued)	Vertic,
			Aquic,
			Abruptic Haplic,
			Abruptic,
			Haplic,
			Typic.
		Natrixeralfs	Vertic,
			Aquic,
			Typic.
		Fragixeralfs	Andic,
			Vitrandic,
			Mollic,
			Aquic,
			Inceptic,
			Typic.
		Plinthoxeralfs	Typic.
		Rhodoxeralfs	Lithic,
			Vertic,
			Petrocalcic,
			Calcic,
			Inceptic,
			Typic.
		Palexeralfs	Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Aquic,
			Petrocalcic,
			Lamellic,
			Psammentic,
			Arenic,
			Natric,
			Fragic,
			Calcic,
			Plinthic,
			Ultic,
			Haplic,
			Mollic,
			Typic.
		Haploxeralfs	Lithic Mollic,
			Lithic Ruptic-Inceptic,
			Lithic,
			Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Aquultic,
			Aquic,
			Natric,
			Fragic,
			Lamellic,
			Psammentic,
			Plinthic,
			Calcic,
			Inceptic,
			Ultic,
			Mollic,
			Typic.
	Udalfs	Natrudalfs	Vertic,
			Glossaquic,
			Aquic,
			Typic.
		Ferrudalfs	Aquic,
			Typic.
		Fraglossudalfs	Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Typic.
		Fragiudalfs	Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Typic.
		Kandiudalfs	Plinthaquic,
			Aquic,
			Oxyaquic,
			Arenic Plinthic,
			Grossarenic Plinthic,
			Arenic,
			Grossarenic,
			Plinthic,
			Rhodic,
			Mollic,
			Typic.
		Kanhapludalfs	Lithic,
			Aquic,
			Oxyaquic,
			Rhodic,
			Typic.
		Paleudalfs	Vertic,
			Andic,
			Vitrandic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Fragiaquic,
			Plinthaquic,
			Glossaquic,
			Albaquic,
			Aquic,
			Anthraquic,
			Oxyaquic,
			Fragic,
			Arenic Plinthic,
			Grossarenic Plinthic,
			Lamellic,
			Psammentic,
			Arenic,
			Grossarenic,
			Plinthic,
			Glossic,
			Rhodic,
			Mollic,
			Typic.
		Rhodudalfs	Typic.
		Glossudalfs	Aquertic,
			Oxyaquic Vertic,
			Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Aquic,
			Oxyaquic,
			Fragic,
			Arenic,
			Haplic,
			Typic.
		Hapludalfs	Lithic,
			Aquertic Chromic,
			Aquertic,
			Oxyaquic Vertic,
			Chromic Vertic,
			Vertic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Fragic Oxyaquic,
			Aquic Arenic,
			Albaquultic,
			Albaquic,
			Glossaquic,
			Aquultic,
			Aquollic,
			Aquic,
			Anthraquic,
			Oxyaquic,
			Fragic,
			Lamellic,
			Psammentic,
			Arenic,
			Glossic,
			Inceptic,
			Ultic,
			Mollic,
			Typic.
Andisols	Aquands	Cryaquands	Lithic,
			Histic,
			Thaptic,
			Typic.
		Placaquands	Lithic,
			Duric Histic,
			Duric,
			Histic,
			Thaptic,
			Typic.
		Duraquands	Histic,
			Acraquoxic,
			Thaptic,
			Typic.
		Vitraquands	Lithic,
			Duric,
			Histic,
			Thaptic,
			Typic.
		Melanaquands	Lithic,
			Acraquoxic,
			Hydric Pachic,
			Hydric,
			Pachic,
			Thaptic,
			Typic.
		Epiaquands	Duric,
			Histic,
			Alic,
			Hydric,
			Thaptic,
			Typic.
		Endoaquands	Lithic,
			Duric,
			Histic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Endoaquands (continued)	Alic,
			Hydric,
			Thaptic,
			Typic.
	Cryands	Duricryands	Aquic,
			Typic.
		Hydrocryands	Lithic,
			Placic,
			Aquic,
			Thaptic,
			Typic.
		Melanocryands	Lithic,
			Vitric,
			Typic.
		Fulvicryands	Lithic,
			Pachic,
			Vitric,
			Typic.
		Vitricryands	Lithic,
			Aquic,
			Oxyaquic,
			Thaptic,
			Humic Xeric,
			Xeric,
			Ultic,
			Alfic,
			Humic,
			Typic.
		Haplocryands	Lithic,
			Alic,
			Aquic,
			Acrudoxic,
			Vitric,
			Thaptic,
			Xeric,
			Typic.
	Torrands	Duritorrands	Petrocalcic,
			Vitric,
			Typic.
		Vitritorrands	Lithic,
			Duric,
			Aquic,
			Calcic,
			Typic.
		Haplotorrands	Lithic,
			Duric,
			Calcic,
			Typic.
	Xerands	Vitrixerands	Lithic,
			Aquic,
			Thaptic,
			Alfic Humic,
			Ultic,
			Alfic,
			Humic,
			Typic.
		Melanoxerands	Pachic,
			Typic.
		Haploxerands	Lithic,
			Aquic,
			Thaptic,
			Calcic,
			Ultic,
			Alfic Humic,
			Alfic,
			Humic,
			Typic.
	Vitrands	Ustivitrands	Lithic,
			Aquic,
			Thaptic,
			Calcic,
			Humic,
			Typic.
		Udivitrands	Lithic,
			Aquic,
			Thaptic,
			Ultic,
			Alfic,
			Humic,
			Typic.
	Ustands	Durustands	Aquic,
			Thaptic,
			Humic,
			Typic.
		Haplustands	Lithic,
			Aquic,
			Dystric Vitric,
			Vitric,
			Pachic,
			Thaptic,
			Calcic,
			Dystric,
			Oxic,
			Ultic,
			Alfic,
			Humic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
	Udands	Placudands	Lithic,
			Aquic,
			Acrudoxic,
			Hydric,
			Typic.
		Durudands	Aquic,
			Acrudoxic,
			Hydric,
			Pachic,
			Typic.
		Melanudands	Lithic,
			Anthraquic,
			Aquic,
			Acrudoxic Vitric,
			Acrudoxic Hydric,
			Acrudoxic,
			Pachic Vitric,
			Vitric,
			Hydric Pachic,
			Pachic,
			Hydric,
			Thaptic,
			Ultic,
			Eutric,
			Typic.
		Hydrudands	Lithic,
			Aquic,
			Acrudoxic Thaptic,
			Acrudoxic,
			Thaptic,
			Eutric,
			Ultic,
			Typic.
		Fulvudands	Eutric Lithic,
			Lithic,
			Aquic,
			Hydric,
			Acrudoxic,
			Ultic,
			Eutric Pachic,
			Eutric,
			Pachic,
			Thaptic,
			Typic.
		Hapludands	Lithic,
			Anthraquic,
			Aquic Duric,
			Duric,
			Alic,
			Aquic,
			Acrudoxic Hydric,
			Acrudoxic Thaptic,
			Acrudoxic Ultic,
			Acrudoxic,
			Vitric,
			Hydric Thaptic,
			Hydric,
			Eutric Thaptic,
			Thaptic,
			Eutric,
			Oxic,
			Ultic,
			Alfic,
			Typic.
Aridisols	Cryids	Salicryids	Aquic,
			Typic.
		Petrocryids	Xereptic,
			Duric Xeric,
			Duric,
			Petrogypsic,
			Xeric,
			Ustic,
			Typic.
		Gypsicryids	Calcic,
			Vitrixerandic,
			Vitrandic,
			Typic.
		Argicryids	Lithic,
			Vertic,
			Natric,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Calcicryids	Lithic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Haplocryids	Lithic,
			Vertic,
			Vitrixerandic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Haplocryids (continued)	Vitrandic,
			Xeric,
			Ustic,
			Typic.
	Salids	Aquisalids	Gypsic,
			Calcic,
			Typic.
		Haplosalids	Duric,
			Petrogypsic,
			Gypsic,
			Calcic,
			Typic.
	Durids	Natridurids	Vertic,
			Aquic Natrargidic,
			Aquic,
			Natrixeralfic,
			Natrargidic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Typic.
		Argidurids	Vertic,
			Aquic,
			Abruptic Xeric,
			Abruptic,
			Haploxeralfic,
			Argidic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Haplodurids	Aquicambidic,
			Aquic,
			Xereptic,
			Cambidic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
	Gypsids	Petrogypsids	Petrocalcic,
			Calcic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Natrigypsids	Lithic,
			Vertic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Argigypsids	Lithic,
			Vertic,
			Calcic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Calcigypsids	Lithic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Haplogypsids	Lithic,
			Leptic,
			Sodic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
	Argids	Petroargids	Petrogypsic Ustic,
			Petrogypsic,
			Duric Xeric,
			Duric,
			Natric,
			Xeric,
			Ustic,
			Typic.
		Natrargids	Lithic Xeric,
			Lithic Ustic,
			Lithic,
			Vertic,
			Aquic,
			Durinodic Xeric,
			Durinodic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Petronodic,
			Glossic Ustic,
			Haplic Ustic,
			Haploxeralfic,
			Haplic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Glossic,
			Typic.
		Paleargids	Vertic,
			Aquic,
			Arenic Ustic,
			Arenic,
			Calcic,
			Durinodic Xeric,
			Durinodic,
			Petronodic Ustic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Gypsiargids	Aquic,
			Durinodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Calciargids	Lithic,
			Xerertic,
			Ustertic,
			Vertic,
			Aquic,
			Arenic Ustic,
			Arenic,
			Durinodic Xeric,
			Durinodic,
			Petronodic Xeric,
			Petronodic Ustic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Haplargids	Lithic Ruptic-Entic,
			Lithic Xeric,
			Lithic Ustic,
			Lithic,
			Xerertic,
			Ustertic,
			Vertic,
			Aquic,
			Arenic Ustic,
			Arenic,
			Durinodic Xeric,
			Durinodic,
			Petronodic Ustic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
	Calcids	Petrocalcids	Aquic,
			Natric,
			Xeralfic,
			Ustalfic,
			Argic,
			Calcic Lithic,
			Calcic,
			Xeric,
			Ustic,
			Typic.
		Haplocalcids	Lithic Xeric,
			Lithic Ustic,
			Lithic,
			Vertic,
			Aquic Durinodic,
			Aquic,
			Duric Xeric,
			Duric,
			Durinodic Xeric,
			Durinodic,
			Petronodic Xeric,
			Petronodic Ustic,
			Petronodic,
			Sodic Xeric,
			Sodic Ustic,
			Sodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Haplocalcids (continued)	Ustic,
			Typic.
	Cambids	Aquicambids	Sodic,
			Durinodic Xeric,
			Durinodic,
			Petronodic,
			Vitrixerandic,
			Vitrandic,
			Fluventic,
			Xeric,
			Ustic,
			Typic.
		Petrocambids	Sodic,
			Vitrixerandic,
			Vitrandic,
			Xeric,
			Ustic,
			Typic.
		Anthracambids	Typic.
		Haplocambids	Lithic Xeric,
			Lithic Ustic,
			Lithic,
			Xerertic,
			Ustertic,
			Vertic,
			Durinodic Xeric,
			Durinodic,
			Petronodic Xeric,
			Petronodic Ustic,
			Petronodic,
			Sodic Xeric,
			Sodic Ustic,
			Sodic,
			Vitrixerandic,
			Vitrandic,
			Xerofluventic,
			Ustifluventic,
			Fluventic,
			Xeric,
			Ustic,
			Typic.
Entisols	Aquents	Sulfaquents	Haplic,
			Histic,
			Thapto-Histic,
			Typic.
		Hydraquents	Sulfic,
			Sodic,
			Thaptic-Histic,
			Typic.
		Cryaquents	Aquandic,
			Typic.
		Psammaquents	Lithic,
			Sodic,
			Spodic,
			Humaqueptic,
			Mollic,
			Typic.
		Fluvaquents	Sulfic,
			Vertic,
			Thapto-Histic,
			Aquandic,
			Aeric,
			Humaqueptic,
			Mollic,
			Typic.
		Epiaquents	Aeric,
			Humaqueptic,
			Mollic,
			Typic.
		Endoaquents	Sulfic,
			Lithic,
			Sodic,
			Aeric,
			Humaqueptic,
			Mollic,
			Typic.
	Arents	Ustarents	Haplic.
		Xerarents	Sodic,
			Duric,
			Alfic,
			Haplic.
		Torriarents	Sodic,
			Duric,
			Haplic.
		Udarents	Alfic,
			Ultic,
			Mollic,
			Haplic.
	Psamments	Cryo-psamments	Lithic,
			Aquic,
			Oxyaquic,
			Vitrandic,
			Spodic,
			Lamellic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Torri-psamments	Lithic,
			Vitrandic,
			Haploduridic,
			Ustic,
			Xeric,
			Rhodic,
			Typic.
		Quartzi-psamments	Lithic,
			Aquodic,
			Aquic,
			Oxyaquic,
			Ustoxic,
			Udoxic,
			Plinthic,
			Lamellic Ustic,
			Lamellic,
			Ustic,
			Xeric,
			Spodic,
			Typic.
		Usti-psamments	Lithic,
			Aquic,
			Oxyaquic,
			Aridic,
			Lamellic,
			Rhodic,
			Typic.
		Xero-psamments	Lithic,
			Aquic Durinodic,
			Aquic,
			Oxyaquic,
			Vitrandic,
			Durinodic,
			Lamellic,
			Dystric,
			Typic.
		Udi-psamments	Lithic,
			Aquic,
			Oxyaquic,
			Spodic,
			Lamellic,
			Plagganthreptic,
			Typic.
	Fluvents	Cryofluvents	Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Mollic,
			Typic.
		Xerofluvents	Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Durinodic,
			Mollic,
			Typic.
		Ustifluvents	Aquertic,
			Torrertic,
			Vertic,
			Anthraquic,
			Aquic,
			Oxyaquic,
			Aridic,
			Udic,
			Mollic,
			Typic.
		Torrifluvents	Ustertic,
			Vertic,
			Vitrixerandic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Duric Xeric,
			Duric,
			Ustic,
			Xeric,
			Anthropic,
			Typic.
		Udifluvents	Aquertic,
			Vertic,
			Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Mollic,
			Typic.
	Orthents	Cryorthents	Lithic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Lamellic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Cryorthents (continued)	Typic.
		Torriorthents	Lithic Ustic,
			Lithic Xeric,
			Lithic,
			Xerertic,
			Ustertic,
			Vertic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Duric,
			Ustic,
			Xeric,
			Typic.
		Xerorthents	Lithic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Durinodic,
			Dystric,
			Typic.
		Ustorthents	Aridic Lithic,
			Lithic,
			Torrertic,
			Vertic,
			Anthraquic,
			Aquic,
			Oxyaquic,
			Durinodic,
			Vitritorrandic,
			Vitrandic,
			Aridic,
			Udic,
			Vermic,
			Typic.
		Udorthents	Lithic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Vermic,
			Typic.
Gelisols	Histels	Folistels	Lithic,
			Glacic,
			Typic.
		Glacistels	Hemic,
			Sapric,
			Typic.
		Fibristels	Lithic,
			Terric,
			Fluvaquentic,
			Sphagnic,
			Typic.
		Hemistels	Lithic,
			Terric,
			Fluvaquentic,
			Typic.
		Sapristels	Lithic,
			Terric,
			Fluvaquentic,
			Typic.
	Turbels	Histoturbels	Lithic,
			Glacic,
			Ruptic,
			Typic.
		Aquiturbels	Lithic,
			Glacic,
			Sulfuric,
			Ruptic-Histic,
			Psammentic,
			Typic.
		Anhyturbels	Lithic,
			Glacic,
			Petrogypsic,
			Gypsic,
			Nitric,
			Salic,
			Calcic,
			Typic.
		Molliturbels	Lithic,
			Glacic,
			Vertic,
			Andic,
			Vitrandic,
			Cumulic,
			Aquic,
			Typic.
		Umbriturbels	Lithic,
			Glacic,
			Vertic,
			Andic,
			Vitrandic,
			Cumulic,
			Aquic,
			Typic.
		Psammoturbels	Lithic,
			Glacic,
			Spodic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Typic.
		Haploturbels	Lithic,
			Glacic,
			Aquic,
			Typic.
	Orthels	Historthels	Lithic,
			Glacic,
			Ruptic,
			Typic.
		Aquorthels	Lithic,
			Glacic,
			Sulfuric,
			Ruptic-Histic,
			Andic,
			Vitrandic,
			Salic,
			Psammentic,
			Typic.
		Anhyorthels	Lithic,
			Glacic,
			Petrogypsic,
			Gypsic,
			Nitric,
			Salic,
			Calcic,
			Typic.
		Mollorthels	Lithic,
			Glacic,
			Vertic,
			Andic,
			Vitrandic,
			Cumulic,
			Aquic,
			Typic.
		Umbrorthels	Lithic,
			Glacic,
			Vertic,
			Andic,
			Vitrandic,
			Cumulic,
			Aquic,
			Typic.
		Argiorthels	Lithic,
			Glacic,
			Natric,
			Typic.
		Psammorthels	Lithic,
			Glacic,
			Spodic,

Order	Suborder	Great Group	Subgroup
			Typic.
		Haplorthels	Lithic,
			Glacic,
			Aquic,
			Typic.
Histosols	Folists	Cryofolists	Lithic,
			Typic.
		Torrifolists	Lithic,
			Typic.
		Ustifolists	Lithic,
			Typic.
		Udifolists	Lithic,
			Typic.
	Fibrists	Cryofibrists	Hydric,
			Lithic,
			Terric,
			Fluvaquentic,
			Sphagnic,
			Typic.
		Sphagno- fibrists	Hydric,
			Lithic,
			Limnic,
			Terric,
			Fluvaquentic,
			Hemic,
			Typic.
		Haplofibrists	Hydric,
			Lithic,
			Limnic,
			Terric,
			Fluvaquentic,
			Hemic,
			Typic.
	Saprists	Sulfosaprists	Typic.
		Sulfisaprists	Terric,
			Typic.
		Cryosaprists	Lithic,
			Terric,
			Fluvaquentic,
			Typic.
		Haplosaprists	Lithic,
			Limnic,
			Halic Terric,
			Halic,
			Terric,
			Fluvaquentic,
			Hemic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
	Hemists	Sulfohemists	Typic.
		Sulfihemists	Terric,
			Typic.
		Luvihemists	Typic.
		Cryohemists	Hydric,
			Lithic,
			Terric,
			Fluvaquentic,
			Typic.
		Haplohemists	Hydric,
			Lithic,
			Limnic,
			Terric,
			Fluvaquentic,
			Fibric,
			Sapric,
			Typic.
Inceptisols	Aquepts	Sulfaquepts	Salidic,
			Hydraquentic,
			Typic.
		Petraquepts	Histic Placic,
			Placic,
			Plinthic,
			Typic.
		Halaquepts	Vertic,
			Aquandic,
			Duric,
			Aeric,
			Typic.
		Fragiaquepts	Aeric,
			Humic,
			Typic.
		Cryaquepts	Sulfic,
			Histic Lithic,
			Lithic,
			Vertic,
			Histic,
			Aquandic,
			Fluvaquentic,
			Aeric Humic,
			Aeric,
			Humic,
			Typic.
		Vermaquepts	Sodic,
			Typic.
		Humaquepts	Hydraquentic,
			Histic,
			Aquandic,
			Cumulic,
			Fluvaquentic,
			Aeric,
			Typic.
		Epiaquepts	Vertic,
			Aquandic,
			Fluvaquentic,
			Fragic,
			Aeric,
			Humic,
			Mollic,
			Typic.
		Endoaquepts	Sulfic,
			Lithic,
			Vertic,
			Aquandic,
			Fluvaquentic,
			Fragic,
			Aeric,
			Humic,
			Mollic,
			Typic.
	Anthrepts	Plagg-anthrepts	Typic.
		Haplanthrepts	Typic.
	Cryepts	Eutrocryepts	Humic Lithic,
			Lithic,
			Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Lamellic,
			Xeric,
			Ustic,
			Humic,
			Typic.
		Dystrocryepts	Humic Lithic,
			Lithic,
			Andic,
			Vitrandic,
			Aquic,
			Oxyaquic,
			Lamellic,
			Spodic,
			Xeric,
			Ustic,
			Humic,
			Typic.
	Ustepts	Durustepts	Typic.
		Calciustepts	Lithic Petrocalcic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Lithic,
			Torrertic,
			Vertic,
			Petrocalcic,
			Gypsic,
			Aquic,
			Aridic,
			Udic,
			Typic.
		Dystrustepts	Lithic,
			Andic,
			Vitrandic,
			Aquic,
			Fluventic,
			Oxic,
			Humic,
			Typic.
		Haplustepts	Aridic Lithic,
			Lithic,
			Udertic,
			Torrertic,
			Vertic,
			Andic,
			Vitrandic,
			Anthraquic,
			Aquic,
			Oxyaquic,
			Oxic,
			Lamellic,
			Torrifluventic,
			Udifluventic,
			Fluventic,
			Gypsic,
			Haplocalcidic,
			Calcic Udic,
			Calcic,
			Aridic,
			Dystric,
			Udic,
			Typic.
	Xerepts	Durixerepts	Aquandic,
			Andic,
			Vitrandic,
			Aquic,
			Entic,
			Typic.
		Calcixerepts	Lithic,
			Vertic,
			Petrocalcic,

Order	Suborder	Great Group	Subgroup
			Sodic,
			Vitrandic,
			Aquic,
			Typic.
		Fragixerepts	Andic,
			Vitrandic,
			Aquic,
			Humic,
			Typic.
		Dystroxerepts	Humic Lithic,
			Lithic,
			Aquandic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Fluvaquentic,
			Aquic,
			Oxyaquic,
			Fragic,
			Fluventic Humic,
			Fluventic,
			Humic,
			Typic.
		Haploxerepts	Humic Lithic,
			Lithic,
			Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Gypsic,
			Aquic,
			Lamellic,
			Fragic,
			Fluventic,
			Calcic,
			Humic,
			Typic.
	Udepts	Sulfudepts	Typic.
		Durudepts	Aquandic,
			Andic,
			Vitrandic,
			Aquic,
			Typic.
		Fragiudepts	Andic,
			Vitrandic,
			Aquic,
			Humic,
			Typic.
		Eutrudepts	Humic Lithic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Eutrudepts (continued)	Lithic,
			Aquertic,
			Vertic,
			Andic,
			Vitrandic,
			Anthraquic,
			Fragiaquic,
			Fluvaquentic,
			Aquic Dystric,
			Aquic,
			Oxyaquic,
			Fragic,
			Lamellic,
			Dystric Fluventic,
			Fluventic,
			Arenic,
			Dystric,
			Rendollic,
			Humic,
			Ruptic-Alfic,
			Typic.
		Dystrudepts	Humic Lithic,
			Lithic,
			Vertic,
			Aquandic,
			Andic,
			Vitrandic,
			Fragiaquic,
			Fluvaquentic,
			Aquic Humic,
			Aquic,
			Oxyaquic,
			Fragic,
			Lamellic,
			Humic Psammentic,
			Fluventic Humic,
			Fluventic,
			Spodic,
			Oxic,
			Humic Pachic,
			Humic,
			Ruptic-Alfic,
			Ruptic-Ultic,
			Typic.
Mollisols	Albolls	Natralbolls	Leptic,
			Typic.
		Argialbolls	Xerertic,
			Vertic,
			Argiaquic Xeric,
			Argiaquic,
			Xeric,
			Aquandic,
			Typic.
	Aquolls	Cryaquolls	Vertic,
			Histic,
			Thapto-Histic,
			Aquandic,
			Argic,
			Calcic,
			Cumulic,
			Typic.
		Duraquolls	Natric,
			Vertic,
			Argic,
			Typic.
		Natraquolls	Vertic,
			Typic.
		Calciaquolls	Petrocalcic,
			Aeric,
			Typic.
		Argiaquolls	Arenic,
			Grossarenic,
			Vertic,
			Abruptic,
			Typic.
		Epiaquolls	Cumulic Vertic,
			Fluvaquentic Vertic,
			Vertic,
			Histic,
			Thapto-Histic,
			Aquandic,
			Duric,
			Cumulic,
			Fluvaquentic,
			Typic.
		Endoaquolls	Lithic,
			Cumulic Vertic,
			Fluvaquentic Vertic,
			Vertic,
			Histic,
			Thapto-Histic,
			Aquandic,
			Duric,
			Cumulic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Fluvaquentic,
			Typic.
	Rendolls	Cryrendolls	Lithic,
			Typic.
		Haprendolls	Lithic,
			Vertic,
			Inceptic,
			Entic,
			Typic.
	Cryolls	Duricryolls	Argic,
			Typic.
		Natricryolls	Typic.
		Palecryrolls	Aquic,
			Oxyaquic,
			Abruptic,
			Pachic,
			Ustic,
			Xeric,
			Typic.
		Argicryolls	Lithic,
			Vertic,
			Andic,
			Vitrandic,
			Abruptic,
			Aquic,
			Oxyaquic,
			Pachic,
			Alfic,
			Ustic,
			Xeric,
			Typic.
		Calcicryolls	Lithic,
			Petrocalcic,
			Pachic,
			Ustic,
			Xeric,
			Typic.
		Haplocryolls	Lithic,
			Vertic,
			Andic,
			Vitrandic,
			Aquic Cumulic,
			Cumulic,
			Fluvaquentic,
			Aquic,
			Oxyaquic,
			Calcic Pachic,
			Pachic,
			Fluventic,
			Calcic,
			Ustic,
			Xeric,
			Typic.
	Xerolls	Durixerolls	Vertic,
			Vitritorrandic,
			Vitrandic,
			Aquic,
			Paleargidic,
			Abruptic Argiduridic,
			Cambidic,
			Haploduridic,
			Argidic,
			Argiduridic,
			Haplic Palexerollic,
			Palexerollic,
			Haplic Haploxerollic,
			Haploxerollic,
			Haplic,
			Typic.
		Natrixerolls	Vertic,
			Aquic Duric,
			Aquic,
			Aridic,
			Duric,
			Typic.
		Palexerolls	Vertic,
			Vitrandic,
			Aquic,
			Pachic,
			Petrocalcidic,
			Duric,
			Aridic,
			Petrocalcic,
			Ultic,
			Haplic,
			Typic.
		Calcixerolls	Lithic,
			Vertic,
			Aquic,
			Oxyaquic,
			Pachic,
			Vitrandic,
			Aridic,
			Vermic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Argixerolls	Lithic Ultic,
			Lithic,
			Torrertic,
			Vertic,
			Andic,
			Vitritorrandic,
			Vitrandic,
			Aquultic,
			Aquic,
			Oxyaquic,
			Alfic,
			Calcic Pachic,
			Pachic Ultic,
			Pachic,
			Argiduridic,
			Duric,
			Calciargidic,
			Aridic,
			Calcic,
			Ultic,
			Typic.
		Haploxerolls	Lithic Ultic,
			Lithic,
			Torrertic,
			Vertic,
			Vitritorrandic,
			Vitrandic,
			Aquic Cumulic,
			Cumulic Ultic,
			Cumulic,
			Fluvaquentic,
			Aquic Duric,
			Aquultic,
			Aquic,
			Oxyaquic,
			Calcic Pachic,
			Pachic Ultic,
			Pachic,
			Torrifluventic,
			Duridic,
			Calcidic,
			Torripsammentic,
			Torriorthentic,
			Aridic,
			Duric,
			Psammentic,
			Fluventic,
			Vermic,
			Calcic,
			Entic Ultic,
			Ultic,
			Entic,
			Typic.
	Ustolls	Durustolls	Natric,
			Haploduridic,
			Argiduridic,
			Entic,
			Haplic,
			Typic.
		Natrustolls	Leptic Torrertic,
			Torrertic,
			Leptic Vertic,
			Glossic Vertic,
			Vertic,
			Aridic Leptic,
			Leptic,
			Aquic,
			Aridic,
			Duric,
			Glossic,
			Typic.
		Calciustolls	Salidic,
			Lithic Petrocalcic,
			Lithic,
			Torrertic,
			Udertic,
			Vertic,
			Petrocalcic,
			Gypsic,
			Pachic,
			Aquic,
			Oxyaquic,
			Aridic,
			Udic,
			Typic.
		Paleustolls	Torrertic,
			Udertic,
			Vertic,
			Pachic,
			Aquic,
			Petrocalcic,
			Calcidic,
			Aridic,
			Udic,
			Calcic,
			Entic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Argiustolls	Aridic Lithic,
			Alfic Lithic,
			Lithic,
			Torrertic,
			Udertic,
			Vertic,
			Andic,
			Vitritorrandic,
			Vitrandic,
			Pachic,
			Aquic,
			Oxyaquic,
			Alfic,
			Calcidic,
			Aridic,
			Udic,
			Duric,
			Typic.
		Vermustolls	Lithic,
			Aquic,
			Pachic,
			Entic,
			Typic.
		Haplustolls	Salidic,
			Ruptic-Lithic,
			Lithic,
			Torrertic,
			Pachic Udertic,
			Udertic,
			Vertic,
			Torroxic,
			Oxic,
			Andic,
			Vitritorrandic,
			Vitrandic,
			Aquic Cumulic,
			Cumulic,
			Anthraquic,
			Fluvaquentic,
			Pachic,
			Aquic,
			Oxyaquic,
			Torrifluventic,
			Torriorthentic,
			Aridic,
			Fluventic,
			Duric,
			Udorthentic,
			Udic,
			Entic,
			Typic.
	Udolls	Natrudolls	Petrocalcic,
			Leptic Vertic,
			Glossic Vertic,
			Vertic,
			Leptic,
			Glossic,
			Calcic,
			Typic.
		Calciudolls	Lithic,
			Vertic,
			Aquic,
			Fluventic,
			Typic.
		Paleudolls	Vertic,
			Petrocalcic,
			Aquic,
			Pachic,
			Oxyaquic,
			Calcic,
			Typic.
		Argiudolls	Lithic,
			Aquertic,
			Oxyaquic Vertic,
			Pachic Vertic,
			Alfic Vertic,
			Vertic,
			Andic,
			Vitrandic,
			Aquic,
			Pachic,
			Oxyaquic,
			Lamellic,
			Psammentic,
			Arenic,
			Abruptic,
			Alfic,
			Oxic,
			Calcic,
			Typic.
		Vermudolls	Lithic,
			Haplic,
			Typic.
		Hapludolls	Lithic,
			Aquertic,
			Vertic,
			Andic,
			Vitrandic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Hapludolls (continued)	Aquic Cumulic,
			Cumulic,
			Fluvaquentic,
			Aquic,
			Pachic,
			Oxyaquic,
			Fluventic,
			Vermic,
			Calcic,
			Entic,
			Typic.
Oxisols	Aquox	Acraquox	Plinthic,
			Aeric,
			Typic.
		Plinthaquox	Aeric,
			Typic.
		Eutraquox	Histic,
			Plinthic,
			Aeric,
			Humic,
			Typic.
		Haplaquox	Histic,
			Plinthic,
			Aeric,
			Humic,
			Typic.
	Torrox	Acrotorrox	Petroferric,
			Lithic,
			Typic.
		Eutrotorrox	Petroferric,
			Lithic,
			Typic.
		Haplotorrox	Petroferric,
			Lithic,
			Typic.
	Ustox	Sombriustox	Petroferric,
			Lithic,
			Humic,
			Typic.
		Acrustox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Anionic Aquic,
			Anionic,
			Plinthic,
			Aquic,
			Eutric,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Eutrustox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Kandiustalfic,
			Humic Inceptic,
			Inceptic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Kandiustox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Haplustox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aqueptic,
			Aquic,
			Oxyaquic,
			Inceptic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Xanthic,
			Typic.
	Perox	Sombriperox	Petroferric,
			Lithic,
			Humic,
			Typic.
		Acroperox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Anionic,
			Plinthic,
			Aquic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Eutroperox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Kandiudalfic,
			Humic Inceptic,
			Inceptic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Kandiperox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Andic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Haploperox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Andic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
	Udox	Sombriudox	Petroferric,
			Lithic,
			Humic,
			Typic.
		Acrudox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Anionic Aquic,
			Anionic,
			Plinthic,
			Aquic,
			Eutric,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Eutrudox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Kandiudalfic,
			Humic Inceptic,
			Inceptic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Kandiudox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Andic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
		Hapludox	Aquic Petroferric,
			Petroferric,
			Aquic Lithic,
			Lithic,
			Plinthaquic,
			Plinthic,
			Aquic,
			Inceptic,
			Andic,
			Humic Rhodic,
			Humic Xanthic,
			Humic,
			Rhodic,
			Xanthic,
			Typic.
Spodosols	Aquods	Cryaquods	Lithic,
			Placic,
			Duric,
			Andic,
			Entic,
			Typic.
		Alaquods	Lithic,
			Duric,
			Histic,
			Alfic Arenic,
			Arenic Ultic,
			Arenic Umbric,
			Arenic,
			Grossarenic,
			Alfic,
			Ultic,
			Aeric,
			Typic.
		Fragiaquods	Histic,
			Plagganthreptic,
			Argic,
			Typic.
		Placaquods	Andic,
			Typic.
		Duraquods	Histic,
			Andic,
			Typic.
		Epiaquods	Lithic,
			Histic,
			Andic,
			Alfic,
			Ultic,
			Umbric,
			Typic.
		Endoaquods	Lithic,
			Histic,
			Andic,
			Argic,
			Umbric,
			Typic.
	Cryods	Placocryods	Andic,
			Humic,
			Typic.
		Duricryods	Aquandic,
			Andic,
			Aquic,
			Oxyaquic,
			Humic,
			Typic.
		Humicryods	Lithic,
			Aquandic,
			Andic,
			Aquic,
			Oxyaquic,
			Typic.
		Haplocryods	Lithic,
			Aquandic,
			Andic,
			Aquic,
			Oxyaquic,
			Entic,
			Typic.
	Humods	Placohumods	Andic,
			Typic.
		Durihumods	Andic,
			Typic.
		Fragihumods	Typic.
		Haplohumods	Lithic,
			Andic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Plagganthreptic,
			Typic.
	Orthods	Placorthods	Typic.
		Durorthods	Andic,
			Typic.
		Fragiorthods	Aquic,
			Alfic Oxyaquic,
			Oxyaquic,
			Plagganthreptic,
			Alfic,
			Ultic,
			Entic,
			Typic.
		Alorthods	Oxyaquic,
			Arenic Ultic,
			Arenic,
			Entic Grossarenic,
			Entic,
			Grossarenic,
			Plagganthreptic,
			Alfic,
			Ultic,
			Typic.
		Haplorthods	Entic Lithic,
			Lithic,
			Fragiaquic,
			Aqualfic,
			Aquentic,
			Aquic,
			Alfic Oxyaquic,
			Oxyaquic Ultic,
			Fragic,
			Lamellic,
			Oxyaquic,
			Andic,
			Alfic,
			Ultic,
			Entic,
			Typic.
Ultisols	Aquults	Plinthaquults	Kandic,
			Typic.
		Fragiaquults	Aeric,
			Plinthic,
			Umbric,
			Typic.
		Albaquults	Vertic,
			Kandic,
			Aeric,
			Typic.
		Kandiaquults	Acraquoxic,
			Arenic Plinthic,
			Arenic Umbric,
			Arenic,
			Grossarenic,
			Plinthic,
			Aeric,
			Umbric,
			Typic.
		Kanhaplaquults	Aquandic,
			Plinthic,
			Aeric Umbric,
			Aeric,
			Umbric,
			Typic.
		Paleaquults	Vertic,
			Arenic Plinthic,
			Arenic Umbric,
			Arenic,
			Grossarenic,
			Plinthic,
			Aeric,
			Umbric,
			Typic.
		Umbraquults	Plinthic,
			Typic.
		Epiaquults	Vertic,
			Aeric Fragic,
			Arenic,
			Grossarenic,
			Fragic,
			Aeric,
			Typic.
		Endoaquults	Arenic,
			Grossarenic,
			Aeric,
			Typic.
	Humults	Sombrihumults	Typic.
		Plinthohumults	Typic.
		Kandihumults	Andic Ombroaquic,
			Ustandic,
			Andic,
			Aquic,
			Ombroaquic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Kandihumults (continued)	Plinthic,
			Ustic,
			Xeric,
			Anthropic,
			Typic.
		Kanhaplohumults	Lithic,
			Ustandic,
			Andic,
			Aquic,
			Ombroaquic,
			Ustic,
			Xeric,
			Anthropic,
			Typic.
		Palehumults	Aquandic,
			Andic,
			Aquic,
			Plinthic,
			Oxyaquic,
			Ustic,
			Xeric,
			Typic.
		Haplohumults	Lithic,
			Aquandic,
			Aquic,
			Andic,
			Plinthic,
			Oxyaquic,
			Ustic,
			Xeric,
			Typic.
	Udults	Plinthudults	Typic.
		Fragiudults	Arenic,
			Plinthaquic,
			Glossaquic,
			Aquic,
			Plinthic,
			Glossic,
			Humic,
			Typic.
		Kandiudults	Arenic Plinthaquic,
			Aquic Arenic,
			Arenic Plinthic,
			Arenic Rhodic,
			Arenic,
			Grossarenic Plinthic,
			Grossarenic,
			Acrudoxic Plinthic,
			Acrudoxic,
			Plinthaquic,
			Aquandic,
			Andic,
			Aquic,
			Plinthic,
			Ombroaquic,
			Oxyaquic,
			Sombric,
			Rhodic,
			Typic.
		Kanhapludults	Lithic,
			Plinthaquic,
			Arenic Plinthic,
			Arenic,
			Acrudoxic,
			Fragiaquic,
			Andic,
			Aquic,
			Ombroaquic,
			Oxyaquic,
			Plinthic,
			Fragic,
			Rhodic,
			Typic.
		Paleudults	Vertic,
			Spodic,
			Arenic Plinthaquic,
			Aquic Arenic,
			Plinthaquic,
			Fragiaquic,
			Aquic,
			Anthraquic,
			Oxyaquic,
			Lamellic,
			Arenic Plinthic,
			Psammentic,
			Grossarenic Plinthic,
			Plinthic,
			Arenic Rhodic,
			Arenic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Grossarenic,
			Fragic,
			Rhodic,
			Typic.
		Rhodudults	Lithic,
			Psammentic,
			Typic.
		Hapludults	Lithic Ruptic-Entic,
			Lithic,
			Vertic,
			Fragiaquic,
			Aquic Arenic,
			Aquic,
			Fragic,
			Oxyaquic,
			Lamellic,
			Psammentic,
			Arenic,
			Grossarenic,
			Inceptic,
			Humic,
			Typic.
	Ustults	Plinthustults	Haplic,
			Typic.
		Kandiustults	Acrustoxic,
			Aquic,
			Arenic Plinthic,
			Arenic,
			Udandic,
			Andic,
			Plinthic,
			Aridic,
			Udic,
			Rhodic,
			Typic.
		Kanhapl-ustults	Lithic,
			Acrustoxic,
			Aquic,
			Arenic,
			Udandic,
			Andic,
			Plinthic,
			Ombroaquic,
			Aridic,
			Udic,
			Rhodic,
			Typic.

Order	Suborder	Great Group	Subgroup
		Paleustults	Typic.
		Rhodustults	Lithic,
			Psammentic,
			Typic.
		Haplustults	Lithic,
			Petroferric,
			Aquic,
			Arenic,
			Ombroaquic,
			Plinthic,
			Kanhaplic,
			Typic.
	Xerults	Palexerults	Aquandic,
			Aquic,
			Andic,
			Typic.
		Haploxerults	Lithic Ruptic-Inceptic,
			Lithic,
			Aquic,
			Andic,
			Lamellic,
			Psammentic,
			Arenic,
			Grossarenic,
			Typic.
Vertisols	Aquerts	Salaquerts	Aridic,
			Ustic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Duraquerts	Aridic,
			Xeric,
			Ustic,
			Aeric,
			Chromic,
			Typic.
		Natraquerts	Typic.
		Calciaquerts	Aeric,
			Typic.
		Dystraquerts	Sulfaqueptic,
			Aridic,
			Ustic,
			Aeric,
			Leptic,
			Entic,
			Chromic,
			Typic.

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
		Epiaquerts	Halic,
			Sodic,
			Aridic,
			Xeric,
			Ustic,
			Aeric,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Endoaquerts	Halic,
			Sodic,
			Aridic,
			Xeric,
			Ustic,
			Aeric,
			Leptic,
			Entic,
			Chromic,
			Typic.
	Cryerts	Humicryerts	Sodic,
			Typic.
		Haplocryerts	Sodic,
			Chromic,
			Typic.
	Xererts	Durixererts	Halic,
			Sodic,
			Aquic,
			Aridic,
			Udic,
			Haplic,
			Chromic,
			Typic.
		Calcixererts	Lithic,
			Petrocalcic,
			Aridic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Haploxererts	Lithic,
			Halic,
			Sodic,
			Aridic,
			Aquic,
			Udic,
			Leptic,
			Entic,
			Chromic,

Order	Suborder	Great Group	Subgroup
			Typic.
	Torrerts	Salitorrerts	Aquic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Gypsitorrerts	Chromic,
			Typic.
		Calcitorrerts	Petrocalcic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Haplotorrerts	Halic,
			Sodic,
			Leptic,
			Entic,
			Chromic,
			Typic.
	Usterts	Dystrusterts	Lithic,
			Aquic,
			Aridic,
			Udic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Salusterts	Lithic,
			Sodic,
			Aquic,
			Aridic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Gypsiusterts	Lithic,
			Halic,
			Sodic,
			Aridic,
			Udic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Calciusterts	Lithic,
			Halic,
			Sodic,
			Petrocalcic,
			Aridic,

Names of Orders, Suborders, Great Groups, and Subgroups--Continued

Order	Suborder	Great Group	Subgroup
			Udic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Haplusterts	Lithic,
			Halic,
			Sodic,
			Petrocalcic,
			Gypsic,
			Calcic,
			Aridic Leptic,
			Aridic,
			Leptic Udic,
			Entic Udic,
			Chromic Udic,
			Udic,
			Leptic,
			Entic,
			Chromic,
			Typic.
	Uderts	Dystruderts	Aquic,
			Oxyaquic,
			Leptic,
			Entic,
			Chromic,
			Typic.
		Hapluderts	Lithic,
			Aquic,
			Oxyaquic,
			Leptic,
			Entic,
			Chromic,
			Typic.

subgroup. Using an adjective taken from the suborder ("Udic") would not suggest that the difference is one of aeration alone.

If the only aberrant feature of a Hapludult is redoximorphic features that are too shallow for a Typic Hapludult, the adjective *Aquic* is used in the subgroup name. If redox depletions (accompanied by aquic conditions unless the soils are artificially drained) appear within the upper 60 cm of the argillic horizon, the soil is called an Aquic Hapludult, not an Aquultic Hapludult.

In other instances, the adjective in the subgroup name is made from the first two formative elements of the appropriate great group name in that suborder. For example, if a Paleudult has both shallow redoximorphic features and some plinthite, it is called a Plinthaquic Paleudult, not a Plinthaquultic Paleudult. Note that the formative element for the order is not repeated in the adjective if the two great groups are in the same order.

Names of Intergrades Toward Great Groups in Other Orders

If a Hapludalf has a surface horizon that is too dark for a Typic subgroup and approaches the properties of the surface horizons of Mollisols, the soil is considered to intergrade to one of the great groups of Mollisols. If the only aberrant feature is the nature of the surface horizon, the soil is called a Mollic Hapludalf. This soil has the feature that is common to all Mollisols, and only the prior formative element of the order name is used. If, in addition, the soil has gray redox depletions in the upper part of the argillic horizon, it is considered an intergrade toward Aquolls and is called an Aquollic Hapludalf. Note that this name is simpler than "Aquic Mollic Hapludalf." The general rule is that the simplest possible name is used. If there are several aberrant features, the adjectival forms of one or more great group names may be required. An exception is the adjective *Argic* when used in great groups of Aquods. Rather than intergrading to one specific taxon, Argic subgroups intergrade to orders that have argillic horizons, specifically Alfisols and Ultisols.

Names of Subgroups not Intergrading Toward Any Known Kind of Soil (Extragrades)

Some soils have aberrant properties that are not characteristic of a class in a higher category of any order, suborder, or great group. One example might be taken from the concave pedons that are at the base of slopes, in depressions, or in other areas where new soil material accumulates slowly on the surface. In these soils material is added to the A horizon. The presence of an overthickened A horizon is not used to define any great group, but the soils lie outside the range of the Typic subgroup and there is no class toward which they intergrade. Hence, a descriptive adjective is required. For this particular situation, the adjective *Cumulic* (L. *cumulus*, heap, plus *ic*, Gr. *ikos*) is used to form the subgroup names. *Pachic* is used to indicate an overthickened epipedon if there is no evidence of new material at the surface.

Other soils lie outside the range of Typic subgroups in an opposite direction. Such soils are, in effect, truncated by hard rock and are shallow or are intermittent between rock outcrops. They are, in effect, intergrades to nonsoil and are called Lithic subgroups. The names of formative elements in groups of this sort, which are called extragrades, are listed together with their derivation in the table "Adjectives in Names of Extragrades and Their Meaning."

Adjectives in Names of Extragrades and Their Meaning

Adjective	Derivation	Connotation
Abruptic	L. *abruptus*, torn off	Abrupt textural change.
Aeric[1]	Gr. *aerios*, air	Aeration.
Albic	L. *albus*, white	Presence of an albic horizon.
Alic	Modified from aluminum	High Al^{3+} status.
Anionic	Gr. *anion*	Positively charged colloid.
Anthraquic	Modified from Gr. *anthropos*, human, and L. *aqua*, water	Controlled flooding.
Anthropic	Modified from Gr. *anthropos*, human	An anthropic epipedon.
Arenic	L. *arena*, sand	Sandy material between 50 and 100 cm thick.
Calcic	L. *calis*, lime	Presence of a calcic horizon.
Chromic	Gr. *chroma*, color	High chroma.
Cumulic	L. *cumulus*, heap	Thickened epipedon.
Durinodic	L. *durus*, hard	Presence of durinodes.
Eutric	Modified from Gr. *eu*, good; eutrophic, fertile	High base status.
Fragic	Modified from L. *fragilis*, brittle	Presence of fragic properties.
Glacic	L. *glacialis*, icy	Presence of ice lenses or wedges.
Glossic	Gr. *glossa*, tongue	Tongued horizon boundaries.
Grossarenic	L. *grossus*, thick, and L. *arena*, sand	Thick sandy layer.
Gypsic	L. *gypsum*, gypsum	Presence of a gypsic horizon.
Halic	Gr. *hals*, salt	Salty.
Humic	L. *humus*, earth	Presence of organic matter.
Hydric	Gr. *hydor*, water	Presence of water.
Kandic	Modified from kandite	Presence of 1:1 layer silicate clays.
Lamellic	L. *lamella*, dim	Presence of lamellae.
Leptic	Gr. *leptos*, thin	A thin soil.
Limnic	Modified from Gr. *limn*, lake	Presence of a limnic layer.
Lithic	Gr. *lithos*, stone	Presence of a shallow lithic contact.
Natric	Modified from *natrium*, sodium	Presence of sodium.
Nitric	Modified from *nitron*	Presence of nitrate salts.
Ombroaquic	Gr. *ombros*, rain, and aquic	Surface wetness.
Oxyaquic	Oxy, representing oxygen, and aquic	Aerated.
Pachic	Gr. *pachys*, thick	A thick epipedon.
Petrocalcic	Gr. *petra*, rock, and calcic from calcium	Presence of a petrocalcic horizon.
Petroferric	Gr. *petra*, rock, and L. *ferrum*, iron	Presence of a petroferric contact (ironstone).
Petrogypsic	Gr. *petra*, rock, and L. *gypsum*, gypsum	Presence of a petrogypsic horizon.
Petronodic	Modified from *petra*, rock, and *nodulus*, a little knot	Presence of concretions and/or nodules.
Placic	Gr. base of *plax*, flat stone	Presence of a thin pan (placic horizon).
Plinthic	Modified from Gr. *plinthos*, brick	Presence of plinthite.
Rhodic	Gr. base of *rhodon*, rose	Dark red color.
Ruptic[1]	L. *ruptum*, broken	Intermittent or broken horizons.
Sodic	Modified from sodium	Presence of sodium salts.
Sombric	F. *sombre*, dark	Presence of a sombric horizon.
Sulfic	L. *sulfur*, sulfur	Presence of sulfides or their oxidation products.
Terric	L. *terra*, earth	A mineral substratum.
Thapto(ic)[1]	Gr. *thapto*, buried	A buried soil.
Umbric	L. base of *umbra*, shade	Presence of an umbric epipedon.
Xanthic	Gr. *xanthos*	Yellow.

[1] Not strictly an extragrade. Name used to indicate a special departure from the Typic subgroup.

Names of Multiple Subgroups Intergrading Between Two Given Great Groups

Two or more subgroups in a given great group may be intergrades to the same class of soil or even to nonsoil. In one area, for example, the horizons may be continuous; in another, discontinuous; and in a third, buried. Also, the properties of two classes may be mixed in a single horizon in one area but may be in separate horizons in another area. A soil of class X may be developing from or toward class Y, producing subgroups that have different properties.

If the intergrade is one in which horizons are intermittent, the adjective *Ruptic* (L. *ruptum*, broken) is used in the subgroup name. The substantive in the name is the one for the kind of soil having the greatest area in the pedon; the adjectives are formed from the names of the kinds that have the lesser area, preceded by the adjective *Ruptic* and connected by hyphens. Thus, if X is dominant and Y is minor, the soil is named Ruptic-Yic X. For example, Ruptic-Lithic Haplustolls have a lithic contact only in part of each pedon. If the entire pedon were lithic and the argillic horizon of the Haploxerult were intermittent, the name would be Lithic Ruptic-Inceptic Haploxerults. The general rule is that modifiers are hyphenated if they apply to only part of the pedon. No hyphens are used if the modifier applies to the entire pedon.

If the subgroup is one in which a buried soil is an important part of the present soil, the name includes *Thapto* (Gr. *thapto*, buried) as a modifier of the name of the buried soil. Hyphens are used to connect *Thapto* with the name of the buried soil, except in the order Andisols, where the name of the buried soil is omitted. In Thaptic subgroups of Andisols, the buried soil is normally an Andisol. Thus, soil X that includes a buried soil, Y, is called Thapto-Yic X. A Humaquept that has a histic epipedon is called a Histic Humaquept, but a Fluvaquent in which a Histosol or Histic epipedon has been buried is called a Thapto-Histic Fluvaquent.

Arrangement of modifiers.—Modifiers are arranged alphabetically, for example, Aquic Arenic Hapludults.

Names of Families

Each family requires one or more names. The technical family name consists of a series of descriptive terms modifying the subgroup name. For these terms we take the class names that are given in chapter 21 for particle-size class, mineralogy, and so on, in family differentiae. The descriptive terms in the names of families are given in a consistent order, which is as follows: particle-size class, mineralogy class, cation-exchange activity class, calcareous and reaction class, soil temperature class, soil depth class, rupture resistance class, classes of coatings, and classes of cracks.

Redundancy in the names of families should be avoided. Particle-size class and temperature classes should not be used in the family name if they are specified above the family level. Psamments, by definition, all have a sand or loamy sand texture and are in a sandy particle-size class, unless they are ashy. It is therefore redundant to specify a particle-size class for Psamments, unless they are ashy.

Rules of Nomenclature

For uniformity, certain rules are followed.

First, the names are considered to be modern vernacular nouns. They are treated as masculine nouns in languages that have grammatical gender. While only the names of the orders have a suffix meaning "soil," this meaning is understood to be included in all names. Thus, the names are not to be converted to adjectives that modify the word "soil." The prior (first) formative elements of the names of suborders and great groups can be converted to adjectives that modify the name of the category. Thus, one may speak of Aquic great groups, referring to all taxa of that rank with names that include the formative element *aqu*.

Second, plural forms of the nouns conform to the rules of the language in which the names are used. If a final vowel or suffix allows the name to fit better into a particular language, it can be added as needed.

Third, adjectives are formed by adding the suffix *ikos* (Gr.), shortened or adapted to the modern vernaculars according to the rules of the language used. For example, in English the ending is *ic*; in French, *ique*; and in German, *isch*. Adjectival forms are placed in the position that is normal for the language in which they are used.

Fourth, the names of the orders, suborders, and great groups are treated as proper nouns, and the first letter is capitalized. The adjectival forms of these names may be capitalized or not, depending on the conventions of printing in the language in which they are used. In the United States, each word in a subgroup name is capitalized.

Fifth, pronunciation of the names follows the rules of the modern vernacular in the language in which the words are used.

Use of Single Formative Elements

The names in the tables "Formative Elements in Names of Soil Orders," "Formative Elements in Names of Suborders," and "Formative Elements in Names of Great Groups" are not the only possible names or uses of the formative elements. There is considerable repetition in the use of a number of formative elements. *Aqu***,** for example, is the prior (first) formative element in the names of nine suborders. In this position, it implies that the soils are completely saturated with water at some season and that they show the effects of permanent or periodic reduction of iron to the ferrous state. If one wishes to specify all mineral soils that are permanently or periodically wet, one may use the appropriate formative element to modify the name of a category and speak of Aquic suborders or Aquic great groups. Such a use of *Aquic* is equivalent to creating an order with all these suborders.

It is necessary, however, to specify the categoric level of the taxa. *Aquic* also is used to define subgroups of soils that are not in Aquic suborders but that have shallow ground water at some period and have the required redox criteria at a depth generally of more than 50 cm. Aquic subgroups are not so wet as Aquic suborders. One should not speak of aquic soils if one means Aquic suborders or Aquic subgroups.

If it serves one's purpose, many formative elements that are repeated in the names of taxa can be used to alter the hierarchy for the moment and to call to mind all the soils with the property one wishes to consider. The soils in the Cryic suborder and Gelisol order bring together all the cold soils. Calcic great groups bring together all the soils that have a horizon of appreciable accumulation of carbonates, and so on. The nomenclature permits a flexible classification in which emphasis can be shifted as needed to any of a number of important properties that are subordinated in the arrangement shown in the table "Names of Orders, Suborders, Great Groups, and Subgroups."

Literature Cited

Heller, J.L. 1963. The Nomenclature of Soils or What's in a Name? Soil Sci. Soc. Amer. Proc. 27: 216-220.

CHAPTER 8

Identification of the Taxonomic Class of a Soil

The taxonomic class of a specific soil can be determined by using the keys that follow in this and other chapters. It is assumed that the reader is familiar with the definitions of diagnostic horizons and properties that are given in chapters 3 and 4 of this publication and with the meanings of the terms used for describing soils given in the *Soil Survey Manual*. The Index at the back of this publication indicates the pages on which definitions of terms are given.

Standard rounding conventions should be used to determine numerical values.

Soil colors (hue, value, and chroma) are used in many of the criteria that follow. Soil colors typically change value and some change hue and chroma, depending on the water state. In many of the criteria of the keys, the water state is specified. If no water state is specified, the soil is considered to meet the criterion if it does so when moist or dry or both moist and dry.

All of the keys in this taxonomy are designed in such a way that the user can determine the correct classification of a soil by going through the keys systematically. The user must start at the beginning of the "Key to Soil Orders" and eliminate, one by one, all classes that include criteria that do not fit the soil in question. The soil belongs to the first class listed for which it meets all the required criteria.

In classifying a specific soil, the user of soil taxonomy begins by checking through the "Key to Soil Orders" to determine the name of the first order that, according to the criteria listed, includes the soil in question. The next step is to go to the page indicated to find the "Key to Suborders" of that particular order. Then the user systematically goes through the key to identify the suborder that includes the soil, i.e., the first in the list for which it meets all the required criteria. The same procedure is used to find the great group class of the soil in the "Key to Great Groups" of the identified suborder. Likewise, going through the "Key to Subgroups" of that great group, the user selects as the correct subgroup name the name of the first taxon for which the soil meets all of the required criteria.

The family level is determined, in a similar manner, after the subgroup has been determined. Chapter 21 can be used, as one would use other keys in this taxonomy, to determine which components are part of the family. The family, however, typically has more than one component, and therefore the entire chapter must be used. The keys to control sections for classes used as components of a family must be used to determine the control section before use of the keys to classes.

The descriptions and definitions of individual soil series are not included in this text. Definitions of the series and of the control section and examples of the application are given in chapter 21. The classification of the series and the list of families and their included series for the soils of the 50 States, Puerto Rico, and the Virgin Islands are given in another publication (Soil Series of the United States, Including Puerto Rico and the Virgin Islands: Their Taxonomic Classification). That publication does not include the descriptions or definitions of the series, but descriptions of specific series are available on request from the Natural Resources Conservation Service. No one publication includes descriptions of all the series.

In the "Key to Soil Orders" and the other keys that follow, the diagnostic horizons and the properties mentioned do not include those below any densic, lithic, paralithic, or petroferric contact. The properties of buried soils and the properties of a surface mantle are considered on the basis of whether or not the soil meets the meaning of the term "buried soil" given in chapter 1.

If a soil has a surface mantle and is not a buried soil, the top of the original surface layer is considered the "soil surface" for determining depth to and thickness of diagnostic horizons and most other diagnostic soil characteristics. The only properties of the surface mantle that are considered are soil temperature, soil moisture (including aquic conditions), any andic or vitrandic properties, and family criteria.

If a soil profile includes a buried soil, the present soil surface is used to determine soil moisture and temperature as well as depth to and thickness of diagnostic horizons and other diagnostic soil characteristics. Diagnostic horizons of the buried soil are not considered in selecting taxa unless the criteria in the keys specifically indicate buried horizons, such as in Thapto-Histic subgroups. Most other diagnostic soil characteristics of the buried soil are not considered, but organic carbon if of Holocene age, andic soil properties, base saturation, and all properties used to determine family and series placement are considered.

Key to Soil Orders

A. Soils that have:

1. Permafrost within 100 cm of the soil surface; *or*

2. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Gelisols, p. 445

B. Other soils that:

1. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

2. Have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[1] *and* directly below these materials, have a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more per year in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

Histosols, p. 473

C. Other soils that do not have a plaggen epipedon or an argillic or kandic horizon above a spodic horizon, *and* have *one or more* of the following:

1. A spodic horizon, an albic horizon in 50 percent or more of each pedon, and a cryic soil temperature regime; *or*

2. An Ap horizon containing 85 percent or more spodic materials; *or*

3. A spodic horizon with *all* of the following characteristics:

a. *One or more* of the following:

(1) A thickness of 10 cm or more; *or*

(2) An overlying Ap horizon; *or*

(3) Cementation in 50 percent or more of each pedon; *or*

(4) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature regime in the soil; *or*

(5) A cryic temperature regime in the soil; *and*

b. An upper boundary within the following depths from the mineral soil surface: *either*

(1) Less than 50 cm; *or*

(2) Less than 200 cm if the soil has a sandy particle-size class in at least some part between the mineral soil surface and the spodic horizon; *and*

c. A lower boundary as follows:

(1) *Either* at a depth of 25 cm or more below the mineral soil surface or at the top of a duripan or fragipan or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(2) At any depth,

(a) If the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime; *or*

(b) If the soil has a cryic temperature regime; *and*

d. *Either*:

(1) A directly overlying albic horizon in 50 percent or more of each pedon; *or*

(2) No andic soil properties in 60 percent or more of the thickness *either*:

(a) Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

(b) Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or

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[1] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

paralithic contact, a duripan, or a petrocalcic horizon.

Spodosols, p. 695

D. Other soils that have andic soil properties in 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Andisols, p. 271

E. Other soils that have *either*:

1. An oxic horizon that has its upper boundary within 150 cm of the mineral soil surface and no kandic horizon that has its upper boundary within that depth; *or*

2. 40 percent or more (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18 cm (after mixing) *and* a kandic horizon that has the weatherable-mineral properties of an oxic horizon and has its upper boundary within 100 cm of the mineral soil surface.

Oxisols, p. 655

F. Other soils that have:

1. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has *either* slickensides *or* wedge-shaped peds that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

2. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, *and* 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

3. Cracks[2] that open and close periodically.

Vertisols, p. 783

G. Other soils that:

1. Have:

a. An aridic soil moisture regime; *and*

b. An ochric or anthropic epipedon; *and*

c. *One or more* of the following with the upper boundary within 100 cm of the soil surface: a cambic horizon with a lower depth of 25 cm or more; a cryic temperature regime and a cambic horizon; a calcic, gypsic, petrocalcic, petrogypsic, or salic horizon; or a duripan; *or*

d. An argillic or natric horizon; *or*

2. Have a salic horizon; *and*

a. Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more during a normal year; *and*

b. A moisture control section that is dry in some or all parts at some time during normal years; *and*

c. No sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface.

Aridisols, p. 329

H. Other soils that have *either*:

1. An argillic or kandic horizon, but no fragipan, and a base saturation (by sum of cations) of less than 35 percent at one of the following depths:

a. If the epipedon has a sandy or sandy-skeletal particle-size class throughout, *either*:

(1) 125 cm below the upper boundary of the argillic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(2) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

b. The shallowest of the following depths:

(1) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(2) 180 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact; *or*

2. A fragipan and *both* of the following:

a. Either an argillic or a kandic horizon above, within, or below it or clay films 1 mm or more thick in one or more of its subhorizons; *and*

b. A base saturation (by sum of cations) of less than 35 percent at the shallowest of the following depths:

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[2] A crack is a separation between gross polyhedrons. If the surface is strongly self-mulching, i.e., a mass of granules, or if the soil is cultivated while cracks are open, the cracks may be filled mainly by granular materials from the surface, but they are open in the sense that the polyhedrons are separated. A crack is regarded as open if it controls the infiltration and percolation of water in a dry, clayey soil.

(1) 75 cm below the upper boundary of the fragipan; *or*

(2) 200 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact.

Ultisols, p. 721

I. Other soils that have *both* of the following:

1. *Either*:

a. A mollic epipedon; *or*

b. *Both* a surface horizon that meets all the requirements for a mollic epipedon except thickness after the soil has been mixed to a depth of 18 cm *and* a subhorizon more than 7.5 cm thick, within the upper part of an argillic, kandic, or natric horizon, that meets the color, organic-carbon content, base saturation, and structure requirements of a mollic epipedon but is separated from the surface horizon by an albic horizon; *and*

2. A base saturation of 50 percent or more (by NH_4OAc) in all horizons *either* between the upper boundary of any argillic, kandic, or natric horizon and a depth of 125 cm below that boundary, *or* between the mineral soil surface and a depth of 180 cm, *or* between the mineral soil surface and a densic, lithic, or paralithic contact, whichever depth is shallowest.

Mollisols, p. 555

J. Other soils that do not have a plaggen epipedon and that have *either*:

1. An argillic, kandic, or natric horizon; *or*

2. A fragipan that has clay films 1 mm or more thick in some part.

Alfisols, p. 163

K. Other soils that have *either*:

1. *One or more* of the following:

a. A cambic horizon with its upper boundary within 100 cm of the mineral soil surface and its lower boundary at a depth of 25 cm or more below the mineral soil surface; *or*

b. A calcic, petrocalcic, gypsic, petrogypsic, or placic horizon or a duripan with an upper boundary within a depth of 100 cm of the mineral soil surface; *or*

c. A fragipan or an oxic, sombric, or spodic horizon with an upper boundary within 200 cm of the mineral soil surface; *or*

d. A sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

e. A cryic temperature regime and a cambic horizon; *or*

2. No sulfidic materials within 50 cm of the mineral soil surface; *and both*:

a. In one or more horizons between 20 and 50 cm below the mineral soil surface, either an *n* value of 0.7 or less or less than 8 percent clay in the fine-earth fraction; *and*

b. *One or both* of the following:

(1) A salic horizon or a histic, mollic, plaggen, or umbric epipedon; *or*

(2) In 50 percent or more of the layers between the mineral soil surface and a depth of 50 cm, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more), which decreases with increasing depth below 50 cm, *and* also ground water within 100 cm of the mineral soil surface at some time during the year when the soil is not frozen in any part.

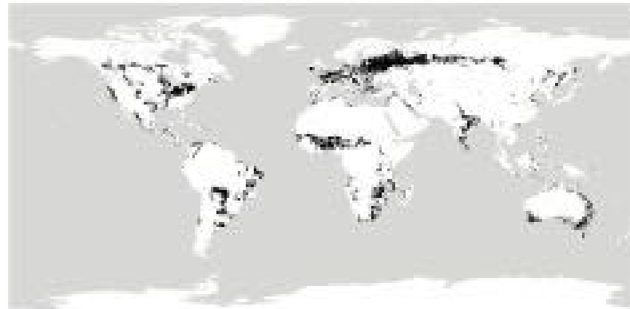
Inceptisols, p. 489

L. Other soils.

Entisols, p. 389

Literature Cited

United States Department of Agriculture, Soil Conservation Service. 1990. Soil Series of the United States, Including Puerto Rico and the Virgin Islands: Their Taxonomic Classification. Misc. Pub. 1483.



CHAPTER 9

Alfisols

The central concept of Alfisols is that of soils that have an ochric epipedon, an argillic horizon, and moderate to high base saturation and in which water is held at less than 1500 kPa tension during at least 3 months each year when the soils are warm enough for plants to grow. Alfisols may also have a fragipan, a duripan, a kandic horizon, a natric horizon, a petrocalcic horizon, plinthite, or other features, and these features are used in defining the great groups within the order. A very few Alfisols that are very wet during part of the year have an umbric epipedon.

Alfisols that have a thermic or warmer soil temperature regime tend to form a belt between the Aridisols of arid regions and the Inceptisols, Ultisols, and Oxisols in areas of warm, humid climates. Where the soil temperature regime is mesic or cooler, the Alfisols in the United States tend to form a belt between the Mollisols of the grasslands and the Spodosols and Inceptisols in areas of very humid climates.

In regions of mesic and frigid soil temperature regimes, Alfisols are mostly on late-Pleistocene deposits or surfaces. In warmer regions, they are on late-Pleistocene or older surfaces if there are only infrequent years when the soils lose bases by leaching or if there is an external source of bases, such as calcareous dust from a desert.

Most Alfisols have a udic, ustic, or xeric moisture regime, and many have aquic conditions. Alfisols are not known to have a perudic moisture regime. Leaching of bases from the soils may occur almost every year or may be infrequent.

Definition of Alfisols and Limits Between Alfisols and Soils of Other Orders

The definition of Alfisols must provide criteria that separate Alfisols from all other orders. The aggregate of these criteria defines the limits of Alfisols in relation to all other known soils.

Alfisols are mineral soils that meet *all* of the following:

1. Unlike Histosols, Alfisols do not have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[1] *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more;

2. Unlike Spodosols, Alfisols do not have a spodic horizon or an Ap horizon containing 85 percent or more spodic materials above the argillic, kandic, or natric horizon and do not have *one or more* of the following:

a. An albic horizon in 50 percent or more of each pedon and a cryic soil temperature regime; *or*

b. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid soil temperature regime; *or*

(e) A cryic soil temperature regime; *and*

[1] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy particle-size class between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface *or* at the top of a duripan or fragipan or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth if the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime, *or* if the soil has a cryic temperature regime;

3. Unlike Andisols, Alfisols have andic soil properties in less than 60 percent of the thickness *either*:

a. Within 60 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon;

4. Unlike Gelisols, Alfisols do not have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

5. Unlike Oxisols, Alfisols do not have:

a. An oxic horizon that has its upper boundary within 150 cm of the mineral soil surface, unless the soil also has *both* an argillic or kandic horizon that has its upper boundary within that depth *and* less than 40 percent (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18 cm (after mixing) or more than 10 percent weatherable minerals; *and*

b. *Both* of the following: (1) a kandic horizon that has less than 10 percent weatherable minerals and has an upper boundary within 150 cm of the mineral soil surface *and* (2) 40 percent or more (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18 cm (after mixing);

6. Unlike Vertisols, Alfisols do not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has *either* slickensides close enough to intersect *or* wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, *and* 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks[2] that open and close periodically;

7. Unlike Aridisols, Alfisols do not have an aridic soil moisture regime;

8. Unlike Ultisols, Alfisols have *either*:

a. An argillic or kandic horizon, but no fragipan, and a base saturation (by sum of cations) of 35 percent or more at *one* of the following depths:

(1) In an epipedon that has a sandy or sandy-skeletal particle-size class throughout, *either*:

(a) 125 cm below the upper boundary of the argillic or kandic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(b) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

(2) The shallowest of the following depths:

(a) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(b) 180 cm below the mineral soil surface; *or*

(c) At a densic, lithic, paralithic, or petroferric contact; *or*

b. A fragipan and a base saturation (by sum of cations) of 35 percent or more at the shallowest of the following depths:

(1) 75 cm below the upper boundary of the fragipan; *or*

(2) 200 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact;

9. Unlike Mollisols, Alfisols do not have *both*:

a. A mollic epipedon *or both* a surface horizon that meets

[2] A crack is a separation between gross polyhedrons. If the surface is strongly self-mulching, i.e., a mass of granules, or if the soil is cultivated while cracks are open, the cracks may be filled mainly by granular materials from the surface, but they are open in the sense that the polyhedrons are separated. A crack is regarded as open if it controls the infiltration and percolation of water in a dry, clayey soil.

all of the requirements for a mollic epipedon except thickness after the surface soil has been mixed to a depth of 18 cm, *and* a subhorizon more than 7.5 cm thick, within the upper part of an argillic, kandic, or natric horizon, that meets the color, organic-carbon content, base saturation, and structure requirements of a mollic epipedon but is separated from the surface horizon by an albic horizon; *and*

b. A base saturation of 50 percent or more (by NH_4OAc) in all horizons *either* between the upper boundary of any argillic, kandic, or natric horizon and a depth of 125 cm below that boundary, *or* between the mineral soil surface and a depth of 180 cm, *or* between the mineral soil surface and a densic, lithic, or paralithic contact, whichever depth is shallowest;

10. Unlike Inceptisols and Entisols, Alfisols have *either*:

a. An argillic, kandic, or natric horizon; *or*

b. A fragipan that has clay films 1 mm or more thick in some part.

Representative Pedon and Data

Following is a description of a representative Alfisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Alfisol."

Classification: Fine, mixed, semiactive, isohyperthermic Typic Haplustalf
Site identification number: 90P0621
Location: Killikulam Agriculture College, India
Latitude: 09 degrees, 00 minutes 00 seconds N.
Longitude: 78 degrees 00 minutes 00 seconds E.
Landscape: Plains
Microrelief: Land leveled or smooth
Slope: Plane
Elevation: 23 m above m.s.l.
Permeability class: Moderate
Drainage class: Well drained
Land use: Cropland
Vegetation: Foxtail millet
Hazard of erosion or deposition: Slight
Parent material: Alluvium derived from igneous material over igneous rock
Diagnostic horizons: An ochric epipedon from a depth of 0 to 23 cm and an argillic horizon from a depth of 23 to 115 cm
Described by: M. Janakiraman, S. Ramu, and R.J. Engel

In the following pedon description, colors are for dry soil unless otherwise indicated.

Ap—0 to 13 cm; yellowish red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; common fine roots throughout; many very fine and fine interstitial and tubular pores; common medium rounded iron-manganese concretions; 5 percent igneous pebbles; clear smooth boundary.

BAt—13 to 23 cm; red (2.5YR 4/6) gravelly sandy clay loam, dark red (2.5YR 3/6) moist; moderate fine subangular blocky structure; slightly hard, friable, sticky and plastic; few fine roots throughout; many fine and medium interstitial and tubular pores; few faint clay films on faces of peds and in pores; common medium rounded iron-manganese concretions; 30 percent igneous pebbles; abrupt smooth boundary.

Bt1—23 to 36 cm; dark reddish brown (2.5YR 3/4) sandy clay, dark reddish brown (2.5YR 3/4) moist; strong fine subangular blocky structure; friable, very sticky and plastic; few fine roots throughout; common fine interstitial and tubular pores; few faint clay films on faces of peds and in pores; common medium rounded iron-manganese concretions; 5 percent igneous pebbles; clear wavy boundary.

Bt2—36 to 48 cm; dark reddish brown (2.5YR 3/4) sandy clay, dark red (2.5YR 3/6) moist; strong medium angular blocky structure; very friable, very sticky and plastic; few fine roots throughout; common fine interstitial and tubular pores; few faint clay films on faces of peds and in pores; common medium rounded iron-manganese concretions; 10 percent igneous pebbles; clear smooth boundary.

Bt3—48 to 81 cm; dark reddish brown (2.5YR 3/4) very gravelly sandy clay, dark red (2.5YR 3/6) moist; strong medium subangular blocky structure; friable, very sticky and plastic; few fine roots throughout; common fine and medium interstitial and tubular pores; few faint clay films on faces of peds and in pores; common medium rounded iron-manganese concretions; 40 percent igneous pebbles; gradual broken boundary.

BCt—81 to 115 cm; yellowish red (5YR 5/6) extremely gravelly sandy clay and weathered bedrock, 50 percent yellowish red (5YR 4/6) and 50 percent reddish yellow (5YR 6/8) moist; moderate fine subangular blocky structure; very friable, very sticky and plastic; few fine roots throughout; common fine and medium interstitial and tubular pores; few faint clay films on faces of peds and in pores; common medium rounded iron-manganese concretions; 65 percent igneous pebbles; clear broken boundary.

Cr—115 to 130 cm; reddish yellow (5YR 6/8), moist, weathered bedrock; massive.

Key to Suborders

JA. Alfisols that have, in one or more horizons within 50 cm of the mineral soil surface, aquic conditions (other than anthraquic conditions) for some time in normal years (or artificial drainage) *and* have *one or both* of the following:

Characterization Data for an Alfisol

SITE IDENTIFICATION NO.: 90P0621
CLASSIFICATION: FINE, MIXED, SEMIACTIVE, ISOHYPERTHERMIC TYPIC HAPLUSTALF
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	-1- CLAY LT .002	-2- SILT .002 -.05	-3- SAND .05 -2	-4- FINE CLAY LT .0002	-5- CO_3 CLAY LT .002	-6- FINE SILT .002 -.02	-7- COARSE SILT .02 -.05	-8- VF SAND .05 -.10	-9- F SAND .10 -.25	-10- M SAND .25 -.50	-11- C SAND .5 -1	-12- VC SAND 1 -2	-13- WEIGHT 2 -5	-14- WEIGHT 5 -20	-15- WEIGHT 20 -75	-16- WEIGHT .1- 75	-17- (>2mm) WT PCT OF WHOLE SOIL
			(- - -TOTAL - - -)			(- -CLAY- -)		(- -SILT- -)		(- - - - - -SAND- - - - - - -)					(-COARSE FRACTIONS(mm)-)				(>2mm)
			<- - - Pct of <2mm (3A1) - - ->												<- Pct of <75mm(3B1)->				
90P3691	0- 13	Ap	28.0	12.3	59.7	21.4		6.6	5.7	12.5	15.8	12.4	11.5	7.5	8	TR	--	51	8
90P3692	13- 23	BAt	17.9	8.6	73.5	12.8		3.4	5.2	11.6	18.5	14.9	14.3	14.2	13	TR	--	67	13
90P3693	23- 36	Bt1	36.9	8.5	54.6	28.1		3.5	5.0	7.4	13.6	12.4	11.7	9.5	6	TR	--	50	6
90P3694	36- 48	Bt2	48.2	9.1	42.7	39.5		4.8	4.3	7.3	10.0	9.1	7.9	8.4	8	1	--	41	9
90P3695	48- 81	Bt3	44.7	9.7	45.6	35.3		5.3	4.4	7.0	8.2	7.4	7.7	15.3	24	2	--	55	26
90P3696	81-115	BCt	45.5	12.6	41.9	30.5		7.3	5.3	6.4	9.4	6.2	5.5	14.4	32	20	1	70	53
90P3697	115-130	Cr1	16.9	13.3	69.8	10.2		6.9	6.4	15.5	24.3	13.9	8.7	7.4	11	2	--	60	13

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	DITH-CIT Al 6G7a	DITH-CIT Mn 6D2a	(RATIO/CLAY) CEC 8D1	(RATIO/CLAY) 15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A3a	BULK DENSITY 1/3 BAR 4A1d	BULK DENSITY OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	WATER CONTENT 1/10 BAR 4B1c	WATER CONTENT 1/3 BAR 4B1c	WATER CONTENT 15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 13	0.68							0.60	0.37				1.62	1.77	0.028			15.7	10.4	0.08
13- 23	0.15							0.40	0.37				1.67	1.77	0.018			13.2	6.7	0.10
23- 36	0.23							0.35	0.33				1.63	1.73	0.019			15.3	12.3	0.05
36- 48	0.22							0.35	0.34				1.59	1.77	0.034			20.5	16.3	0.06
48- 81	0.13							0.39	0.32										14.3	
81-115	0.09							0.50	0.37				1.58	1.70	0.015			19.1	16.7	0.02
115-130	0.02							1.24	0.63				1.70	1.78	0.014			15.6	10.6	0.08

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9b	CEC SUM CATS 5A3a	CEC NH_4-OAc 5A8b	CEC BASES + Al 5A3b	Al SAT 5G1	BASE SAT SUM 5C3	BASE SAT NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	PH $CaCl_2$ .01M 8C1f 1:2	PH H_2O 8C1f 1:1
	<- - - - - - - - - - - - -meq / 100 g - - - - - - - - - - - ->										<- - - - -Pct - - - ->							
0- 13	12.5	5.5	0.2	0.6	18.8	2.5		21.3	16.8			88	100	TR		0.22	7.1	7.7
13- 23	5.8	2.3	0.2	0.2	8.5	1.4		9.9	7.2			86	100	TR		0.14	7.1	7.8
23- 36	10.0	4.1	0.4	0.2	14.7	2.5		17.2	12.9			85	100	TR		0.11	7.0	7.5
36- 48	13.1	6.3	0.6	0.3	20.3	2.7		23.0	16.7			88	100	--		0.17	7.1	7.8
48- 81	12.5	6.3	0.6	0.3	19.7	2.3		22.0	17.6			90	100	TR		0.16	7.0	7.7
81-115	15.3	8.2	0.7	0.5	24.7	3.0		27.7	22.8			89	100			0.16	6.8	7.5
115-130	16.9	6.1	0.5	0.2	23.7	2.1		25.8	20.9			92	100			0.11	6.8	7.7

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i (Peak size)					THERMAL DTA 7A6	TGA 7A4b	ELEMENTAL 7C3 SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O		EGME RETN 7D2 mg/g	INTERPRETATION
							Percent		Percent									
90P3693	TCLY	KK 3	MI 1	GE 1	HE 1					29.0	13.3			0.9				
90P3695	TCLY	KK 4	MT 2	GE 2	MI 1	HE 1				26.0	11.4			1.0				

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm.
Mineral interpretation: KK, kaolinite; MI, mica; GE, goethite; HE, hematite; MT, montmorillonite.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.
Pedon mineralogy based on clay: Mixed.
Family mineralogy: Mixed.

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm; *and one* of the following within the upper 12.5 cm of the argillic, natric, glossic, or kandic horizon:

a. 50 percent or more redox depletions with chroma of 2 or less on faces of peds and redox concentrations within peds; *or*

b. Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less in the matrix; *or*

c. 50 percent or more redox depletions with chroma of 1 or less on faces of peds or in the matrix, or both; *or*

2. In the horizons that have aquic conditions, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aqualfs, p. 167

JB. Other Alfisols that have a cryic or isofrigid temperature regime.

Cryalfs, p. 189

JC. Other Alfisols that have an ustic moisture regime.

Ustalfs, p. 228

JD. Other Alfisols that have a xeric moisture regime.

Xeralfs, p. 253

JE. Other Alfisols.

Udalfs, p. 200

Aqualfs

Aqualfs are the Alfisols that have aquic conditions for some time in normal years (or artificial drainage) at or near the soil surface. Their appearance is normally controlled by gray redox depletions and higher chroma redox concentrations. In some of these soils, ground water is near the surface during a considerable part of the year but drops to depths below the argillic or kandic horizon in another part of the year. In others, the ground water may be deep most of the year but horizons that have low hydraulic conductivity restrict the downward movement of water and extend the period of saturation.

Aqualfs occur in many parts of the world, mostly in small areas of late-Pleistocene deposits. In either of these situations, the fluctuating water table that seems essential to the genesis of Aqualfs does not occur. The wetness of a few Aqualfs is the result of seepage.

Most Aqualfs, except for those that have a frigid or cryic temperature regime, have some artificial drainage or other water control and are cultivated. Rice is a common crop on the Aqualfs that have a thermic or warmer temperature regime. Before they were cultivated, some of the Aqualfs were under forest vegetation and others were under grass. Nearly all Aqualfs are believed to have supported forest vegetation at some time in the past.

Definition

Aqualfs are the Alfisols that have, within 50 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and have *one or both* of the following:

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm or more; *and one* of the following:

a. 50 percent or more redox depletions with chroma of 2 or less on faces of peds, and redox concentrations within peds, of the argillic, natric, or kandic horizon; *or*

b. 50 percent or more redox depletions with chroma of 2 or less, and redox concentrations, in the matrix of the argillic, natric, or kandic horizon; *or*

c. 50 percent or more redox depletions with chroma of 1 or less either on faces of peds or in the matrix of the argillic, natric, or kandic horizon; *or*

2. In the horizons that have aquic conditions, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

JAA. Aqualfs that have a cryic temperature regime.

Cryaqualfs, p. 171

JAB. Other Aqualfs that have one or more horizons, at a depth between 30 and 150 cm from the mineral soil surface, in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthaqualfs, p. 188

JAC. Other Aqualfs that have a duripan.

Duraqualfs, p. 171

JAD. Other Aqualfs that have a natric horizon.

Natraqualfs, p. 186

JAE. Other Aqualfs that have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Fragiaqualfs, p. 181

JAF. Other Aqualfs that have a kandic horizon.

Kandiaqualfs, p. 184

JAG. Other Aqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermaqualfs, p. 188

JAH. Other Aqualfs that have an abrupt textural change between the ochric epipedon or the albic horizon and the argillic horizon and have a moderately low or lower saturated hydraulic conductivity in the argillic horizon.

Albaqualfs, p. 168

JAI. Other Aqualfs that have a glossic horizon.

Glossaqualfs, p. 182

JAJ. Other Aqualfs that have episaturation.

Epiaqualfs, p. 175

JAK. Other Aqualfs.

Endoaqualfs, p. 171

Albaqualfs

These are the Aqualfs with ground water seasonally perched above a slowly permeable argillic horizon. Commonly, an albic horizon rests abruptly on the argillic horizon, with virtually no transitional horizon between the two. The soil temperature regime is frigid, isomesic, mesic, or warmer. Albaqualfs do not have a kandic horizon, a natric horizon, a fragipan, or a duripan. They have no horizon at a depth between 30 and 150 cm from the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. In the United States, most Albaqualfs have a mesic, thermic, or hyperthermic temperature regime and, unless the soils are irrigated, the albic horizon is dry for short periods in summer in normal years. The dryness seems essential to the genesis. Thus, Aqualfs in which the albic horizon is rarely dry are in great groups other than Albaqualfs.

Definition

Albaqualfs are the Aqualfs that:

1. Have an abrupt textural change between an ochric epipedon or, more commonly, an albic horizon and the argillic horizon and have moderately low or lower saturated hydraulic conductivity in the argillic horizon;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Have no fragipan, no duripan, no kandic horizon, and no natric horizon;

4. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

5. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite.

Key to Subgroups

JAHA. Albaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Albaqualfs

JAHB. Other Albaqualfs that have *both* of the following:

1. *One or both*:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface.

Aeric Vertic Albaqualfs

JAHC. Other Albaqualfs that have *both* of the following:

1. *One or both*:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

   a. A color value, moist, of 4 or more; *or*

   b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Albaqualfs

JAHD. Other Albaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Albaqualfs

JAHE. Other Albaqualfs that have *both*:

1. Chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface; *and*

2. A mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Udollic Albaqualfs

JAHF. Other Albaqualfs that have chroma of 3 or more in 40 percent or more of the matrix between the lower boundary of the A or Ap horizon and a depth of 75 cm from the mineral soil surface.

Aeric Albaqualfs

JAHG. Other Albaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Albaqualfs

JAHH. Other Albaqualfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Albaqualfs

JAHI. Other Albaqualfs that have an umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Umbric Albaqualfs

JAHJ. Other Albaqualfs.

Typic Albaqualfs

Definition of Typic Albaqualfs

Typic Albaqualfs are the Albaqualfs that:

1. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

2. Have chroma of 2 or less in 60 percent or more of the mass between the bottom of the A or Ap horizon and a depth of 75 cm;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, in the fraction less than 2.0 mm in size and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

5. Do not have a mollic or umbric epipedon, an Ap horizon that meets all of the requirements for a mollic or umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Description of Subgroups

Typic Albaqualfs.—The central concept or Typic subgroup of Albaqualfs is fixed on soils that have dominantly low chroma throughout the upper part to a depth of 75 cm or more; that have relatively high color value in the plow layer, too high for a mollic epipedon; that do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout; and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. Chroma of 3 or more, if dominant in the horizons directly below the A or Ap horizon, indicates saturation with water for only short periods and is a defining feature for Aeric Albaqualfs and other subgroups that intergrade to freely drained soils.

An Ap horizon that has the color of a mollic epipedon and similar upper horizons that would be mixed by plowing are associated in some parts of the United States with a native prairie vegetation. Horizons with such colors are used to define intergrades to the Mollisols. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic or combination Vertic subgroups because these properties are shared with Vertisols. Typic Albaqualfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. Typic Albaqualfs are extensive in parts of the Mississippi Valley in Illinois, Missouri, Arkansas, and Louisiana and in part of Oregon and Florida. They are uncommon elsewhere in the United States. These soils are nearly level and are difficult to drain. Some are cultivated, but many are used as pasture or are in forests.

Aeric Albaqualfs.—Chroma in these soils is more than 2 in more than 40 percent of the mass between the bottom of the A or Ap horizon and a depth of 75 cm. Most commonly, the chroma in the matrix of the argillic horizon is 3 or more. The period of saturation with water in these soils is shorter than the one characteristic of Typic Albaqualfs. Aeric Albaqualfs are intergrades between Albaqualfs and Hapludalfs. They generally are steep enough for water to run off the surface rather than stand on the surface. They genarally are either cultivated or used as pasture. If they are cultivated, erosion is commonly a problem. These soils are not extensive. They occur mostly in Louisiana and Missouri.

Aeric Vertic Albaqualfs.—These soils are like Typic Albaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils also have chroma of more than 2 in more than 40 percent of the mass between the bottom of the A or Ap horizon and a depth of 75 cm. Most commonly, the chroma in the matrix of the argillic horizon is 3 or more. These soils are permitted, but not required, to have upper horizons that have a color value of 3 or less, moist, and 5 or less, dry, or have these colors after mixing to a depth of 15 cm. The period of saturation with water in these soils is shorter than the one characteristic of Typic Albaqualfs. Aeric Vertic Albaqualfs are considered to be transitional to Uderts and are not extensive in the United States.

Aquandic Albaqualfs.—These soils are like Typic Albaqualfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are not known to occur in the United States.

Arenic Albaqualfs.—Arenic Albaqualfs have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface. They may have chroma of more than 2 in more than 40 percent of the mass between the A or Ap horizon and a depth of 75 cm. They may also either have an Ap horizon in which the color value, moist, is less than 4 and the value, dry, is less than 6 after the soils have been crushed and smoothed or, if not disturbed, have these colors to a depth of 18 cm, after mixing. These soils are not extensive. They are most common in Florida.

Chromic Vertic Albaqualfs.—These soils are like Typic Albaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are one kind of intergrade between Albaqualfs and Aquerts. Chromic Vertic Albaqualfs are not extensive.

Mollic Albaqualfs.—These soils are like Typic Albaqualfs, but they have either a mollic epipedon or an Ap horizon that meets all of the requirements for a mollic epipedon except thickness or have materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. Many of these soils had a prairie vegetation before they were cultivated. Mollic Albaqualfs are intergrades between Albaqualfs and Argialbolls or Argiaquolls. They are nearly level and cannot be easily drained. They are most extensive in Florida and are rare elsewhere in the United States. Most of them are cultivated.

Udollic Albaqualfs.—These soils are like Typic Albaqualfs, but they have either a mollic epipedon or an Ap horizon that meets all of the requirements for a mollic epipedon except thickness or have materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. These soils also have chroma of more than 2 in more than 40 percent of the mass between the bottom of the A or Ap horizon and a depth of 75 cm. Most commonly, the chroma in the matrix of the argillic horizon is 3 or more. The period of saturation with water in these soils is shorter than the one characteristic of Typic Albaqualfs. Udollic Albaqualfs are intergrades between Albaqualfs and Argiudolls and are of very small extent in the United States.

Umbric Albaqualfs.—These soils are like Typic Albaqualfs, but they have either an umbric epipedon or an Ap horizon that meets all of the requirements for an umbric epipedon except thickness or have materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. They are nearly level and cannot be easily drained. They are most common in Florida and are rare elsewhere in the United States.

Vertic Albaqualfs.—These soils are like Typic Albaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. They also have upper horizons that have a color value of 3 or less, moist, and 5 or less, dry, or have these colors after mixing to a depth of 15 cm. These soils are one kind of intergrade between Albaqualfs and Aquerts. Vertic Albaqualfs are mostly in the central part of the United States and are common in parts of Illinois and Missouri. Their slopes are gentle. Most of these soils have been cleared and are used as cropland. Some of the soils are used as woodland or pasture.

Cryaqualfs

Cryaqualfs are the Aqualfs that have a cryic or isofrigid temperature regime. These soils are not known to occur in the United States. The group has been proposed for other countries, but definitions of subgroups have not been suggested.

Key to Subgroups

JAAA. All Cryaqualfs (provisionally).

Typic Cryaqualfs

Duraqualfs

Duraqualfs are the Aqualfs that have a duripan and a frigid, mesic, isomesic, or warmer temperature regime. These soils have no horizon at a depth between 30 and 150 cm from the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. Duraqualfs are not known to occur in the United States. The group has been proposed for other countries, but definitions of subgroups have not been suggested.

Key to Subgroups

JACA. All Duraqualfs (provisionally).

Typic Duraqualfs

Endoaqualfs

Endoaqualfs are the Aqualfs that have an epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has moderately low or lower saturated hydraulic conductivity. These soils do not have a kandic horizon, a natric horizon, a fragipan, or a duripan. The soil temperature regime is frigid, isomesic, mesic, or warmer. Endoaqualfs have no horizon at a depth between 30 and 150 cm from the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. Endoaqualfs are characterized by endoaquic saturation. The ground water fluctuates from a level near the soil surface to below the argillic horizon and is sometimes below a depth of 200 cm.

Before cultivation, most Endoaqualfs supported either a deciduous broadleaf or a coniferous forest. Generally, Endoaqualfs are nearly level, and their parent materials are typically late-Pleistocene sediments.

Definition

Endoaqualfs are the Aqualfs that:

1. Have endosaturation and a frigid, mesic, isomesic, or warmer soil temperature regime; *and*

2. Do not have a glossic, kandic, or natric horizon or a duripan; *and*

3. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have an abrupt textural change between the albic and argillic horizons if the saturated hydraulic conductivity of the argillic horizon is moderately low or lower; *and*

5. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts; *and*

6. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite.

Key to Subgroups

JAKA. Endoaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaqualfs

JAKB. Other Endoaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Endoaqualfs

JAKC. Other Endoaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaqualfs

JAKD. Other Endoaqualfs that have:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Aeric Fragic Endoaqualfs

JAKE. Other Endoaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Endoaqualfs

JAKF. Other Endoaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Endoaqualfs

JAKG. Other Endoaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Endoaqualfs

JAKH. Other Endoaqualfs that have *both*:

1. A mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Udollic Endoaqualfs

JAKI. Other Endoaqualfs that have *both*:

1. An umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Aeric Umbric Endoaqualfs

JAKJ. Other Endoaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Endoaqualfs

JAKK. Other Endoaqualfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Endoaqualfs

JAKL. Other Endoaqualfs that have an umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Umbric Endoaqualfs

JAKM. Other Endoaqualfs.

Typic Endoaqualfs

Definition of Typic Endoaqualfs

Typic Endoaqualfs are the Endoaqualfs that:

1. Do not have, in any horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following: *either*

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations;

2. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have a mollic or umbric epipedon, an Ap horizon that meets all of the requirements for a mollic or umbric epipedon except thickness, or materials between the mineral soil surface and a depth of 18 cm that meet these requirements after mixing;

5. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

6. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Endoaqualfs.—The Typic subgroup of Endoaqualfs is fixed on soils that have dominantly low chroma throughout the upper part to a depth of 75 cm or more; that have relatively high color value in the plow layer, too high for a mollic or umbric epipedon; that do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout; and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. Chroma of 3 or more, if dominant in the horizons directly below the A or Ap horizon, indicates saturation with water for only short periods and is a defining feature for Aeric Endoaqualfs and other subgroups that intergrade to freely drained soils.

Soils with a mollic or umbric epipedon, or an Ap horizon and similar upper horizons that, when mixed, have the color of a mollic or umbric epipedon, are associated in some parts of the United States with a native prairie vegetation. Horizons with such colors are used to define intergrades to Mollisols and to define Umbric extragrades. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic or combination Vertic subgroups because these properties are shared with Vertisols. Soils that have fragic soil properties in a significant volume are assigned to Fragic or combination Fragic subgroups because these properties are shared with Fragiaqualfs and Fragiudalfs. Typic Endoaqualfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. A thick layer of sand or loamy sand, starting at the mineral soil surface, is the basis for defining the Arenic and Grossarenic subgroups. Typic Endoaqualfs are moderately extensive. They are not extensive in any one State but occur throughout a large part of the Eastern United States and in Oregon and Washington. These soils are nearly level. Most have been cleared and are used as cropland, but some are used as pasture or are in forests.

Aeric Endoaqualfs.—Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup, but they are otherwise like Typic Endoaqualfs in their defined properties and in most other properties. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. Aeric Endoaqualfs are moderately extensive in the north-central part of the United States, which was covered by Wisconsinan glaciers and their valley trains. Nearly all of the soils have been cleared and are used as cropland.

Aeric Fragic Endoaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup.

The high chroma commonly occurs in the matrix of the peds in the argillic horizon. The soils are otherwise like Typic Endoaqualfs in their defined properties and in most other properties. Aeric Fragic Endoaqualfs are rare in the United States.

Aeric Umbric Endoaqualfs.—These soils have an umbric epipedon or a surface horizon that meets all of the requirements for an umbric epipedon except thickness. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. The soils are otherwise like Typic Endoaqualfs in their defined properties and in most other properties. Aeric Umbric Endoaqualfs are rare in the United States.

Aquandic Endoaqualfs.—These soils are like Typic Endoaqualfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are rare in the United States and are known to occur only in the Pacific Northwest. They are in forests or have been cleared and are used as cropland or pasture.

Arenic Endoaqualfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface. The upper part of the argillic horizon or the lower part of the epipedon is permitted to have, in 50 percent or more of the matrix, chroma that is too high for Typic Endoaqualfs. Arenic Endoaqualfs may also have either an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or, if undisturbed, materials between the soil surface and a depth of 18 cm that have these colors after mixing. These soils are otherwise like those of the Typic subgroup in their defined properties, but their argillic horizon generally is sandier than that of the Typic Endoaqualfs. In the United States, Arenic Endoaqualfs occur principally in Florida. Many have been cleared and drained and are used as cropland.

Chromic Vertic Endoaqualfs.—These soils are like Typic Endoaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. These soils may also have a somewhat higher chroma in the upper part of the argillic horizon than Typic Endoaqualfs. Chromic Vertic Endoaqualfs are rare in the United States.

Fragic Endoaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. The soils are otherwise like Typic Endoaqualfs in their defined properties and in most other properties. Fragic Endoaqualfs are rare in the United States.

Grossarenic Endoaqualfs.—The sandy or sandy-skeletal layer is thicker in these soils than in Arenic Endoaqualfs. Grossarenic Endoaqualfs are not known to occur in the United States.

Mollic Endoaqualfs.—These soils have a mollic epipedon or a surface horizon that meets all of the requirements for a mollic epipedon except thickness but have a base saturation of less than 50 percent (by NH_4OAc) in some part of the argillic horizon. In the United States, the dark colored surface horizon generally is too thin to be a mollic epipedon. These soils are intergrades between Endoaqualfs and Argiaquolls. They are extensive in the glaciated parts of the United States. Most of them have been cleared and drained and are used as cropland.

Udollic Endoaqualfs.—These soils are like Typic Endoaqualfs, but they have chroma in the upper part of the argillic horizon that is too high for the Typic subgroup and have a mollic epipedon or a surface horizon that meets all of the requirements for a mollic epipedon except thickness. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. Udollic Endoaqualfs are widely scattered in the glaciated parts of the United States, particularly in the north-central region. Most of them have been cleared and drained and are used as cropland.

Umbric Endoaqualfs.—These soils are like Typic Endoaqualfs, but they have an umbric epipedon or a surface horizon that meets all of the requirements for an umbric epipedon except thickness. These soils are rare in the United States.

Vertic Endoaqualfs.—These soils are like Typic Endoaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. In addition, because Vertisols can have a mollic epipedon, the soils in this subgroup may have either an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less or, if undisturbed, materials between the mineral soil surface and a depth of 18 cm that have these color values after mixing. A mollic epipedon is permitted if some subhorizon of the argillic horizon has a base saturation of less than 50 percent (by NH_4OAc). Vertic Endoaqualfs may also have a somewhat higher chroma than Typic Endoaqualfs.

Epiaqualfs

Epiaqualfs are the Aqualfs that have an epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has low saturated hydraulic conductivity. These soils do not have a kandic horizon, a natric horizon, a fragipan, or a duripan. The soil temperature regime is frigid, isomesic, mesic, or warmer. The soils have no horizon at a depth between 30 and 150 cm from the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. The soils have epiaquic saturation during some part of the year. Ground water is commonly perched on horizons below the argillic horizon. It fluctuates from a level near the soil surface to below the argillic horizon and sometimes is not evident.

Before cultivation, most Epiaqualfs supported either a deciduous broadleaf or a coniferous forest. Generally, Epiaqualfs are nearly level, and their parent materials are typically late-Pleistocene sediments.

Definition

Epiaqualfs are the Aqualfs that:

1. Have episaturation and a frigid, mesic, isomesic, or warmer temperature regime;

2. Do not have a glossic, kandic, or natric horizon or a duripan;

3. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

4. Do not have an abrupt textural change between the albic and argillic horizons if the saturated hydraulic conductivity of the argillic horizon is moderately low or lower;

5. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts; *and*

6. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite.

Key to Subgroups

JAJA. Epiaqualfs that have *all* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations; *and*

3. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Aeric Chromic Vertic Epiaqualfs

JAJB. Other Epiaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Vertic Epiaqualfs

JAJC. Other Epiaqualfs that have *both* of the following:

1. *One or both*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Epiaqualfs

JAJD. Other Epiaqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaqualfs

JAJE. Other Epiaqualfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaqualfs

JAJF. Other Epiaqualfs that have:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Fragic Epiaqualfs

JAJG. Other Epiaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaqualfs

JAJH. Other Epiaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Epiaqualfs

JAJI. Other Epiaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Epiaqualfs

JAJJ. Other Epiaqualfs that have:

1. An umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Umbric Epiaqualfs

JAJK. Other Epiaqualfs that have *both*:

1. A mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing; *and*

2. In 50 percent or more of the matrix in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Udollic Epiaqualfs

JAJL. Other Epiaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Epiaqualfs

JAJM. Other Epiaqualfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Epiaqualfs

JAJN. Other Epiaqualfs that have an umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Umbric Epiaqualfs

JAJO. Other Epiaqualfs.

Typic Epiaqualfs

Definition of Typic Epiaqualfs

Typic Epiaqualfs are the Epiaqualfs that:

1. Do not have, in any horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following: *either*

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations;

2. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Do not have a mollic or umbric epipedon, an Ap horizon that meets all of the requirements for a mollic or umbric epipedon except thickness, or materials between the mineral soil surface and a depth of 18 cm that meet these requirements after mixing;

4. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

6. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Epiaqualfs.—The central concept or Typic subgroup of Epiaqualfs is fixed on soils that (1) have dominantly low chroma between the A or Ap horizon and a depth of 75 cm or more from the mineral soil surface; (2) have a lighter color value, moist, in the plow layer, or in comparable horizons if undisturbed, than in a mollic epipedon; and (3) do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout. In addition, the soils have no surface mantle affected by pyroclastic materials, have no cracks and slickensides or wedge-shaped aggregates, and do not have a linear extensibility of 6.0 cm or more to a depth of 100 cm from the mineral soil surface.

Chroma higher than that of Typic Epiaqualfs is characteristic of soils that are saturated for shorter periods and serves to define intergrades to freely drained soils. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic or combination Vertic subgroups because these properties are shared with Vertisols. Soils that have fragic soil properties in a significant volume are assigned to Fragic or combination Fragic subgroups because these properties are shared with Fragiaqualfs and Fragiudalfs. Typic Epiaqualfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. Color values, moist, of 2 or 3 in a plow layer indicate a higher-than-normal content of organic matter and form the basis for defining intergrades to other great groups. A thick layer of sand or loamy sand, starting at the mineral soil surface, is the basis for defining the Arenic subgroup. Typic Epiaqualfs are moderately extensive. They are not extensive in any one State but occur throughout a large part of the Eastern United States and in California and Texas. These soils are nearly level. Most have been cleared and are used as cropland, but some are used as pasture or are in forests.

Aeric Chromic Vertic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. Below the A or Ap horizon, they have higher chroma than that in Typic Epiaqualfs. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. Aeric Chromic Vertic Epiaqualfs are rare in the United States.

Aeric Epiaqualfs.—Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup, but they are otherwise like Typic Epiaqualfs in their defined properties and in most other properties. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. In the United States, Aeric Epiaqualfs are extensive in the north-central region, which was covered by Wisconsinan glaciers, but are of small extent elsewhere. Nearly all have been cleared and are used as cropland, but some are used as pasture or are in forests.

Aeric Fragic Epiaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. The soils are otherwise like Typic Epiaqualfs in their defined properties and in most other properties. Aeric Fragic Epiaqualfs are rare in the United States.

Aeric Umbric Epiaqualfs.—These soils have an umbric epipedon or a surface horizon that meets all of the requirements for an umbric epipedon except thickness. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. The soils are otherwise like Typic Epiaqualfs in their defined properties and in most other properties. Aeric Umbric Epiaqualfs are rare in the United States.

Aeric Vertic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. Aeric Vertic Epiaqualfs are rare in the United States.

Aquandic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are rare in the United States and are known to occur only in the Pacific Northwest. They are in forests or have been cleared and are used as cropland or pasture.

Arenic Epiaqualfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface. The upper part of the argillic horizon or the lower part of the epipedon is permitted to have, in 50 percent or more of the matrix, chroma that is too high for Typic Epiaqualfs. Arenic Epiaqualfs may also have either an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or, if undisturbed, materials between the soil surface and a depth of 18 cm that have these colors after mixing. These soils are otherwise like those of the Typic subgroup in their defined properties. They are of small extent in the United States and occur principally in Minnesota.

Chromic Vertic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. In the upper part of the argillic horizon, they may also have somewhat higher chroma than that in Typic Epiaqualfs. Chromic Vertic Epiaqualfs are rare in the United States.

Fragic Epiaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. The soils are otherwise like Typic Epiaqualfs in their defined properties and in most other properties. Fragic Epiaqualfs are rare in the United States.

Grossarenic Epiaqualfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface. These soils are not known to occur in the United States.

Mollic Epiaqualfs.—These soils have a mollic epipedon or a surface horizon that meets all of the requirements for a mollic epipedon except thickness. Soils with a mollic epipedon have a base saturation of less than 50 percent (by NH_4OAc) in some part of the argillic horizon. In the United States, the dark colored surface horizon of these soils generally is too thin to be a mollic epipedon. These soils are intergrades between Epiaqualfs and Argiaquolls. They are moderately extensive in the Great Lakes region of the United States. Most of them have been cleared and drained and are used as cropland, but some are used as pasture or are in forests.

Udollic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they have (1) in 50 percent or more of the matrix of some horizon between the A or Ap horizon and a depth of 75 cm from the mineral soil surface, chroma that is too high for Typic Epiaqualfs, and (2) either a mollic epipedon or a surface horizon that meets all of the requirements for a mollic epipedon except thickness. A mollic epipedon is permitted in this subgroup only if the base saturation in some part of the argillic horizon is less than 50 percent (by NH_4OAc).

Udollic Epiaqualfs are moderately extensive in the Great Lakes region of the United States. Most of them have been cleared and drained and are used as cropland, but some are used as pasture or are in forests.

Umbric Epiaqualfs.—These soils are like Typic Epiaqualfs, but they have either an umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. These soils are rare in the United States.

Vertic Epiaqualfs.—These soils are like Typic Epiaqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. In addition, because Typic Vertisols have a dark colored epipedon, Vertic Epiaqualfs have either an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less or, if undisturbed, materials between the mineral soil surface and a depth of 18 cm that have these color values after mixing. A mollic epipedon is permitted if some subhorizon of the argillic horizon has a base saturation of less than 50 percent (by NH_4OAc).

Vertic Epiaqualfs are moderately extensive. They are most extensive in the Midwest but occur throughout a large part of the Eastern United States. These soils are nearly level. Most have been cleared and are used as cropland, but some are used as pasture or are in forests.

Fragiaqualfs

Fragiaqualfs are the Aqualfs that have a fragipan within 100 cm of the mineral soil surface. Most of them have ground water that is perched above a fragipan at some period and saturates the soils at another period. These soils have no duripan or natric horizon and do not have plinthite that forms a continuous phase or constitutes more than one-half of the matrix within some subhorizon at a depth between 30 and 150 cm from the soil surface. The soil temperature regime is frigid, isomesic, mesic, or warmer. In the United States, the soils generally have frigid to thermic temperature regimes. In normal years, the albic horizon generally does not become dry, but the ground water drops below the base of the fragipan during summer and the soil moisture content is below field capacity at some period. Most Fragiaqualfs in the United States formed in Wisconsinan deposits of late-Pleistocene age and had a broadleaf deciduous forest vegetation before they were cultivated. Most of the soils are nearly level. Fragiaqualfs as a group have lower base saturation than other Aqualfs.

Definition

Fragiaqualfs are the Aqualfs that:

1. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Have no duripan or natric horizon;

4. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite.

Key to Subgroups

JAEA. Fragiaqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermic Fragiaqualfs

JAEB. Other Fragiaqualfs that have, between the A or Ap horizon and a fragipan, a horizon with 50 percent or more chroma of 3 or more if hue is 10YR or redder or of 4 or more if hue is 2.5Y or yellower.

Aeric Fragiaqualfs

JAEC. Other Fragiaqualfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Fragiaqualfs

JAED. Other Fragiaqualfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Humic Fragiaqualfs

JAEE. Other Fragiaqualfs.

Typic Fragiaqualfs

Definition of Typic Fragiaqualfs

Typic Fragiaqualfs are the Fragiaqualfs that:

1. Have, in all horizons between the A or Ap horizon and the fragipan, more than 50 percent chroma of 2 or less if hue is 10YR or redder or of 3 or less if hue is 2.5Y or yellower;

2. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

3. Have an Ap horizon that has either or both a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed and smoothed or have these color values in the upper 18 cm after mixing; *and*

4. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Description of Subgroups

Typic Fragiaqualfs.—The central concept or Typic subgroup of Fragiaqualfs is fixed on soils that have dominantly low chroma in all horizons between the fragipan and the plow layer, if one occurs, and that have a color value in the plow layer that is lighter than that of an umbric epipedon. Typic Fragiaqualfs have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface and have less than 25 percent (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts, in all subhorizons at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. These soils are nearly level and are saturated for long periods in winter and early spring. Most Typic Fragiaqualfs in the United States are in the Central and Northeastern States. Typic Fragiaqualfs are of moderate extent. Most of them have been cleared and are used as cropland. Artificial drainage is difficult, however, and some of the soils are used as pasture or are in forests.

Aeric Fragiaqualfs.—These soils are like Typic Fragiaqualfs, but, in some subhorizon between the A or Ap horizon and the fragipan, they have chroma of 3 or more if hue is 10YR or redder or chroma of 4 or more if hue is 2.5Y or yellower. The period of saturation with water in these soils is shorter than that in the Typic subgroup. In most areas the slope is slightly greater in areas of Aeric Fragiaqualfs than in areas of Typic Fragiaqualfs. Aeric Fragiaqualfs are considered intergrades between Fragiaqualfs and Fragiudalfs.

Aeric Fragiaqualfs generally are steep enough for water to run off the surface rather than stand on the surface. They are extensive locally in the glaciated areas of the north-central region of the United States but are rare elsewhere in the United States. Most Aeric Fragiaqualfs in the United States have been cleared and are used as cropland, but some are used as pasture or are in forests.

Plinthic Fragiaqualfs.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Fragiaqualfs.—These soils have a mollic or umbric epipedon or a plow layer or A horizon that meets all of the requirements for a mollic or umbric epipedon except thickness. These soils are known to occur only in Missouri. They had a prairie vegetation before they were cultivated. Most of them are now used as cropland.

Vermic Fragiaqualfs.—These soils have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts. These soils are known to occur only in Texas.

Glossaqualfs

Glossaqualfs are the Aqualfs that have a frigid, mesic, isomesic, or warmer temperature regime and have a glossic horizon. These soils do not have a fragipan, a duripan, a kandic horizon, or a natric horizon. Plinthite constitutes less than one-half of the volume of the matrix in all subhorizons at a depth between 30 and 150 cm from the soil surface. The glossic horizon is interpreted as evidence that the argillic horizon has been partly destroyed. Tubular intrusions of albic materials into the argillic horizon may be formed by filling of burrows made by crayfish or of traces of taproots. Light colored krotovinas or filled root channels should be considered albic materials only if they have no fine stratifications and no lamellae, if all sealing along krotovina walls has been destroyed, and if these intrusions have, after deposition, been leached of some free iron oxides and/or clay.

Characteristically, these soils have the most humid climates of the Alfisols and the most water passing through the profile and have a relatively low base saturation for soils of this order. Before the soils were cultivated, the vegetation was mostly deciduous hardwood forest. The parent materials are largely basic or calcareous sediments of late-Pleistocene age. Slopes are nearly level or concave.

Glossaqualfs are mostly in the most northern and southern parts of the range of Aqualfs. They generally are in the Great Lakes area and on the gulf coast. A few are in the Pacific Northwest. Except where the temperature regime is frigid, most of these soils have been drained and are used for cultivated crops.

Definition

Glossaqualfs are the Aqualfs that:

1. Have a glossic horizon;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite;

4. Do not have a fragipan, a duripan, a kandic horizon, or a natric horizon;

5. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

6. Do not have both an abrupt textural change between the ochric epipedon or albic horizon and the argillic horizon and a moderately low or lower saturated hydraulic conductivity in the argillic horizon.

Key to Subgroups

JAIA. Glossaqualfs that have a histic epipedon.

Histic Glossaqualfs

JAIB. Other Glossaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Glossaqualfs

JAIC. Other Glossaqualfs that have:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, one or a combination of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more if there are no redox concentrations.

Aeric Fragic Glossaqualfs

JAID. Other Glossaqualfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossaqualfs

JAIE. Other Glossaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Glossaqualfs

JAIF. Other Glossaqualfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Glossaqualfs

JAIG. Other Glossaqualfs.

Typic Glossaqualfs

Definition of Typic Glossaqualfs

Typic Glossaqualfs are the Glossaqualfs that:

1. Do not have a histic epipedon;

2. Do not have, in any horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following: *either*

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations;

3. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

4. Do not have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing;

5. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Glossaqualfs.—The central concept or Typic subgroup of Glossaqualfs is fixed on soils that have dominantly low chroma throughout the horizons below the A or Ap horizon, to a depth of 75 cm or more. These soils do not have a mollic epipedon, nor do they have a plow layer or an equivalent horizon that meets all of the requirements for a mollic epipedon except thickness. Soils that have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout are assigned to the Arenic subgroup. Soils that have fragic soil properties in a significant volume are assigned to Fragic or combination Fragic subgroups because these properties are shared with Fragiaqualfs and Fragiudalfs. Typic Glossaqualfs are the wettest Glossaqualfs.

Higher chroma than that of Typic Glossaqualfs is characteristic of the somewhat better drained Glossaqualfs and is used to define the Aeric subgroup, which consists of intergrades to Glossudalfs. Typic Glossaqualfs occur throughout the areas of Glossaqualfs in the United States. Most of them are cultivated.

Aeric Fragic Glossaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. The high chroma commonly occurs in the matrix of the peds in the argillic horizon. The soils are otherwise like Typic Glossaqualfs in their defined properties and in most other properties. Aeric Fragic Glossaqualfs are rare in the United States.

Aeric Glossaqualfs.—These soils have some subhorizon between the A or Ap horizon and a depth of 75 cm that has chroma that is too high for Typic Glossaqualfs. The period of saturation is somewhat shorter than that in soils of the Typic subgroup. Aeric Glossaqualfs occur throughout the areas of Glossaqualfs in the United States. Most of them are cultivated.

Arenic Glossaqualfs.—These soils have a sandy or sandy-skeletal layer, starting at the mineral soil surface, that is 50 cm or more thick. The epipedon overlies an argillic horizon. The chroma may or may not be higher than that in the Typic subgroup. These soils occur in Florida but are not extensive in the United States.

Fragic Glossaqualfs.—These soils have fragic soil properties in a significant volume but do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. The soils are otherwise like Typic Glossaqualfs in their defined properties and in most other properties. Fragic Glossaqualfs are rare in the United States.

Histic Glossaqualfs.—These soils have a Histic epipedon. They occur near sea level and are thought to have had a lower water table at the time the argillic horizon formed than they have now. They are known to occur only in Florida in the United States.

Mollic Glossaqualfs.—These soils have a mollic epipedon or a plow layer or its equivalent, if not plowed, that meets all of the requirements for a mollic epipedon except thickness. These soils are known to occur only in Minnesota in the United States.

Kandiaqualfs

These are the Aqualfs that have a frigid, mesic, isomesic, or warmer temperature regime and a kandic horizon. These soils do not have a fragipan, a duripan, or a natric horizon. Plinthite constitutes less than half of the volume of the matrix in all subhorizons at a depth between 30 and 150 cm from the soil surface. The soils are allowed, but not required, to have a glossic horizon. Characteristically, they have the most warm and humid climates of the Aqualfs and the most water passing through the profile and have a relatively low base saturation for soils of this order. The vegetation is mostly tropical or subtropical hardwood forest. Slopes are nearly level or concave.

Kandiaqualfs are mostly in tropical and subtropical areas. They are rare in the United States.

Definition

Kandiaqualfs are the Aqualfs that:

1. Have a kandic horizon;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Do not have a natric horizon or a duripan;

4. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite;

5. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

JAFA. Kandiaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface.

Arenic Kandiaqualfs

JAFB. Other Kandiaqualfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface.

Grossarenic Kandiaqualfs

JAFC. Other Kandiaqualfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiaqualfs

JAFD. Other Kandiaqualfs that have *both*:

1. An Ap horizon with a color value, moist, of 3 or less

and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

2. In one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more (both moist and dry); *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Umbric Kandiaqualfs

JAFE. Other Kandiaqualfs that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following colors:

1. Hue of 7.5YR or redder; *and*

a. If peds are present, chroma of 2 or more (both moist and dry) on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less (both moist and dry) in ped interiors; *or*

b. If peds are absent, chroma of 2 or more (both moist and dry); *or*

2. Hue of 10YR or yellower *and either*:

a. Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

b. Chroma of 2 or more (both moist and dry) and no redox concentrations.

Aeric Kandiaqualfs

JAFF. Other Kandiaqualfs that have an umbric epipedon, an Ap horizon that meets all of the requirements for an umbric epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Umbric Kandiaqualfs

JAFG. Other Kandiaqualfs.

Typic Kandiaqualfs

Definition of Typic Kandiaqualfs

Typic Kandiaqualfs are the Kandiaqualfs that:

1. Do not have, in any horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, in 50 percent or more of the matrix, one or a combination of the following: *either*

a. Hue of 7.5YR or redder; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. Hue of 10YR or yellower *and either*:

(1) Both a color value of 3 or more (moist) and chroma of 3 or more (moist and dry); *or*

(2) Chroma of 2 or more (both moist and dry) and no redox concentrations;

2. Have an Ap horizon that has either a color value, moist, of 4 or more or a color value, dry, of 6 or more after the soil has been crushed or have these color values in the upper 18 cm after mixing;

3. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

4. Do not have a horizon within 150 cm of the soil surface that has 5 percent or more plinthite, by volume.

Description of Subgroups

Typic Kandiaqualfs.—The central concept or Typic subgroup of Kandiaqualfs is fixed on soils that (1) have dominantly low chroma between the A or Ap horizon and a depth of 75 cm or more from the mineral soil surface; (2) have a lighter color value, moist, in the plow layer, or in comparable horizons if undisturbed, than in an umbric epipedon; and (3) do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout.

Chroma higher than that of Typic Kandiaqualfs is characteristic of soils that are saturated for shorter periods and serves to define intergrades to freely drained soils. Color values, moist, of 2 or 3 in a plow layer indicate a higher-than-normal content of organic matter and form the basis for defining intergrades to other great groups. A thick layer of sand or loamy sand, starting at the mineral soil surface, is the basis for defining the Arenic and Grossarenic subgroups. Typic Kandiaqualfs are not known to occur in the United States.

Aeric Kandiaqualfs.—Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup, but they are otherwise like Typic Kandiaqualfs in their defined properties and in most other properties. Aeric Kandiaqualfs are not known to occur in the United States.

Aeric Umbric Kandiaqualfs.—These soils have an umbric epipedon or a surface horizon that meets all of the requirements for an umbric epipedon except thickness. Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup. They are otherwise like Typic Kandiaqualfs in their defined properties and in most other properties. Aeric Umbric Kandiaqualfs are not known to occur in the United States.

Arenic Kandiaqualfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. The upper part of the kandic horizon or the lower part of the epipedon is permitted to have, in 50 percent or more of the matrix, chroma that is too high for Typic Kandiaqualfs. Arenic Kandiaqualfs may also have either an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or, if undisturbed, materials between the soil surface and a depth of 18 cm that have these colors after mixing. These soils are otherwise like those of the Typic subgroup in their defined properties. Arenic Kandiaqualfs are not known to occur in the United States.

Grossarenic Kandiaqualfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. These soils are not known to occur in the United States.

Plinthic Kandiaqualfs.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States.

Umbric Kandiaqualfs.—These soils have an umbric epipedon or a plow layer or its equivalent, if not plowed, that meets all of the requirements for an umbric epipedon except thickness. These soils are not known to occur in the United States.

Natraqualfs

Natraqualfs are the Aqualfs that have a natric horizon and have a frigid, mesic, isomesic, or warmer temperature regime. These soils do not have a duripan, and plinthite constitutes less than one-half of the volume of the matrix in all subhorizons at a depth between 30 and 150 cm from the soil surface. Typically, ground water perches above the natric horizon at one period and saturates the soils at another period. Natraqualfs are allowed, but not required, to have a glossic horizon. In the United States, most of these soils have a mesic, thermic, or hyperthermic temperature regime, but a few are frigid. If undisturbed, Natraqualfs commonly have a thin A horizon overlying a thin albic horizon that, in turn, overlies the natric horizon. If the soils are plowed, the two upper horizons and part of the natric horizon or only part of the two upper horizons may be mixed.

In the United States, the vegetation on Natraqualfs before cultivation most commonly was grass or mixed grass and drought-tolerant trees. In humid regions where the precipitation is 100 cm or more, the presence of sodium generally is attributed to very slow permeability in the natric horizon. The permeability is so slow that there is thought to be less leaching of sodium than there is release of sodium by the weathering of feldspars. Many Natraqualfs in the United States formed in loess or alluvium of Wisconsinan age.

Some Natraqualfs are in basins or on lowlands and are subject to flooding, and the sodium in them may be supplied by salty ground water or sea water. Characteristically, areas of Natraqualfs are small.

Definition

Natraqualfs are the Aqualfs that:

1. Have a natric horizon;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Do not have a duripan;

4. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite.

Key to Subgroups

JADA. Natraqualfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natraqualfs

JADB. Other Natraqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermic Natraqualfs

JADC. Other Natraqualfs that have *both*:

1. A glossic horizon or interfingering of albic materials into the natric horizon; *and*

2. An exchangeable sodium percentage of less than 15 and less magnesium plus sodium than calcium plus extractable acidity either throughout the upper 15 cm of the natric

horizon or in all horizons within 40 cm of the mineral soil surface, whichever is deeper.

Albic Glossic Natraqualfs

JADD. Other Natraqualfs that have an exchangeable sodium percentage of less than 15 and less magnesium plus sodium than calcium plus extractable acidity either throughout the upper 15 cm of the natric horizon or in all horizons within 40 cm of the mineral soil surface, whichever is deeper.

Albic Natraqualfs

JADE. Other Natraqualfs that have a glossic horizon or interfingering of albic materials into the natric horizon.

Glossic Natraqualfs

JADF. Other Natraqualfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Natraqualfs

JADG. Other Natraqualfs.

Typic Natraqualfs

Definition of Typic Natraqualfs

Typic Natraqualfs are the Natraqualfs that:

1. Do not have a glossic horizon or interfingering of albic materials more than 2.5 cm into the natric horizon;

2. Do not have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing;

3. Have, in some horizon within 40 cm of the soil surface or within the upper 15 cm of the natric horizon, whichever is deeper, 15 percent or more saturation with sodium or more magnesium plus sodium than calcium plus extractable acidity;

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

5. Do not have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Description of Subgroups

Typic Natraqualfs.—The central concept or Typic subgroup of Natraqualfs is fixed on soils that (1) have high saturation with sodium or more magnesium and sodium than calcium and extractable acidity in the upper part; (2) have dominantly low chroma between the A or Ap horizon and a depth of 75 cm or more from the mineral soil surface; (3) do not have a glossic horizon or interfingering of albic materials more than 2.5 cm into the natric horizon; (4) have an ochric epipedon and do not meet any of the requirements for a mollic epipedon, except for thickness, in the plow layer or in comparable horizons if undisturbed; and (5) do not have both cracks and slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more to a depth of 100 cm from the mineral soil surface.

Chroma higher than that of Typic Natraqualfs is characteristic of soils that are saturated for shorter periods and serves to define intergrades to freely drained soils. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic subgroups because these properties are shared with Vertisols. Natraqualfs that have a mollic epipedon or an epipedon that meets all of the requirements for a mollic epipedon except thickness are considered intergrades to Natraquolls and form the basis for defining the Mollic subgroup. Typic Natraqualfs are not extensive. The Typic subgroup is not necessarily the most extensive, but it provides what seems to be the best base for defining other subgroups. Many of these soils are in Texas, and others are widely distributed in the United States. Because the area of Typic Natraqualfs is small, their use generally is determined by the use of the associated soils. Many Typic Natraqualfs have been cleared and are used as cropland, but some are used as pasture or are in forests. Some of these soils are used for rice. The amount of calcium in some of these soils is inadequate for some plants.

Albic Glossic Natraqualfs.—These soils have less than 15 percent sodium and less sodium plus magnesium than calcium plus exchangeable acidity in the upper part of the natric horizon or the upper part of the soils if the top of the natric horizon is deep. These soils also have a glossic horizon or albic materials interfingering into the natric horizon. There are fewer problems of plant nutrition in these soils than in soils of the Typic subgroup. Nevertheless, moisture relations as a rule negatively affect the productivity of Albic Glossic Natraqualfs. These soils are of small extent in the United States and are mostly near the gulf coast. Commonly, they occur in small areas, and the use of these soils is closely associated with the use of the surrounding soils.

Albic Natraqualfs.—These soils have less than 15 percent sodium and less sodium plus magnesium than calcium plus exchangeable acidity in the upper part of the natric horizon or the upper part of the soils if the top of the natric horizon is deep. These soils are otherwise much like Typic Natraqualfs in defined properties. There are fewer problems of plant nutrition in Albic Natraqualfs than in soils of the Typic subgroup. Nevertheless, moisture relations as a rule negatively affect the productivity of Albic Natraqualfs. Commonly, the extent of these soils is small, and the use of the soils is closely associated with the use of the surrounding soils.

Glossic Natraqualfs.—These soils have a glossic horizon or interfingering of albic materials in the upper part of the natric horizon but are otherwise like Typic Natraqualfs in defined properties. In general, the natric horizon is deeper in soils of this subgroup than in Typic Natraqualfs. In the United States, Glossic Natraqualfs are of only small extent. They occur principally in the Mississippi River Valley, California, and Montana. Their use generally is determined by the use of the associated soils.

Mollic Natraqualfs.—These soils have a mollic epipedon or a surface horizon that meets all of the requirements for a mollic epipedon except thickness. The soils are intergrades to Natraquolls. They are of very small extent in the United States.

Vermic Natraqualfs.—These soils have one or more layers, at least 25 cm thick within 100 cm of the mineral soil surface, that have 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts. The soils are intergrades to Vermaqualfs. They are of very small extent in the United States and are mainly in Texas.

Vertic Natraqualfs.—These soils are like Typic Natraqualfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. These soils are not extensive. They are nearly level. Most have been cleared and are used as cropland, but some are used as pasture or are in forests.

Plinthaqualfs

Plinthaqualfs are the Aqualfs that have a frigid, mesic, isomesic, or warmer temperature regime. Plinthite constitutes one-half or more of the volume of the matrix in some subhorizon at a depth between 30 and 150 cm from the soil surface. These soils are mainly in depressions in areas of wet-dry tropical and subtropical climates. They are not known to occur in the United States, but they are reported to be extensive in Africa south of the Sahara. They are perhaps the least used of the Alfisols, at least in part because they tend to be too wet in the rainy season and too dry in the dry season for most crops. On most of these soils, the vegetation is or was savanna or a deciduous broadleaf forest.

Definition

Plinthaqualfs are the Aqualfs that:

1. Have one or more horizons at a depth between 30 and 150 cm from the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume;

2. Have a frigid, mesic, isomesic, or warmer temperature regime.

Key to Subgroups

JABA. All Plinthaqualfs (provisionally).

Typic Plinthaqualfs

Vermaqualfs

Vermaqualfs are the Aqualfs that have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts. Bioturbation has destroyed less than one-half of the volume of some part of the argillic horizon. Krotovinas restrict water movement because they are dense, massive, compact, and stratified. Soil horizons are obliterated where the krotovinas occur. Significant amounts of krotovinas in a soil affect soil morphology, soil hydrology, and soil behavior. These soils are known to in areas occur along the coastal plain of Texas where the bioturbation is caused by crayfish.

Definition

Vermaqualfs are the Aqualfs that:

1. Have one or more layers, at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, that have 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

2. Have a frigid, mesic, isomesic, or warmer temperature regime;

3. Have, in all horizons at a depth between 30 and 150 cm from the mineral soil surface, less than 50 percent (by volume) plinthite;

4. Do not have a duripan, a kandic horizon, or a natric horizon;

5. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

JAGA. Vermaqualfs that have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio of 6 or more) *either or both*:

1. Throughout the upper 15 cm of the argillic horizon; *and/or*

2. Throughout all horizons within 40 cm of the mineral soil surface.

Natric Vermaqualfs

JAGB. Other Vermaqualfs.

Typic Vermaqualfs

Definition of Typic Vermaqualfs

Typic Vermaqualfs are the Vermaqualfs that have an exchangeable sodium percentage of less than 7 throughout the upper 15 cm of the argillic horizon and throughout all horizons within 40 cm of the mineral soil surface.

Description of Subgroups

Typic Vermaqualfs.—Typic Vermaqualfs are the Vermaqualfs that have an exchangeable sodium percentage of less than 7 (and a sodium adsorption ratio of less than 6) both in some part of the upper 15 cm of the argillic horizon and in some horizon within 40 cm of the mineral soil surface.

Natric Vermaqualfs.—Natric Vermaqualfs are the Vermaqualfs that have an exchangeable sodium percentage of 7 or more (and a sodium adsorption ratio of 6 or more) either in some part of the upper 15 cm of the argillic horizon or in some horizon within 40 cm of the mineral soil surface.

Cryalfs

Cryalfs are the more or less freely drained Alfisols of cold regions. Nearly all of these soils have a cryic temperature regime and normally have a udic moisture regime.

Cryalfs are not extensive. They formed in North America, Eastern Europe, and Asia above 49° N. latitude and in some high mountains south of that latitude. In the mountains, they tend to form below the Spodosols or Inceptisols. Most Cryalfs are or have been under a coniferous forest. In North America they are mainly in forests because of their short, cool growing season.

Characteristically, Cryalfs have an O horizon, an albic horizon, and an argillic horizon. In some areas they have a thin A horizon. In regions of the least rainfall, they are neutral or slightly acid in all horizons and a Bk horizon may underlie the argillic horizon. In many of the more humid areas of their occurrence, the lower part of the albic horizon and the upper part of the argillic horizon are strongly or very strongly acid.

Cryalfs in the United States generally developed in Pleistocene deposits, mostly of Wisconsinan age.

Definition

Cryalfs are the Alfisols that:

1. Do not have both aquic conditions and the colors defined for Aqualfs; *and*

2. Have a cryic temperature regime.

Key to Great Groups

JBA. Cryalfs that have *all* of the following:

1. An argillic, kandic, or natric horizon that has its upper boundary 60 cm or more below *both*:

   a. The mineral soil surface; *and*

   b. The lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

2. A texture (in the fine-earth fraction) finer than loamy fine sand in one or more horizons above the argillic, kandic, or natric horizon; *and*

3. Either a glossic horizon or interfingering of albic materials into the argillic, kandic, or natric horizon.

Palecryalfs, p. 198

JBB. Other Cryalfs that have a glossic horizon.

Glossocryalfs, p. 189

JBC. Other Cryalfs.

Haplocryalfs, p. 193

Glossocryalfs

Glossocryalfs are the Cryalfs that have a glossic horizon and normally have an argillic horizon that has an upper boundary within 60 cm of the mineral soil surface. The argillic, kandic, or natric horizon has its upper boundary within 60 cm of the soil surface, unless there is either a sandy or sandy-skeletal particle-size class throughout the layers above the argillic, kandic, or natric horizon or there is a surface mantle or layer in the upper 75 cm consisting of slightly or moderately weathered pyroclastic materials.

The glossic horizon commonly has tonguelike projections of albic materials extending into the argillic horizon. These projections are thought to indicate that the argillic horizon is being moved deeper into the soils. In the areas where the soils are transitional between Spodosols and Alfisols, some Glossocryalfs have a cambic horizon that appears to be an incipient spodic horizon. The cambic horizon is commonly separated from the argillic horizon by an albic horizon. The vegetation is mostly coniferous trees. A few Glossocryalfs have been cleared and are used mostly as pasture.

Definition

Glossocryalfs are the Cryalfs that have:

1. A glossic horizon; *and*

2. *One or more* of the following:

   a. An argillic, kandic, or natric horizon that has its upper boundary at less than 60 cm below the mineral soil surface; *or*

   b. An argillic, kandic, or natric horizon that has its upper boundary at less than 60 cm below the lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *or*

c. No texture (in the fine-earth fraction) finer than loamy fine sand in any horizon above the argillic, kandic, or natric horizon.

Key to Subgroups

JBBA. Glossocryalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Glossocryalfs

JBBB. Other Glossocryalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Glossocryalfs

JBBC. Other Glossocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Glossocryalfs

JBBD. Other Glossocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Glossocryalfs

JBBE. Other Glossocryalfs that have, in one or more subhorizons within the upper 25 cm of the argillic, kandic, or natric horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Glossocryalfs

JBBF. Other Glossocryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Glossocryalfs

JBBG. Other Glossocryalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossocryalfs

JBBH. Other Glossocryalfs that have:

1. A xeric moisture regime; *and*

2. An Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

3. A base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Xerollic Glossocryalfs

JBBI. Other Glossocryalfs that have:

1. A xeric moisture regime; *and*

2. An Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Umbric Xeric Glossocryalfs

JBBJ. Other Glossocryalfs that:

1. Are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years; *and*

2. Have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

3. Have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Ustollic Glossocryalfs

JBBK. Other Glossocryalfs that have a xeric moisture regime.

Xeric Glossocryalfs

JBBL. Other Glossocryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Glossocryalfs

JBBM. Other Glossocryalfs that:

1. Have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

2. Have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Glossocryalfs

JBBN. Other Glossocryalfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Umbric Glossocryalfs

JBBO. Other Glossocryalfs that have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Eutric Glossocryalfs

JBBP. Other Glossocryalfs.

Typic Glossocryalfs

Definition of Typic Glossocryalfs

Typic Glossocryalfs are the Glossocryalfs that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have *one or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. In any subhorizon within the upper 25 cm of the argillic, kandic, or natric horizon, do not have redox depletions with chroma of 2 or less and also aquic conditions;

5. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years;

6. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

7. Have a udic moisture regime;

8. Are dry in some part of the moisture control section for less than 45 days (cumulative) in normal years;

9. Have an Ap horizon with a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing;

10. Have a base saturation of less than 50 percent (by

NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Glossocryalfs.—The central concept or Typic subgroup of Glossocryalfs is fixed on freely drained soils that are deep or moderately deep to hard rock and that have a high color value to a depth comparable to that of an Ap horizon. The soils have a glossic horizon and are moist in all but short periods during the growing season.

These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks because these properties are shared with Vertisols. Soils that have both a low bulk density and a high content of weakly crystalline minerals or that have a high content of volcanic glass are excluded from Typic Glossocryalfs because these properties are shared with Andisols. Soils that have both redox depletions with low chroma in the upper 25 cm of the argillic, kandic, or natric horizon and ground water within this depth are excluded from Typic Glossocryalfs because these properties are shared with Aqualfs. Other soils that are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years are excluded because of importance to the use of these soils. Soils with a layer having fragic soil properties also are excluded because these properties are shared with Fraglossudalfs and Fragiudalfs. Typic Glossocryalfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. Soils that have a xeric moisture regime and other soils that are dry for more than 45 days also are excluded because they share properties with Xeralfs and Ustalfs. Soils that have a surface horizon as thick as 15 cm that is dark enough to be near or within the range of a mollic or umbric epipedon are recognized as Mollic intergrades or Umbric extragrades.

Typic Glossocryalfs are in the mountains in the Western United States. They generally are under a coniferous forest. They have gentle to very steep slopes. They are of small extent in the United States and are rare elsewhere.

Andic and Vitrandic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the high mountains of the Western United States. They are permitted, but not required, to have redox depletions and also a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. They also are permitted to be dry for more than 45 days. They are not extensive. Most of them have moderate or strong slopes and are used for limited summer grazing, as forest, or as wildlife habitat.

Aquic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have redox depletions with chroma of 2 or less and have horizons, within 75 cm of the surface, that are saturated with water at some time during the year. The gray redox depletions should not be confused with low chroma of the glossic horizon. In addition to the redox depletions, Aquic Glossocryalfs are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Eutric Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a base saturation of 50 percent or more (by NH_4OAc) in all parts between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils formed mostly in calcareous materials. They support range or coniferous forest vegetation and have gentle to very steep slopes. They are of small extent in the United States and are rare elsewhere.

Fragic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a fragipan or at least 30 percent (by volume) peds with fragic soil properties in the upper part of the argillic horizon. Fragic Glossocryalfs have not been recognized in the United States.

Lithic Glossocryalfs.—These soils are permitted to have any of the properties of Glossocryalfs. They are required to have a lithic contact within 50 cm of the surface. These soils are of small extent in the Western United States.

Mollic Glossocryalfs.—These soils are like Typic Glossocryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. Mollic Glossocryalfs have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. These soils commonly support a coniferous forest in which the trees are more widely spaced than is typical for Glossocryalfs. Mollic Glossocryalfs are not extensive in the United States except very locally.

Oxyaquic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. Oxyaquic Glossocryalfs are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Umbric Glossocryalfs.—These soils are like Typic Glossocryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. The soils commonly support coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. The soils are not extensive in the United States.

Umbric Xeric Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a xeric moisture regime and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower. Umbric Xeric Glossocryalfs commonly support coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. They are not extensive in the United States.

Ustic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years. They are considered to be transitional to Ustalfs. Ustic Glossocryalfs commonly support a sparse coniferous forest with widely spaced trees or are used as rangeland. They are not extensive in the United States except very locally.

Ustollic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. They are considered to be transitional to Ustolls. They commonly support rangeland vegetation or a sparse coniferous forest with widely spaced trees. They are not extensive in the United States.

Vertic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are considered to be transitional to Vertisols. Vertic Glossocryalfs support coniferous forest or are used as rangeland. They are not extensive in the United States.

Xeric Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a xeric moisture regime. They are considered to be transitional to Xeralfs. Xeric Glossocryalfs commonly support coniferous forest. Some forests have widely spaced trees. In some areas Xeric Glossocryalfs are used as rangeland. These soils are not extensive in the United States.

Xerollic Glossocryalfs.—These soils are like Typic Glossocryalfs, but they have a xeric moisture regime and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. They are considered to be transitional to Xerolls. Xerollic Glossocryalfs commonly support a sparse coniferous forest with widely spaced trees or support rangeland vegetation. They are not extensive in the United States.

Haplocryalfs

These are the Cryalfs with no glossic horizon. Most of these soils have no interfingering of albic materials into the argillic, kandic, or natric horizon. Most have an argillic horizon that has an upper boundary within 60 cm of the mineral soil surface. The common sequence of horizons is an O horizon, an albic horizon, and an argillic horizon. There also are transitional horizons and a Bw, Btk, or Bk horizon in some pedons.

The Haplocryalfs of the United States are in the mountains of the Western States and have a cryic temperature regime. Most support coniferous forest vegetation. Virtually none of them are cultivated because their slopes are steep and the growing season is short and cool. In other countries, Haplocryalfs occur on mountains and also on plains nearly as far north as the line of continuous permafrost. Some of the associated soils on these landscapes are Gelisols on north-facing slopes and Histosols.

Definition

Haplocryalfs are the Cryalfs that:

1. Do not have a glossic horizon; *and*

2. Have *one or more* of the following:

a. An argillic, kandic, or natric horizon that has its upper boundary at less than 60 cm below the mineral soil surface; *or*

b. An argillic, kandic, or natric horizon that has its upper boundary at less than 60 cm below the lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *or*

c. No texture (in the fine-earth fraction) finer than loamy fine sand in any horizon above the argillic, kandic, or natric horizon; *or*

d. No interfingering of albic materials into the argillic or natric horizon.

Key to Subgroups

JBCA. Haplocryalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryalfs

JBCB. Other Haplocryalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryalfs

JBCC. Other Haplocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplocryalfs

JBCD. Other Haplocryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplocryalfs

JBCE. Other Haplocryalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryalfs

JBCF. Other Haplocryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryalfs

JBCG. Other Haplocryalfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haplocryalfs

JBCH. Other Haplocryalfs that have a sandy or sandy-skeletal particle-size class throughout the upper 75 cm of the argillic, kandic, or natric horizon or throughout the entire argillic, kandic, or natric horizon if it is less than 75 cm thick.

Psammentic Haplocryalfs

JBCI. Other Haplocryalfs that have:

1. An argillic, kandic, or natric horizon that is 35 cm or less thick; *and*

2. No densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haplocryalfs

JBCJ. Other Haplocryalfs that have:

1. A xeric moisture regime; *and*

2. An Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

3. A base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Xerollic Haplocryalfs

JBCK. Other Haplocryalfs that have:

1. A xeric moisture regime; *and*

2. An Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Umbric Xeric Haplocryalfs

JBCL. Other Haplocryalfs that:

1. Are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years; *and*

2. Have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

3. Have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Ustollic Haplocryalfs

JBCM. Other Haplocryalfs that have a xeric moisture regime.

Xeric Haplocryalfs

JBCN. Other Haplocryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Haplocryalfs

JBCO. Other Haplocryalfs that:

1. Have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

2. Have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Haplocryalfs

JBCP. Other Haplocryalfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Umbric Haplocryalfs

JBCQ. Other Haplocryalfs that have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Eutric Haplocryalfs

JBCR. Other Haplocryalfs.

Typic Haplocryalfs

Definition of Typic Haplocryalfs

Typic Haplocryalfs are the Haplocryalfs that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have *one or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

5. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years;

6. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5

cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

7. Have an argillic, kandic, or natric horizon that is finer than the sandy or sandy-skeletal particle-size class in some part of the upper 75 cm if the argillic, kandic, or natric horizon is more than 75 cm thick or in any part if the argillic, kandic, or natric horizon is less than 75 cm thick;

8. Have an argillic, kandic, or natric horizon that is more than 35 cm thick;

9. Have a udic moisture regime;

10. Are dry in some part of the moisture control section for less than 45 days (cumulative) in normal years;

11. Have an Ap horizon with a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

12. Have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Haplocryalfs.—The central concept or Typic subgroup of Haplocryalfs is fixed on freely drained soils that are deep or moderately deep to hard rock and that do not have a glossic horizon. These soils have a high color value in an Ap horizon or in a layer of comparable depth after mixing and have a loamy or finer textured argillic horizon not composed entirely of thin lamellae.

These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks because these properties are shared with Vertisols. Soils with both a low bulk density and a high content of weakly crystalline minerals or that consist of thin layers of pyroclastic materials are excluded from Typic Haplocryalfs because they have properties that are shared with the Andisols. Redox depletions and saturation with water within 100 cm of the surface for extended periods cause a soil to be excluded from the Typic subgroup because they are properties shared with Aqualfs. A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy.

Soils that have a xeric moisture regime and other soils that are dry for more than 45 days also are excluded because they share properties with Xeralfs and Ustalfs. Soils that have a surface horizon as thick as 15 cm that is dark enough to be near or within the range of a mollic or umbric epipedon are excluded from the Typic subgroup because the thick, dark horizon is believed to indicate a transitional form to Mollisols or an Umbric extragrade.

Haplocryalfs with an argillic, kandic, or natric horizon that has a sandy or sandy-skeletal particle-size class are excluded from the Typic subgroup and are assigned to the Psammentic subgroup. Soils that have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a root-limiting layer are considered atypical and are assigned to the Eutric subgroup.

Typic Haplocryalfs are not extensive in the United States. They are in the mountains of the Western States. Most of them are under a coniferous forest. Slopes generally are moderately steep to very steep.

Andic and Vitrandic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the high mountains of the Western United States. They are permitted, but not required, to have redox depletions and also color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. They also are permitted to be dry for more than 45 days. They are not extensive. Most of them have moderate or strong slopes and are used for limited summer grazing, as forest, or as wildlife habitat.

Aquic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have redox depletions with chroma of 2 or less and have, within 75 cm of the surface, horizons that are saturated with water at some time during the year. In addition to the redox depletions, Aquic Haplocryalfs are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Eutric Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have a base saturation of 50 percent or more (by NH_4OAc) in all parts between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower. Most of these soils formed in calcareous materials. Eutric Haplocryalfs support range or coniferous forest vegetation and have gentle to very steep slopes. They are of small extent in the United States and are rare elsewhere.

Inceptic Haplocryalfs.—These soils are like Typic Haplocryalfs in defined properties, but they have an argillic, kandic, or natric horizon that is 35 cm or less thick and have no densic, lithic, or paralithic contact within 100 cm of the mineral soil surface. These soils may also have an Ap horizon that has a color value, moist, of 3 or less or upper horizons that have a color value, moist, of less than 4 after the surface soil has been mixed to a depth of 15 cm. These soils are not extensive in the United States.

Lamellic Haplocryalfs.—These soils are like Typic Haplocryalfs in defined properties, but they have an argillic horizon that consists entirely or partially of lamellae. Most of these soils have a sandy particle-size class, and the upper boundary of the argillic horizon or the upper lamella may be below a depth of 60 cm. The upper several lamellae are commonly broken or discontinuous horizontally. These soils may also have a glossic horizon, and they are allowed to have an Ap horizon that has a color value, moist, of 3 or less or upper horizons that have a color value, moist, of less than 4 after the surface soil has been mixed to a depth of 15 cm. These soils are not extensive in the United States.

Lithic Haplocryalfs.—These soils are permitted to have any of the properties of Haplocryalfs. They are required to have a lithic contact within 50 cm of the surface. They are of small extent in the Western United States.

Mollic Haplocryalfs.—These soils are like Typic Haplocryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. Mollic Haplocryalfs commonly support a coniferous forest in which the trees are more widely spaced than in areas of the Typic subgroup. These soils are not extensive in the United States except very locally.

Oxyaquic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Psammentic Haplocryalfs.—These soils are like Typic Haplocryalfs in defined properties, but they have a sandy or sandy-skeletal particle-size class throughout the upper 75 cm of the argillic, kandic, or natric horizon or throughout the entire argillic, kandic, or natric horizon if it is less than 75 cm thick. These soils may also have a glossic horizon and an Ap horizon that has a color value, moist, of 3 or less or upper horizons that have a color value, moist, of less than 4 after the surface soil has been mixed to a depth of 15 cm. These soils are not extensive in the United States.

Umbric Haplocryalfs.—These soils are like Typic Haplocryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a root-limiting layer, whichever is shallower. Umbric Haplocryalfs commonly support coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. The soils are not extensive in the United States.

Umbric Xeric Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have a xeric moisture regime and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. They also have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a densic, lithic, or paralithic contact, whichever is shallower. Umbric Xeric Haplocryalfs commonly support coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. The soils are not extensive in the United States.

Ustic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years. They are considered to be transitional to Ustalfs. Ustic Haplocryalfs commonly support a sparse coniferous forest with widely spaced trees or are used as rangeland. They are not extensive in the United States except very locally.

Ustollic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. They are considered to be transitional to Ustolls. Ustollic Haplocryalfs commonly support rangeland vegetation or a sparse coniferous forest with widely spaced trees. They are not extensive in the United States.

Vertic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are considered to be transitional to Vertisols. They support coniferous forest or are used as rangeland. They are not extensive in the United States.

Xeric Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have a xeric moisture regime. They are considered to be transitional to Xeralfs. Xeric Haplocryalfs commonly support coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. The soils are not extensive in the United States.

Xerollic Haplocryalfs.—These soils are like Typic Haplocryalfs, but they have a xeric moisture regime and their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. They are considered to be transitional to Xerolls. Xerollic Haplocryalfs commonly support a sparse coniferous forest with widely spaced trees or support rangeland vegetation. They are not extensive in the United States.

Palecryalfs

Palecryalfs are the Cryalfs that have a thick epipedon and a glossic horizon or interfingering of albic materials into the argillic, kandic, or natric horizon. Most of these soils have an albic horizon and a glossic horizon. The soils are thought to be restricted to relatively stable surfaces in the mountains, many of which are older than the Wisconsinan Glaciation. The stability may be the result of stoniness. The vegetation on these soils is mostly coniferous forest. The temperature regimes are mostly cryic. The moisture regimes are mostly udic.

Definition

Palecryalfs are the Cryalfs that:

1. Have an argillic, kandic, or natric horizon that has its upper boundary 60 cm or more below *both*:

   a. The mineral soil surface; *and*

   b. The lower boundary of any surface mantle containing 60 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

2. Have a glossic horizon or interfingering of albic materials in the argillic, kandic, or natric horizon; *and*

3. Have texture (in the fine-earth fraction) finer than loamy fine sand in some subhorizon above the argillic, kandic, or natric horizon.

Key to Subgroups

JBAA. Palecryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palecryalfs

JBAB. Other Palecryalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palecryalfs

JBAC. Other Palecryalfs that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palecryalfs

JBAD. Other Palecryalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Palecryalfs

JBAE. Other Palecryalfs that have a xeric moisture regime.

Xeric Palecryalfs

JBAF. Other Palecryalfs that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Palecryalfs

JBAG. Other Palecryalfs that:

1. Have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

2. Have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Mollic Palecryalfs

JBAH. Other Palecryalfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Umbric Palecryalfs

JBAI. Other Palecryalfs.

Typic Palecryalfs

Definition of Typic Palecryalfs

Typic Palecryalfs are the Palecryalfs that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years;

4. Have a udic moisture regime;

5. Are dry in some part of the moisture control section for less than 45 days (cumulative) in normal years; *and*

6. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed or have materials to a depth of 18 cm that have these colors after mixing.

Description of Subgroups

Typic Palecryalfs.—The central concept or Typic subgroup of Palecryalfs is fixed on freely drained soils that are deep to the top of the argillic horizon and that have a glossic horizon. These soils have a high color value in an Ap horizon or in a layer of comparable depth after mixing and have a loamy or finer texture above the argillic horizon.

Soils with both a low bulk density and a high content of weakly crystalline minerals or that consist of thin layers of pyroclastic materials are excluded from Typic Palecryalfs because they have properties that are shared with Andisols. Redox depletions and saturation with water within 100 cm of the surface for extended periods cause a soil to be excluded from the Typic subgroup because they are properties shared with Aqualfs.

Soils that have a xeric moisture regime and other soils that are dry for more than 45 days also are excluded because they share properties with Xeralfs and Ustalfs. Soils that have a surface horizon as thick as 15 cm that is dark enough to be near or within the range of a mollic or umbric epipedon are excluded from the Typic subgroup because the thick, dark horizon is believed to indicate a transitional form to Mollisols or an Umbric extragrade.

Typic Palecryalfs are not extensive in the United States. They are in the mountains of the Western States. Most are under a coniferous forest. Slopes generally are moderately steep to very steep.

Andic and Vitrandic Palecryalfs.—These soils are like Typic Palecryalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the high mountains of the Western United States. They are permitted, but not required, to have redox depletions and also color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. They also are permitted to be dry for more than 45 days. They are not extensive. Most of them are moderately steep to very steep and are used for limited summer grazing, as forest, or as wildlife habitat.

Aquic Palecryalfs.—These soils are like Typic Palecryalfs, but they have redox depletions with chroma of 2 or less and have, within 75 cm of the surface, horizons that are saturated with water at some time during the year. In addition to the redox depletions, Aquic Palecryalfs are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Mollic Palecryalfs.—These soils are like Typic Palecryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of 50 percent or more (by NH_4OAc) in all parts from the mineral soil surface to a depth of 180 cm or to a densic, lithic, or paralithic contact, whichever is shallower. The soils commonly support a coniferous forest in which the trees are more widely spaced than is typical for Palecryalfs. Mollic Palecryalfs are not extensive in the United States.

Oxyaquic Palecryalfs.—These soils are like Typic Palecryalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are permitted to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States.

Umbric Palecryalfs.—These soils are like Typic Palecryalfs, but their upper horizons have a color value of 3 or less, moist, and 5 or less, dry, after mixing to a depth of 15 cm. These soils have a base saturation of less than 50 percent (by NH_4OAc) in some part between the mineral soil surface and a depth of 180 cm or a root-limiting layer, whichever is shallower. They commonly support a coniferous forest. Some forests have widely spaced trees. In some areas Umbric Palecryalfs are used as rangeland. The soils are not extensive in the United States.

Ustic Palecryalfs.—These soils are like Typic Palecryalfs, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years. They are considered to be transitional to Ustalfs. Ustic Palecryalfs commonly support a sparse coniferous forest with widely spaced trees or are used as rangeland. They are not extensive in the United States.

Xeric Palecryalfs.—These soils are like Typic Palecryalfs, but they have a xeric moisture regime. They are considered to be transitional to Xeralfs. Xeric Palecryalfs commonly support a coniferous forest. Some forests have widely spaced trees. In some areas these soils are used as rangeland. The soils are not extensive in the United States.

Udalfs

Udalfs are the more or less freely drained Alfisols that have a udic moisture regime and a frigid, mesic, isomesic, or warmer temperature regime. These soils are principally but not entirely in areas of late-Pleistocene deposits and erosional surfaces of about the same age. Some of the Udalfs that are on the older surfaces are underlain by limestone or other calcareous sediments.

Udalfs are very extensive in the United States and in Western Europe. All of them are believed to have supported forest vegetation at some time during development. Most Udalfs with a mesic or warmer temperature regime have or had deciduous forest vegetation, and many with a frigid temperature regime have or had mixed coniferous and deciduous forest vegetation.

Many Udalfs have been cleared of trees and are intensively farmed. As a result of erosion, many now have only an argillic or kandic horizon below an Ap horizon that is mostly material once part of the argillic or kandic horizon. Other Udalfs are on stable surfaces and retain most of their eluvial horizons above the argillic or kandic horizon. Normally, the undisturbed soils have a thin A horizon darkened by humus. A few Udalfs have a natric horizon. Others have a fragipan in or below the argillic or kandic horizon.

Definition

Udalfs are the Alfisols that:

1. Have a frigid, mesic, isomesic, or warmer temperature regime;

2. Have a udic moisture regime; *and*

3. Have, in no horizon within 50 cm of the mineral soil surface, both aquic conditions (other than anthraquic conditions) for some time in normal years (or artificial drainage) *and either* of the following:

a. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm; *and one* of the following within the upper 12.5 cm of the argillic, kandic, natric, or glossic horizon:

(1) 50 percent or more redox depletions with chroma of 2 or less on faces of peds and redox concentrations within peds; *or*

(2) Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less in the matrix; *or*

(3) 50 percent or more redox depletions with chroma of 1 or less on faces of peds or in the matrix, or both; *or*

b. In a horizon that has aquic conditions, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

JEA. Udalfs that have a natric horizon.

Natrudalfs, p. 221

JEB. Other Udalfs that have:

1. A glossic horizon; *and*

2. In the argillic or kandic horizon, discrete nodules, 2.5 to 30 cm in diameter, that:

a. Are enriched with iron and extremely weakly cemented to indurated; *and*

b. Have exteriors with either a redder hue or a higher chroma than the interiors.

Ferrudalfs, p. 201

JEC. Other Udalfs that have *both*:

1. A glossic horizon; *and*

2. A fragipan with an upper boundary within 100 cm of the mineral soil surface.

Fraglossudalfs, p. 203

JED. Other Udalfs that have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Fragiudalfs, p. 202

JEE. Other Udalfs that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured noncarbonate clay or based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiudalfs, p. 217

JEF. Other Udalfs that have a kandic horizon.

Kanhapludalfs, p. 219

JEG. Other Udalfs that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured noncarbonate clay or based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

3. Have an argillic horizon with *one or more* of the following:

a. In 50 percent or more of the matrix of one or more subhorizons in its lower one-half, hue of 7.5YR or redder and chroma of 5 or more; *or*

b. In 50 percent or more of the matrix of horizons that total more than one-half the total thickness, hue of 2.5YR or redder, value, moist, of 3 or less, and value, dry, of 4 or less; *or*

c. Many coarse redox concentrations with hue of 5YR or redder or chroma of 6 or more, or both, in one or more subhorizons; *or*

4. Have a frigid temperature regime and *all* of the following:

a. An argillic horizon that has its upper boundary 60 cm or more below *both*:

(1) The mineral soil surface; *and*

(2) The lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

b. A texture (in the fine-earth fraction) finer than loamy fine sand in one or more horizons above the argillic horizon; *and*

c. Either a glossic horizon or interfingering of albic materials into the argillic horizon.

Paleudalfs, p. 222

JEH. Other Udalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodudalfs, p. 228

JEI. Other Udalfs that have a glossic horizon.

Glossudalfs, p. 205

JEJ. Other Udalfs.

Hapludalfs, p. 208

Ferrudalfs

Ferrudalfs are the Udalfs that do not have a natric horizon and have both a glossic horizon and an argillic or kandic horizon that has been partially cemented by iron. In some areas these soils formed under a heath vegetation. The heath vegetation may have succeeded a forest following many years of collection and removal of forest litter. Under the heath, which is efficient in complexing iron and aluminum, the upper part of the argillic horizon was destroyed and fragments of the argillic horizon became coated and weakly cemented with iron. Some Ferrudalfs have a fragipan at some depth, commonly about 100 cm. Ferrudalfs are not known to occur in the United States and are rare elsewhere. Only two subgroups are provided.

Definition

Ferrudalfs are the Udalfs that:

1. Do not have a natric horizon;

2. Have a glossic horizon; *and*

3. In the argillic or kandic horizon, have discrete nodules, 2.5 to about 30 cm in diameter, that are enriched with iron, that are extremely weakly cemented to indurated, and that have exteriors with either a redder hue and/or a higher chroma than the interiors.

Key to Subgroups

JEBA. Ferrudalfs that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ferrudalfs

JEBB. Other Ferrudalfs.

Typic Ferrudalfs

Definition of Typic Ferrudalfs

Typic Ferrudalfs are the Ferrudalfs that do not have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years.

Description of Subgroups

Typic Ferrudalfs.—These soils are the Ferrudalfs that do not have, in any horizon within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions. These soils are not known to occur in the United States.

Aquic Ferrudalfs.—These soils are like Typic Ferrudalfs, but they have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). These soils are intergrades between Aqualfs and Ferrudalfs. They are not known to occur in the United States.

Fragiudalfs

Fragiudalfs are the Udalfs that have a fragipan within 100 cm of the soil surface but do not have a glossic or natric horizon. They commonly have an argillic or cambic horizon above the fragipan. Redoximorphic features are in many pedons, starting at a depth 50 to 100 cm below the mineral soil surface. Ground water is perched seasonally above the fragipan, and a thin eluvial horizon commonly is directly above the fragipan.

Most Fragiudalfs in the United States are on gentle slopes and formed, at least in part, in silty or loamy deposits. The deposits are largely of late-Pleistocene age. The duripan formed in an older buried soil in some areas. A duripan seems to form if the burial was to a depth of about 50 to 75 cm. Temperature regimes are mostly frigid, mesic, or thermic. In the United States, the native vegetation on these soils was primarily a broadleaf deciduous forest.

Definition

Fragiudalfs are the Udalfs that:

1. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

2. Do not have a natric horizon; *and*

3. Do not have a glossic horizon.

Key to Subgroups

JEDA. Fragiudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragiudalfs

JEDB. Other Fragiudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragiudalfs

JEDC. Other Fragiudalfs that have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiudalfs

JEDD. Other Fragiudalfs that are saturated with water in one or more layers above the fragipan in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fragiudalfs

JEDE. Other Fragiudalfs.

Typic Fragiudalfs

Definition of Typic Fragiudalfs

Typic Fragiudalfs are the Fragiudalfs that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any subhorizon within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions; *and*

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years.

Description of Subgroups

Typic Fragiudalfs.—The central concept or Typic subgroup of Fragiudalfs is fixed on the most freely drained soils of this great group. Typic Fragiudalfs are not the most extensive subgroup, but they furnish the best basis for definition of subgroups. No Fragiudalfs are freely drained because in all of them ground water is perched above the fragipan in many years. The perched water table is a probable cause of the very common albic materials and bleached clay depletions directly above the fragipan. Soils that have these features and also redox depletions with low chroma at a shallow depth, normally along with redox concentrations of high chroma or of reddish hue, are considered to be intergrades toward Aqualfs. Typic Fragiudalfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols.

Andic and Vitrandic Fragiudalfs.—These soils are like Typic Fragiudalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are permitted, but not required, to have redox depletions and to be saturated with water within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years. They are not extensive. They are used mainly as forest, but some have been cleared and are used as cropland or pasture.

Aquic Fragiudalfs.—These soils are like Typic Fragiudalfs, but they have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They are intergrades between Fragiaqualfs and Fragiudalfs. In the United States, they are widely scattered from Pennsylvania to Illinois and from Illinois to Louisiana. They are moderately extensive locally within this area. They have gentle slopes, and most of them are farmed.

Oxyaquic Fragiudalfs.—These soils are like Typic Fragiudalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The wetness is caused by slow permeability in the fragipan. These soils are common in the United States. Most of them have been cleared and are used for crops or pasture.

Fraglossudalfs

Fraglossudalfs have both a fragipan within 100 cm of the soil surface and a glossic horizon. They do not have a natric horizon or discrete iron-cemented nodules 2.5 to 30 cm in diameter in an argillic or kandic horizon. The upper boundary of the argillic or kandic horizon generally is broken. These soils are not extensive in the United States. They are more extensive in Europe.

Definition

Fraglossudalfs are the Udalfs that:

1. Have a glossic horizon;

2. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have a natric horizon; *and*

4. Do not have, in the argillic or kandic horizon, discrete nodules, 2.5 to 30 cm in diameter, that have exteriors with either a redder hue or a higher chroma than the interiors, that are enriched with iron, and are extremely weakly cemented to indurated.

Key to Subgroups

JECA. Fraglossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fraglossudalfs

JECB. Other Fraglossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fraglossudalfs

JECC. Other Fraglossudalfs that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fraglossudalfs

JECD. Other Fraglossudalfs that are saturated with water in one or more layers above the fragipan in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fraglossudalfs

JECE. Other Fraglossudalfs.

Typic Fraglossudalfs

Definition of Typic Fraglossudalfs

Typic Fraglossudalfs are the Fraglossudalfs that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

2. Do not have, in any subhorizon within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions; *and*

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years.

Description of Subgroups

Typic Fraglossudalfs.—The central concept or Typic subgroup of Fraglossudalfs is fixed on moderately well drained soils that have a fragipan at a depth of 50 to 100 cm from the mineral soil surface. These soils are more freely drained than most soils in this great group. Typic Fraglossudalfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. Typic Fraglossudalfs are rare in the United States.

Andic and Vitrandic Fraglossudalfs.—These soils are like Typic Fraglossudalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are permitted, but not required, to have redox depletions and to be saturated with water within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years. They are not extensive. They are used mainly as forest, but some have been cleared and are used as cropland or pasture.

Aquic Fraglossudalfs.—These soils are like Typic Fraglossudalfs, but they have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). These soils are intergrades between Fragiaqualfs and Fraglossudalfs. In the United States, they are widely scattered from New York to Louisiana and some are in Idaho. These soils are moderately extensive locally within this area. They have gentle slopes, and most of them are farmed.

Oxyaquic Fraglossudalfs.—These soils are like Typic Fraglossudalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The wetness is caused by slow permeability in the fragipan. These soils are common in the United States. Most of them have been cleared and are used for crops or pasture.

Glossudalfs

Glossudalfs do not have a fragipan, a kandic horizon, or a natric horizon. They have an argillic horizon that shows evidence of destruction in the form of a glossic horizon, but they do not have discrete iron-cemented nodules 2.5 to 30 cm in diameter. The glossic horizon extends through the argillic horizon in some of these soils. Glossudalfs do not have very dark red colors throughout the argillic horizon. They are more extensive in Europe than in the United States.

Definition

Glossudalfs are the Udalfs that:

1. Have a glossic horizon;

2. Do not have, in the argillic horizon, discrete nodules, 2.5 to 30 cm in diameter, that have enriched exteriors and are cemented or indurated with iron;

3. Do not have a natric or kandic horizon;

4. Do not have a fragipan within 100 cm of the soil surface;

5. Have an argillic horizon that in some part has hue of 5YR or yellower, a color value, moist, of 3.5 or more, or a color value, dry, more than 1 unit higher than the moist value.

Key to Subgroups

JEIA. Glossudalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquertic Glossudalfs

JEIB. Other Glossudalfs that have *both*:

1. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Oxyaquic Vertic Glossudalfs

JEIC. Other Glossudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Glossudalfs

JEID. Other Glossudalfs that have *both*:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Glossudalfs

JEIE. Other Glossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Glossudalfs

JEIF. Other Glossudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Glossudalfs

JEIG. Other Glossudalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Glossudalfs

JEIH. Other Glossudalfs that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Glossudalfs

JEII. Other Glossudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Glossudalfs

JEIJ. Other Glossudalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Glossudalfs

JEIK. Other Glossudalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Glossudalfs

JEIL. Other Glossudalfs that have a glossic horizon less than 50 cm in total thickness.

Haplic Glossudalfs

JEIM. Other Glossudalfs.

Typic Glossudalfs

Definition of Typic Glossudalfs

Typic Glossudalfs are the Glossudalfs that:

1. Do not have cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface;

2. Have a linear extensibility of less than 6.0 cm between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. Do not have, in any subhorizon within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions;

5. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years;

6. Do not have fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick;

7. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface;

8. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick; *and*

9. Have a glossic horizon that is 50 cm or more thick.

Description of Subgroups

Typic Glossudalfs.—The central concept or Typic subgroup of Glossudalfs is fixed on freely drained soils that have a glossic horizon that is at least 50 cm in total thickness. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks because these properties are shared with Vertisols.

Soils with both a low bulk density and a high content of weakly crystalline minerals or that consist of thin layers of pyroclastic materials are excluded from Typic Glossudalfs because they have properties that are shared with Andisols. Redox depletions and saturation with water within 100 cm of the surface for extended periods cause a soil to be excluded from the Typic subgroup because these properties are shared with Aqualfs. Typic Glossudalfs do not have fragic soil properties in a large volume in any layer 15 cm or more thick because these are properties shared with Fragiudalfs and Fraglossudalfs. Typic Glossudalfs do not have a layer, starting at the mineral soil surface, that has a texture of loamy fine sand or coarser in all parts and that is more than 50 cm thick because this property is used to define the Arenic subgroup.

Typic Glossudalfs are of small extent in the United States. They occur in areas from Texas to Michigan.

Andic and Vitrandic Glossudalfs.—These soils are like Typic Glossudalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are not extensive. Most of them have gently sloping to steep slopes and are used as cropland, forest, or pasture.

Aquandic Glossudalfs.—These soils are like Typic Glossudalfs, but they have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are not extensive. Most of them are level to gently sloping and are used as cropland, forest, or pasture.

Aquertic Glossudalfs.—These soils have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they have an appreciable amount of swelling clays. The aquic conditions, swelling clays, and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Aquertic Glossudalfs are of small extent. Slopes are gentle, but the soils are highly erodible. Most of the soils are farmed, but some of them are used as pasture or forest.

Aquic Glossudalfs.—These soils have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they are permitted to have fragic soil properties. These soils are permitted, but not required, to have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more. In the United States, these soils are moderately extensive on the lower coastal plain along the Gulf of Mexico and are known to occur elsewhere. Many of them are in forests, but much of the acreage of these soils has been cleared and is used as cropland or pasture.

Arenic Glossudalfs.—These soils have a layer that has a sandy or sandy-skeletal particle-size class throughout and extends from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface. These soils are known to occur only in Texas and Michigan in the United States.

Fragiaquic Glossudalfs.—These soils are like Typic Glossudalfs, but they have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Fragic Glossudalfs.—These soils are like Typic Glossudalfs, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Haplic Glossudalfs.—These soils are like Typic Glossudalfs, but the glossic horizon is less than 50 cm thick. Thus, the soils have some characteristics of Hapludalfs. They occur locally in Michigan and Wisconsin and in the central part of the Southern United States.

Oxyaquic Glossudalfs.—These soils are like Typic Glossudalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are of small extent and are mostly in the south-central and north-central parts of the United States.

Oxyaquic Vertic Glossudalfs.—These soils are like Typic Glossudalfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils also are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The wetness is caused mainly by slowly permeable materials in the lower horizons or the substratum. These soils are rare in the United States and are considered to be transitional to Vertisols.

Vertic Glossudalfs.—These soils are like Typic Glossudalfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are rare in the United States and are considered to be transitional to Vertisols.

Hapludalfs

Hapludalfs are the Udalfs that do not have a glossic, kandic, or natric horizon or a fragipan within 100 cm of the mineral soil surface. They do not have very dark red colors throughout the argillic horizon. The base of the argillic horizon is normally less than 150 cm below the soil surface and, in many areas, is less than 100 cm below the surface. In an undisturbed soil, there generally is a thin, very dark brown A horizon, 5 to 10 cm thick, over a lighter colored brownish eluvial horizon. The eluvial horizon grades into a finer textured argillic horizon, generally at a depth of about 30 to 45 cm in loamy materials. Because the Hapludalfs have been cultivated extensively, many of those on slopes have lost their eluvial horizons.

These soils formed principally in late-Pleistocene deposits or on a surface of comparable age. They are extensive soils in the Northeastern States, excluding New England, and in Europe, excluding most of Scandinavia.

The vegetation on Hapludalfs in the United States was a deciduous broadleaf forest, but the soils are now mostly farmed. Temperature regimes are mesic or thermic.

Definition

Hapludalfs are the Udalfs that:

1. Do not have a glossic, kandic, or natric horizon;

2. Have an argillic horizon that in some part has hue of 5YR or yellower, a color value, moist, of 3.5 or more, or a color value, dry, more than 1 unit higher than the moist value;

3. Do not have a fragipan within 100 cm of the mineral soil surface;

4. Either have a densic, lithic, or paralithic contact within 150 cm of the soil surface or have a clay distribution in which the clay content decreases with increasing depth by 20 percent or more from its maximum within 150 cm of the soil surface and, if there is a clay increase of 3 percent or more (absolute) below that layer, less than 5 percent of the volume in the layer where the clay content decreases consists of skeletans on faces of peds, if:

  a. Hue is redder than 10YR and chroma of more than 4 is dominant;

  b. Hue is 2.5YR or redder, the value, moist, is less than 4, and the value, dry, is less than 5 throughout the major part of the argillic horizon; *or*

c. There are many coarse redox concentrations that have hue redder than 7.5YR or chroma of more than 5.

Key to Subgroups

JEJA. Hapludalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludalfs

JEJB. Other Hapludalfs that have *all* of the following:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

3. An Ap horizon or materials between the mineral soil surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Aquertic Chromic Hapludalfs

JEJC. Other Hapludalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquertic Hapludalfs

JEJD. Other Hapludalfs that have *both*:

1. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Oxyaquic Vertic Hapludalfs

JEJE. Other Hapludalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. An Ap horizon or materials between the mineral soil

surface and a depth of 18 cm that, after mixing, have *one or more* of the following:

a. A color value, moist, of 4 or more; *or*

b. A color value, dry, of 6 or more; *or*

c. Chroma of 4 or more.

Chromic Vertic Hapludalfs

JEJF. Other Hapludalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludalfs

JEJG. Other Hapludalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludalfs

JEJH. Other Hapludalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Hapludalfs

JEJI. Other Hapludalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Hapludalfs

JEJJ. Other Hapludalfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Fragic Oxyaquic Hapludalfs

JEJK. Other Hapludalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Aquic Arenic Hapludalfs

JEJL. Other Hapludalfs that have:

1. An abrupt textural change; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

3. A base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm from the top of the argillic horizon, at a depth of 180 cm from the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Albaquultic Hapludalfs

JEJM. Other Hapludalfs that have *both*:

1. An abrupt textural change; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Albaquic Hapludalfs

JEJN. Other Hapludalfs that have *both*:

1. Interfingering of albic materials in the upper part of the argillic horizon; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Glossaquic Hapludalfs

JEJO. Other Hapludalfs that have *both*:

1. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface; *and*

2. A base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm from the top of the argillic horizon, at a depth of 180 cm from the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Aquultic Hapludalfs

JEJP. Other Hapludalfs that have *both*:

1. An Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquollic Hapludalfs

JEJQ. Other Hapludalfs that have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

1. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

2. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Aquic Hapludalfs

JEJR. Other Hapludalfs that have anthraquic conditions.

Anthraquic Hapludalfs

JEJS. Other Hapludalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludalfs

JEJT. Other Hapludalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Hapludalfs

JEJU. Other Hapludalfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Hapludalfs

JEJV. Other Hapludalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Hapludalfs

JEJW. Other Hapludalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Hapludalfs

JEJX. Other Hapludalfs that have interfingering of albic materials in one or more subhorizons of the argillic horizon.

Glossic Hapludalfs

JEJY. Other Hapludalfs that have:

1. An argillic, kandic, or natric horizon that is 35 cm or less thick; *and*

2. No densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Hapludalfs

JEJZ. Other Hapludalfs that have a base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the mineral soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest.

Ultic Hapludalfs

JEJZa. Other Hapludalfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Hapludalfs

JEJZb. Other Hapludalfs.

Typic Hapludalfs

Definition of Typic Hapludalfs

Typic Hapludalfs are the Hapludalfs that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. Do not have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface;

5. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years;

6. Do not have anthraquic conditions;

7. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

8. Do not have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing;

9. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

10. Have a base saturation (by sum of cations) of 60 percent or more at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest;

11. Do not have interfingering of albic materials in any subhorizon of the argillic horizon;

12. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

13. Have an argillic horizon that is more than 35 cm thick; *and*

14. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Hapludalfs.—The central concept or Typic subgroup of Hapludalfs is fixed on freely drained soils that have an argillic horizon that does not have an abrupt upper boundary, that does not have interfingering of albic materials, that has a relatively high base saturation, and that has a loamy or clayey texture and is not composed entirely of thin lamellae. In addition, these soils are deep or moderately deep to hard rock, have a light colored plow layer, and do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout. They do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks.

An abrupt upper boundary of the argillic horizon and redox concentrations in the argillic horizon are properties shared with Albaqualfs and Albaquults and define intergrades to those great groups.

If the upper 25 cm of the argillic horizon has aquic conditions for some time in normal years (or artificial drainage) and redox depletions with chroma of 2 or less, or saturation with water within 100 cm of the surface for extended periods, the soil is excluded from Typic Hapludalfs because these properties are shared with Aqualfs.

A thick layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class is considered atypical and defines the Arenic subgroup. Interfingering of albic materials in the argillic horizon causes a soil to be excluded because this property is shared with Glossudalfs. Typic Glossudalfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols.

A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy. Surface horizons above a depth of 18 cm that, after mixing, have the color of a mollic epipedon and a plow layer that has this color are believed to indicate a transition to Mollisols.

An argillic horizon that has a sandy particle-size class or that is composed entirely of thin lamellae is the basis for defining the Lamellic and Psammentic subgroups. A relatively low base saturation in the deeper horizons is a property shared with Ultisols and is used to define the intergrades to that order.

Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are excluded from the Typic Hapludalfs because these properties are shared with Vertisols.

Albaquic Hapludalfs.—These soils have an abrupt textural change between an eluvial horizon, commonly an albic horizon, and the argillic horizon. They also have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage). These soils are intergrades between Albaqualfs and Hapludalfs. They are mostly in the Southern United States and are widely distributed. Most of them are used as forest, but some have been cleared and are used as pasture or cropland. Some of them developed under grass and are used as rangeland, pasture, or cropland.

Albaquultic Hapludalfs.—These soils are like Typic Hapludalfs, but they have an abrupt textural change between an eluvial horizon, commonly an albic horizon, and the argillic horizon and have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage). They also have a base saturation (by sum of cations) of less than 60 percent at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest. They differ from soils of the Albaquic subgroup because they have a lower base saturation and from soils of the Aquultic subgroup because they have an abrupt textural change at the top of the argillic horizon. Albaquultic Hapludalfs are intergrades between Albaquults and Hapludalfs. They are mostly on the coastal plain bordering the Gulf of Mexico and are not extensive. Nearly all of these soils are in forests.

Andic and Vitrandic Hapludalfs.—These soils are like Typic Hapludalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are permitted, but not required, to have redox depletions and to be saturated with water within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years. These soils are of very small extent but are locally important. They are used mainly as forest, but some areas have been cleared and are used as cropland or pasture.

Anthraquic Hapludalfs.—These soils are like Typic Hapludalfs, but they have been irrigated for paddy rice production for many years and have developed anthraquic conditions. They are permitted, but not required, to have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years either within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface or within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is deeper than 50 cm. These soils are not extensive and are rare in the United States. They have level or nearly level slopes.

Aquertic Hapludalfs.—These soils are like Typic Hapludalfs, but they have redox depletions with low chroma, aquic conditions at a shallow depth for some time in normal years, and an appreciable amount of swelling clays. The Ap horizon or the surface soil to a depth of 18 cm after mixing has a color value of 3 or less, moist, and 5 or less, dry. A few of these soils have a mollic epipedon, but the base saturation is less than 50 percent (by NH_4OAc) in at least part of the argillic horizon. The aquic conditions, swelling clays, and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Aquertic Hapludalfs are of small extent. Slopes are gentle. Most of the soils have been cleared and are used as cropland or pasture, but some of them are used as forest. Some of the soils developed under grass vegetation and are used as cropland or rangeland.

Aquertic Chromic Hapludalfs.—These soils are like Typic Hapludalfs, but they have redox depletions with low chroma and also have aquic conditions at a shallow depth for some time in normal years. In addition, they have an appreciable amount of swelling clays. The aquic conditions, swelling clays, and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Aquertic Chromic Hapludalfs are of small extent. Slopes are gentle. Most of the soils have been cleared and are used as cropland or pasture, but some are used as forest.

Aquic Arenic Hapludalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They also have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more. The plow layer or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry. There is no restriction on the base saturation other than that imposed by the definition of Alfisols. Aquic Arenic Hapludalfs are not extensive in the United States. They are mostly on the lake plains adjacent to the Great Lakes. Their slopes are very gentle. Most of the soils have been cleared and are used as cropland, but some of them are used as pasture or forest.

Aquic Hapludalfs.—These soils are like Typic Hapludalfs, but they have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) either within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface or within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is deeper than 50 cm. These soils are intergrades between Aqualfs and Hapludalfs. They are moderately extensive in the United States, particularly in the glaciated areas of the north-central region. Most of the soils have gentle slopes and have been cleared and are used as cropland, but some of them are used as pasture or forest.

Aquollic Hapludalfs.—These soils have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, the Ap horizon or the surface soil to a depth of 18 cm after mixing has a color value of 3 or less, moist, and 5 or less, dry. These soils are intergrades between Argiaquolls and Hapludalfs. They are moderately extensive in the United States, particularly in the glaciated parts of the north-central region. Slopes are very gentle. Nearly all of the soils have been cleared and are used as cropland, but some of them are used as pasture or forest.

Aquultic Hapludalfs.—These soils have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, the base saturation (by sum of cations) is less than 60 percent at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest. The Ap horizon or the surface soil to a depth of 18 cm after mixing may have any color value when moist. These soils are intergrades between Aquults and Hapludalfs. They are not extensive in the United States and are known to occur only on the low Atlantic Coastal Plain. Their slopes are very gentle. Many of the soils have been cleared and are used as cropland, but some of them are used as pasture or forest.

Arenic Hapludalfs.—These soils have a sandy or sandy-skeletal particle-size class in all subhorizons to the top of an argillic horizon at a depth of 50 cm or more. The plow layer or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry. There is no restriction on the base saturation other than that imposed by the definition of Alfisols. Arenic Hapludalfs are not extensive in the United States. They occur mostly in the glaciated parts of the north-central region of the United States and in Florida. Their slopes are mostly gentle. Where slopes are suitable, the soils have been cleared and are used as cropland. Some of the soils are used as pasture or forest.

Chromic Vertic Hapludalfs.—These soils are like Typic Hapludalfs, but they have an appreciable amount of swelling clays. The swelling clays and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Chromic Vertic Hapludalfs are of small extent. Slopes are gentle to steep. Most of the less sloping soils have been cleared and are used as cropland or pasture. Some of the soils are used as forest.

Fragiaquic Hapludalfs.—These soils are like Typic Hapludalfs, but they have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fraqiaqualfs. They are not extensive in the United States.

Fragic Hapludalfs.—These soils are like Typic Hapludalfs, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fraqiudalfs. They are not extensive in the United States.

Fragic Oxyaquic Hapludalfs.—These soils are like Typic Hapludalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fraqiaqualfs. They are not extensive in the United States.

Glossaquic Hapludalfs.—These soils have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, there is evidence of destruction of the argillic horizon in the form of albic materials interfingering in or into the argillic horizon. The Ap horizon or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value, moist, of 3 or less. These soils are intergrades between Glossaqualfs and Hapludalfs. They are primarily in cool areas that were glaciated and along the gulf coast of the United States. Where they have gentle slopes, most of these soils have been cleared and are used as cropland or pasture. Some of the soils are used as forest.

Glossic Hapludalfs.—These soils show evidence of destruction of the argillic horizon in the form of albic materials interfingering in or into the argillic horizon. The soils are intergrades between Glossudalfs and Hapludalfs. The Ap horizon or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value, moist, of 3 or less. In most undisturbed areas of Glossic Hapludalfs, the color value is 4 or more after the upper layers to a depth of 18 cm have been mixed, but the cultivated soils have a darker Ap horizon. Glossic Hapludalfs are moderately extensive in the United States. They are primarily in cool areas that were glaciated. Where they have gentle slopes, many of these soils have been cleared and are used as cropland or pasture. Some of the soils are used as forest.

Inceptic Hapludalfs.—These soils have an argillic horizon that is less than 35 cm thick and have no densic, lithic, or paralithic contact within 100 cm of the mineral soil surface. They are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a base saturation (by sum of cations) that is less than 60 percent. These soils are not extensive in the United States. They are considered intergrades between Udepts and Hapludalfs. They are of small extent in the United States. Where slopes are suitable, many of these soils have been cleared and are used as cropland or pasture. Some of the soils, mostly the more sloping ones, are used as forest.

Lamellic Hapludalfs.—These soils are like Typic Hapludalfs, but they have an argillic horizon that consists entirely of lamellae or is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon. In some of the soils, the argillic horizon consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are either two or more lamellae with a combined thickness of 5 cm or more or a combination of lamellae and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon. Lamellic Hapludalfs are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a base saturation (by sum of cations) that is less than 60 percent. The soils are not extensive in the United States. They are intergrades between Psamments and Hapludalfs. Many of the Lamellic Hapludalfs in the United States are on lake plains adjacent to the Great Lakes. Where they have gentle slopes, many of these soils have been cleared and are used as cropland or pasture. Some of the soils are used as forest.

Lithic Hapludalfs.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are permitted to have any other property that is allowed in Hapludalfs. They can have redox depletions with low chroma and aquic conditions at a shallow depth for some time in normal years. There can be evidence of destruction of the argillic horizon in the form of albic materials interfingering in or into the argillic horizon. The Ap horizon or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value, moist, of 3 or less. These soils are not extensive in the United States, and they are widely distributed. Their slopes range from gentle to very steep. Most of the soils are used as pasture or forest.

Mollic Hapludalfs.—These soils are like Typic Hapludalfs, but they have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. The soils that have a mollic epipedon also have a base saturation of less than 50 percent (by NH_4OAc) in at least part of the argillic horizon. Mollic Hapludalfs are mostly transitional in morphology and in location to Udolls. They are moderately extensive in the United States. Their slopes range from gentle to strong. Where slopes are suitable, nearly all of these soils have been cleared and are used as cropland or pasture. Some of the soils, mainly the most sloping ones, are used as forest.

Oxyaquic Hapludalfs.—These soils are like Typic Hapludalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, the soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a base saturation (by sum of cations) that is less than 60 percent. These soils are moderately extensive in the United States. They are considered intergrades to Aqualfs. Slopes are gentle. Most Oxyaquic Hapludalfs have been cleared and are used as cropland or pasture, but some of them are used as forest.

Oxyaquic Vertic Hapludalfs.—These soils are like Typic Hapludalfs, but they have an appreciable amount of swelling clays and are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, the soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a base saturation (by sum of cations) that is less than 60 percent. A few of these soils have a mollic epipedon, but the base saturation is less than 50 percent (by NH_4OAc) in at least part of the argillic horizon. The swelling clays, saturation, and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Oxyaquic Vertic Hapludalfs are considered intergrades to Aquerts. They are not extensive in the United States. Slopes are gentle. Most of the soils have been cleared and are used as cropland or pasture, but some of them are used as forest.

Psammentic Hapludalfs.—These soils have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick. Depth to the argillic horizon may be more than 100 cm. Generally, the depth is more than 50 cm, and all horizons above the argillic horizon have a texture of loamy fine sand or coarser. These soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a base saturation (by sum of cations) that is less than 60 percent. The soils are not extensive in the United States. They are intergrades between Psamments and Hapludalfs. Most Psammentic Hapludalfs are in the parts of the United States that were glaciated, but a few are in Florida. Slopes generally are gentle. Most of these soils have been cleared and are used as cropland or pasture, but some of them are used as forest.

Ultic Hapludalfs.—These soils have a base saturation (by sum of cations) that is less than 60 percent at a depth of 125 cm below the top of the argillic horizon, at a depth of 180 cm below the soil surface, or directly above a densic, lithic, or paralithic contact, whichever is shallowest. In addition, the Ap horizon or the surface soil to a depth of 18 cm after mixing is permitted, but not required, to have a color value, moist, of 3 or less. Commonly, the argillic horizon has hue of 7.5YR or redder or has chroma of more than 4. Some Typic Hapludalfs have these same colors. Ultic Hapludalfs are intergrades between Hapludults and Hapludalfs. They are moderately extensive in the United States. Most of them developed from weathered country rocks but not from acid rocks. Ultic Hapludalfs are mostly in highly dissected areas where the landscape is hilly or mountainous. Their slopes range from gentle to strong. Where slopes are suitable, most of the soils have been cleared and are used as cropland or pasture. Some of the soils, mostly the most sloping ones, are used as forest.

Vertic Hapludalfs.—These soils have deep cracks and appreciable amounts of swelling clays. The swelling clays and low saturated hydraulic conductivity seem to be the most important properties of the soils in this subgroup. Most of the soils formed in clayey parent materials. Vertic Hapludalfs are moderately extensive. Slopes are gentle to steep, and the soils are highly erodible. Some of these soils have been cleared and are used as cropland or pasture, and some, mainly the most sloping ones, are used as forest.

Kandiudalfs

Kandiudalfs are the Udalfs that have a kandic horizon. These soils have a clay distribution in which the content of clay does not decrease from its maximum amount by 20 percent or more within 150 cm of the soil surface or the layer with the decrease has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in content of clay below this layer. Kandiudalfs do not have a natric horizon, nor do they have a fragipan within 100 cm of the mineral soil surface. They do not have both a glossic horizon and discrete nodules, 2.5 to 30 cm in diameter, that are enriched with iron and cemented to indurated. These soils are 150 cm or more deep to a densic, lithic, paralithic, or petroferric contact. The base of the kandic horizon is commonly more than 150 cm below the soil surface and in some areas is more than 200 cm below the surface. Most of these soils have a thermic or warmer soil temperature regime. The natural vegetation was forest, mostly deciduous, but many of the soils are now cleared and used as cropland.

Definition

Kandiudalfs are the Udalfs that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within 150 cm of the soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in content of clay below this layer;

4. Do not have a natric horizon;

5. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

6. Do not have both a glossic horizon and, in the kandic horizon, discrete nodules, 2.5 to 30 cm in diameter, that have enriched exteriors, are weakly cemented with iron, and have exteriors with redder hue or higher chroma than the interiors.

Key to Subgroups

JEEA. Kandiudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthaquic Kandiudalfs

JEEB. Other Kandiudalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudalfs

JEEC. Other Kandiudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kandiudalfs

JEED. Other Kandiudalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiudalfs

JEEE. Other Kandiudalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Kandiudalfs

JEEF. Other Kandiudalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiudalfs

JEEG. Other Kandiudalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiudalfs

JEEH. Other Kandiudalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiudalfs

JEEI. Other Kandiudalfs that have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kandiudalfs

JEEJ. Other Kandiudalfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Kandiudalfs

JEEK. Other Kandiudalfs.

Typic Kandiudalfs

Definition of Typic Kandiudalfs

Typic Kandiudalfs are the Kandiudalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

3. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

4. Do not have, in all subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value;

5. Have a kandic horizon that has a color value, dry, of 5 or more in some subhorizon, or a color value, moist, that is less than the value, dry, by more than 1 unit unless hue in some part of the kandic horizon is 5YR or yellower;

6. Do not have a horizon within 150 cm of the surface that has 5 percent or more plinthite, by volume; *and*

7. Do not have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Description of Subgroups

Typic Kandiudalfs.—The central concept or Typic subgroup of Kandiudalfs is fixed on freely drained soils that do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout and that do not have the color of a mollic epipedon in any Ap horizon or in subhorizons of comparable thickness if the soils are undisturbed. The kandic horizon has a color value, dry, of 4.5 or more in some subhorizon, or the color values, moist and dry, differ by more than 1 unit unless hue in some part of the kandic horizon is 5YR or yellower. The kandic horizon does not have an appreciable amount of plinthite.

Soils that have shallow redox depletions with low chroma in horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Kandiudalfs because these properties are shared with Kandiaqualfs. A thick epipedon with a sandy or sandy-skeletal particle-size class throughout is considered atypical and defines the Arenic and Grossarenic subgroups. The color of a mollic epipedon in the plow layer or, if the soils are undisturbed, in surface horizons of comparable thickness is not typical and defines the Mollic subgroup. Plinthite in appreciable volume defines the Plinthic subgroup. Typic Kandiudalfs are rare in the United States.

Aquic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are permitted, but not required, to have a color value, moist, of less than 4 and a color value, dry, of less than 6 in the Ap horizon or in the upper 18 cm after mixing and to have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more below the mineral soil surface. The soils also are permitted to have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. They are not known to occur in the United States.

Arenic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. These soils are not known to occur in the United States.

Arenic Plinthic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. They also have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. During rainy seasons ground water tends to perch above the horizon that contains plinthite. These soils are not known to occur in the United States.

Grossarenic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. These soils are not known to occur in the United States.

Grossarenic Plinthic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. They also have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. During rainy seasons ground water tends to perch above the horizon that contains plinthite. These soils are not known to occur in the United States.

Mollic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. These soils are considered intergrades between Paleudolls and Kandiudalfs. They are not known to occur in the United States.

Oxyaquic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, the soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm after mixing and to have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more below the mineral soil surface. They also are permitted to have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. These soils are considered intergrades to Aqualfs.

Plinthaquic Kandiudalfs.—These soils are like Typic Kandiudalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. In addition, the soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm, after mixing. These soils are intergrades between Plinthaqualfs and Kandiudalfs. They are not known to occur in the United States.

Plinthic Kandiudalfs.—These soils have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. In addition, they are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm, after mixing. During rainy seasons ground water tends to perch above the horizons that contain plinthite. These soils are not known to occur in the United States.

Rhodic Kandiudalfs.—These soils are like Typic Kandiudalfs, but all parts of the kandic horizon have a color value, moist, of less than 3.5 and a dry color value no more than 1 unit higher than the moist value and hue in the kandic horizon is redder than 5YR. In addition, the Ap horizon or the upper 18 cm after mixing commonly has a color value, moist, of less than 3.5 and value, dry, no more than 1 unit higher than the moist value. These soils are rare in the United States.

Kanhapludalfs

Kanhapludalfs are the Udalfs that have a kandic horizon. They do not have a natric horizon, nor do they have a fragipan with an upper boundary within 100 cm of the mineral soil surface. They do not have both a glossic horizon and discrete nodules, 2.5 to 30 cm in diameter, that are enriched with iron and cemented to indurated. The base of the kandic horizon is less than 150 cm below the soil surface, or the kandic horizon has a clay distribution in which the content of clay decreases from its maximum amount by 20 percent or more within 150 cm of the soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is less than a 3 percent (absolute) increase in content of clay below this layer. Most of these soils have a thermic or warmer soil temperature regime. The natural vegetation on Kanhapludalfs was forest, mostly deciduous, but many of the soils are now cleared and used as cropland.

Definition

Kanhapludalfs are the Udalfs that:

1. Have a kandic horizon;

2. Have a clay distribution in which the content of clay decreases from its maximum amount by 20 percent or more within 150 cm of the soil surface, and the layer in which the

percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is less than a 3 percent (absolute) increase in content of clay below this layer;

3. Do not have a natric horizon;

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have both a glossic horizon and, in the kandic horizon, discrete nodules, 2.5 to about 30 cm in diameter, that are enriched with iron, are extremely weakly cemented to indurated, and have exteriors with either redder hue and/or higher chroma than the interiors.

Key to Subgroups

JEFA. Kanhapludalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhapludalfs

JEFB. Other Kanhapludalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhapludalfs

JEFC. Other Kanhapludalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kanhapludalfs

JEFD. Other Kanhapludalfs that have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kanhapludalfs

JEFE. Other Kanhapludalfs.

Typic Kanhapludalfs

Definition of Typic Kanhapludalfs

Typic Kanhapludalfs are the Kanhapludalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

3. Do not have a lithic contact within 50 cm of the soil surface; *and*

4. Do not have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value.

Description of Subgroups

Typic Kanhapludalfs.—The central concept or Typic subgroup of Kanhapludalfs is fixed on freely drained soils that are more than 50 cm deep to a lithic contact.

Soils with a kandic horizon that has 50 percent or more colors with hue of 2.5YR or redder, value, dry, of 3 or less, and color values, moist and dry, that differ by 1 or less than 1 unit are excluded from Typic Kanhapludalfs because these properties are shared with Rhodudalfs. Soils that have shallow redox depletions with low chroma in horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Kanhapludalfs because these properties are shared with Kandiaqualfs. Typic Kanhapludalfs are rare in the United States.

Aquic Kanhapludalfs.—These soils are like Typic Kanhapludalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are permitted, but not required, to have a kandic horizon that has 50 percent or more colors with hue of 2.5YR or redder, value, dry, of 3 or less, and color values, moist and dry, that differ by 1 or less than 1 unit, and they are excluded from Typic Kanhapludalfs because these properties are shared with Rhodudalfs. Aquic Kanhapludalfs are not known to occur in the United States.

Lithic Kanhapludalfs.—These soils have a lithic contact within 50 cm of the mineral soil surface. In addition, they are permitted to have any color, saturation, or redox feature allowed in Kanhapludalfs. Lithic Kanhapludalfs are not known to occur in the United States.

Oxyaquic Kanhapludalfs.—These soils are like Typic Kanhapludalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, these soils are permitted, but not required, to have a kandic horizon that has 50 percent or more colors with hue of 2.5YR or redder, value, dry, of 3 or less, and color values, moist and dry, that differ by 1 or less than 1 unit, and they are excluded from Typic Kanhapludalfs because these properties are shared with Rhodudalfs. Oxyaquic Kanhapludalfs are considered intergrades to Aqualfs. They are not known to occur in the United States.

Rhodic Kanhapludalfs.—These soils are like Typic Kanhapludalfs, but all parts of the kandic horizon have a color value, moist, of less than 3.5 and a dry color value no more than 1 unit higher than the moist value and hue in the kandic horizon is redder than 5YR. In addition, the Ap horizon or the upper 18 cm after mixing commonly has a color value, moist, of less than 3.5 and value, dry, no more than 1 unit higher than the moist value. These soils are considered intergrades to Rhodudalfs. They are rare in the United States.

Natrudalfs

Natrudalfs are the Udalfs that have a natric horizon. Because the natric horizon is slowly permeable, perched ground water is common for short periods and the natric horizon commonly has redoximorphic features. These soils are of small extent in the United States. Some of the soils were forested. Some supported open forests, and some supported grass. Most of the soils have been cleared and are used as cropland or pasture. The soils are not so productive as most Udalfs, but they generally are farmed if they occur in very small areas and the associated soils are productive.

Key to Subgroups

JEAA. Natrudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrudalfs

JEAB. Other Natrudalfs that have:

1. Either a glossic horizon or interfingering of albic materials into the natric horizon; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the natric horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the natric horizon is 50 cm or more below the mineral soil surface.

Glossaquic Natrudalfs

JEAC. Other Natrudalfs that have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

1. Within the upper 25 cm of the natric horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

2. Within 75 cm of the mineral soil surface if the upper boundary of the natric horizon is 50 cm or more below the mineral soil surface.

Aquic Natrudalfs

JEAD. Other Natrudalfs.

Typic Natrudalfs

Definition of Typic Natrudalfs

Typic Natrudalfs are the Natrudalfs that:

1. Do not have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the natric horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the natric horizon is 50 cm or more below the mineral soil surface; *and*

2. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Natrudalfs.—Typic Natrudalfs are not the most extensive subgroup, but they furnish the best basis for definition of subgroups. Most Natrudalfs are not freely drained because the ground water is perched above the natric horizon in many years. The perched water table is a probable cause of the very common albic materials and glossic horizon at the upper boundary of the natric horizon. Soils that have redox depletions with low chroma at a shallow depth and also have aquic conditions are considered to be intergrades toward

Aqualfs. Soils that have cracks and slickensides or wedge-shaped aggregates are excluded from the Typic subgroup because these properties are shared with Vertisols.

Aquic Natrudalfs.—Aquic Natrudalfs are not so well drained as Typic Natrudalfs because the natric horizon commonly has low or very low saturated hydraulic conductivity. Soils that have a glossic horizon and interfingering of albic materials into the upper part of the natric horizon are excluded from the aquic subgroup because these properties are shared with Glossaqualfs.

Glossaquic Natrudalfs.—These soils are not so well drained as Typic Natrudalfs because the natric horizon commonly has low or very low saturated hydraulic conductivity. Glossaquic Natrudalfs also have a glossic horizon or albic materials that interfinger into the natric horizon, mostly between columns or prisms, commonly to a depth of 10 to 20 cm below their tops. These soils are not extensive in the United States.

Vertic Natrudalfs.—These soils are like Typic Natrudalfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. Vertic Natrudalfs are considered intergrades between Natrudalfs and Vertisols. They are rare in the United States.

Paleudalfs

Paleudalfs are the Alfisols that have a thick solum. These soils do not have a kandic or natric horizon, nor do they have a fragipan within 100 cm of the mineral soil surface. Some have an argillic horizon that shows evidence of destruction in the form of a glossic horizon, but they do not have both a glossic horizon and discrete iron-cemented nodules 2.5 to 30 cm in diameter. Paleudalfs are on relatively stable surfaces. Most of them are older than the Wisconsinan Glaciation. The time of soil formation dates from the Sangamon interglacial period or earlier. Base saturation commonly is lower than that in many other Alfisols. Before cultivation, most Paleudalfs in the United States had a vegetation of mixed deciduous hardwood forest.

Definition

Paleudalfs are the Udalfs that:

1. Do not have a kandic or natric horizon;

2. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within 150 cm of the soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in content of clay below this layer;

4. Do not have a densic, lithic, or paralithic contact within 150 cm of the soil surface;

5. Have an argillic horizon with *one or more* of the following:

   a. In 50 percent or more of the matrix of one or more subhorizons in its lower one-half, hue of 7.5YR or redder and chroma of 5 or more; *or*

   b. In 50 percent or more of the matrix of horizons that total more than one-half the total thickness, hue of 2.5YR or redder, value, moist, of 3 or less, and value, dry, of 4 or less; *or*

   c. Many coarse redox concentrations with hue of 5YR or redder or chroma of 6 or more, or both, in one or more subhorizons;

6. Do not have both a glossic horizon and, in the argillic horizon, discrete nodules, 2.5 to 30 cm in diameter, that are cemented or indurated with iron and that have exteriors with redder hue or higher chroma than the interiors; *and*

7. Have a frigid temperature regime and *all* of the following:

   a. An argillic horizon that has its upper boundary 60 cm or more below *both*:

      (1) The mineral soil surface; *and*

      (2) The lower boundary of any surface mantle containing 30 percent or more vitric volcanic ash, cinders, or other vitric pyroclastic materials; *and*

   b. A texture (in the fine-earth fraction) finer than loamy fine sand in one or more horizons above the argillic horizon; *and*

   c. Either a glossic horizon or interfingering of albic materials into the argillic horizon.

Key to Subgroups

JEGA. Paleudalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudalfs

JEGB. Other Paleudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Paleudalfs

JEGC. Other Paleudalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Paleudalfs

JEGD. Other Paleudalfs that have *both*:

1. Fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

   a. Within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

   b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Paleudalfs

JEGE. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthaquic Paleudalfs

JEGF. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A glossic horizon or, in the upper part of the argillic horizon, one or more subhorizons that have 5 percent or more (by volume) clay depletions with chroma of 2 or less.

Glossaquic Paleudalfs

JEGG. Other Paleudalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A clay increase of 15 percent or more (absolute) in the fine-earth fraction within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon.

Albaquic Paleudalfs

JEGH. Other Paleudalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudalfs

JEGI. Other Paleudalfs that have anthraquic conditions.

Anthraquic Paleudalfs

JEGJ. Other Paleudalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudalfs

JEGK. Other Paleudalfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Paleudalfs

JEGL. Other Paleudalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleudalfs

JEGM. Other Paleudalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Paleudalfs

JEGN. Other Paleudalfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleudalfs

JEGO. Other Paleudalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleudalfs

JEGP. Other Paleudalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleudalfs

JEGQ. Other Paleudalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleudalfs

JEGR. Other Paleudalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleudalfs

JEGS. Other Paleudalfs that have *either*:

1. A glossic horizon; *or*

2. In the upper part of the argillic horizon, one or more subhorizons that have 5 percent or more (by volume) skeletans with chroma of 2 or less; *or*

3. 5 percent or more (by volume) albic materials in some subhorizon of the argillic horizon.

Glossic Paleudalfs

JEGT. Other Paleudalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Paleudalfs

JEGU. Other Paleudalfs that have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Mollic Paleudalfs

JEGV. Other Paleudalfs.

Typic Paleudalfs

Definition of Typic Paleudalfs

Typic Paleudalfs are the Paleudalfs that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions and do not have an increase of 15 percent or more (absolute) clay within a vertical distance of 2.5 cm at the upper boundary of the argillic horizon;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

4. Do not have anthraquic conditions;

5. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

6. Do not have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value;

7. Have an argillic horizon that has a color value, dry, of 4.5 or more in some subhorizon, or a color value, moist, that is less than the value, dry, by more than 1 unit unless hue in some part of the argillic horizon is 5YR or yellower;

8. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

9. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the surface;

10. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

11. Do not have a glossic horizon or subhorizons in the upper part of the argillic horizon that have clay depletions that:

a. Have moist chroma of 2 or less; *and*

b. Occupy 5 percent or more of the volume of the subhorizon;

12. Do not have albic materials that constitute as much as 5 percent of any subhorizon of the argillic horizon;

13. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

14. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

15. Do not have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing.

Description of Subgroups

Typic Paleudalfs.—The central concept or Typic subgroup of Paleudalfs is fixed on freely drained soils that do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout. These soils do not have a mollic epipedon or an Ap horizon or subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon except thickness. The argillic horizon has a color value, dry, of 5 or more in some subhorizon, or the color values, moist and dry, differ by more than 1 unit unless hue in some part of the argillic horizon is 5YR or yellower. The argillic horizon does not have cracks and slickensides or wedge-shaped aggregates, and it does not have an appreciable amount of plinthite or a sandy texture throughout. These soils do not have albic materials that constitute as much as 5 percent of any subhorizon of the argillic horizon.

Soils that have shallow redox depletions with low chroma in horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Paleudalfs because these properties are shared with Aqualfs. A thick epipedon with a sandy or sandy-skeletal particle-size class throughout is considered atypical and defines the Arenic and Grossarenic subgroups. Typic Paleudalfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols. Soils that have a mollic epipedon or that meet all of the requirements for a mollic epipedon, except for thickness, in the plow layer or in surface horizons of comparable thickness are considered atypical, and these properties define the Mollic subgroup. Plinthite in appreciable volume defines the Plinthic subgroup. An argillic horizon that has a sandy particle-size class throughout its upper 75 cm is the basis for defining the Psammentic subgroup. An argillic horizon that is composed entirely of lamellae is the basis for defining the Lamellic subgroup.

Typic Paleudalfs are moderately extensive in the United States. Many are in the unglaciated areas of the Southern States. Most of the soils that have gentle or moderate slopes have been cleared of the original forests and are used as cropland.

Albaquic Paleudalfs.—These soils are like Typic Paleudalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have an increase of 15 percent or more in the amount of clay (absolute) within a vertical distance of 2.5 cm at the top of the argillic horizon. They are intergrades between Albaqualfs and Paleudalfs. They are mainly in Oklahoma and are not extensive in the United States.

Andic and Vitrandic Paleudalfs.—These soils are like Typic Paleudalfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur in the foothills and mountains of the Western United States. They are permitted, but not required, to have redox depletions and to be saturated with water within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years. The soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. These soils are of very small extent but are locally important. They generally have a frigid temperature regime and are used as forest. Some areas have been cleared and are used as cropland or pasture.

Anthraquic Paleudalfs.—These soils are like Typic Paleudalfs, but they have been irrigated for paddy rice production for many years and have developed anthraquic conditions. They are permitted, but not required, to have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years either within the upper 25 cm of the argillic horizon if its upper boundary is within 50 cm of the mineral soil surface or within 75 cm of the mineral soil surface if the upper boundary of the argillic horizon is deeper than 50 cm. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon that meets all of the requirements for a mollic epipedon except thickness. They have level or nearly level slopes. They are not extensive and are not known to occur in the United States. They have been cleared of the original forests and are used mostly for paddy rice.

Aquic Paleudalfs.—These soils are like Typic Paleudalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). A gray, sandy albic horizon is not adequate evidence of wetness. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. The soils are not extensive in the United States. Most of them are in the Southern States. Slopes are gentle, and most of the soils have been cleared of the original forests and are used as cropland.

Arenic Paleudalfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface. The argillic horizons are mostly loamy and tend to have more sand than those in Typic Paleudalfs. Arenic Paleudalfs are rare in the United States. They occur on plains and high terraces, mostly in Texas and Oklahoma. Slopes are mostly gentle. Most of these soils are used as pasture, but some are used as cropland.

Arenic Plinthic Paleudalfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm below the mineral soil surface. They have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the surface. During rainy seasons ground water tends to perch above the horizon that contains plinthite. These soils are rare in the United States. They are mostly on the coastal plain in Texas. Most of the soils are in forests.

Fragiaquic Paleudalfs.—These soils are like Typic Paleudalfs, but they have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. These soils are considered intergrades to Fraqiaqualfs. They are not extensive in the United States.

Fragic Paleudalfs.—These soils are like Typic Paleudalfs, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fraqiudalfs. They are not extensive in the United States.

Glossaquic Paleudalfs.—These soils are like Typic Paleudalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have a glossic horizon or a subhorizon within the argillic horizon, commonly 25 cm or more below its upper boundary, that has thick skeletans of low chroma. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. These soils are of minor extent in the central part of the Southern United States.

Glossic Paleudalfs.—These soils have a glossic horizon or a subhorizon within the argillic horizon, commonly 25 cm or more below its upper boundary, that has thick skeletans of low chroma that occupy an appreciable part of the mass of the subhorizon. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. The soils are otherwise like Typic Paleudalfs in defined properties and in accessory properties. They are not extensive in the United States. They occur mostly in the central part of the Southern United States. Slopes are very gentle, and most of the soils are used as cropland.

Grossarenic Paleudalfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface. The argillic horizons are mostly loamy and tend to have more sand than those in Typic Paleudalfs. Grossarenic Paleudalfs are of small extent in the United States. They occur on the coastal plain in Texas and Florida. Slopes are gentle. The soils are used mainly as pasture, but some are used as cropland.

Grossarenic Plinthic Paleudalfs.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more below the mineral soil surface. The argillic horizon contains some plinthite, and ground water may be perched above the plinthite during rainy seasons. These soils are rare in the United States. They are mostly on the coastal plain in Texas. Slopes are gentle. Most of these soils are used as forest.

Lamellic Paleudalfs.—These soils are like Typic Paleudalfs, but they have an argillic horizon that consists entirely of lamellae or is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon. In some of the soils, the argillic horizon consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are either two or more lamellae with a combined thickness of 5 cm or more or a combination of lamellae and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon These soils are permitted, but not required, to have a color value, moist, of 3 or less in the Ap horizon or in the surface soil to a depth of 18 cm, after mixing. They are not extensive in the United States.

Mollic Paleudalfs.—These soils are like Typic Paleudalfs, but they have a mollic epipedon, an Ap horizon that meets all of the requirements for a mollic epipedon except thickness, or materials between the soil surface and a depth of 18 cm that meet these requirements after mixing. Many of the Mollic Paleudalfs in the United States had grass vegetation or open forest vegetation before they were cultivated. Mollic Paleudalfs are considered intergrades between Paleudalfs and Paleudolls. They are not extensive in the United States. Most of them are in the center of the country, from Wisconsin to Oklahoma and the adjacent states. Slopes are mainly gentle, and most of the soils are used as cropland.

Oxyaquic Paleudalfs.—These soils are like Typic Paleudalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. The soils are not extensive in the United States.

Plinthaquic Paleudalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They also have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the soil surface. These soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. They are of small extent, mostly in Texas, in the United States.

Plinthic Paleudalfs.—These soils have 5 percent or more (by volume) plinthite in some subhorizon within 150 cm of the soil surface. During rainy seasons ground water tends to perch for short periods above the horizons that contain plinthite.

These soils are not extensive in the United States. They occur mainly along the gulf coast in Texas. Their slopes are mostly gentle. Many of the soils are used as cropland, but some are in forests.

Psammentic Paleudalfs.—These soils have an argillic horizon that has a sandy particle-size class throughout the upper 75 cm or throughout the entire thickness if it is less than 75 cm thick. The clay content of the argillic horizon approaches that of a sandy loam in most of the soils. Psammentic Paleudalfs commonly have an epipedon that has a texture of loamy fine sand or coarser throughout its thickness and that may be either more or less than 50 cm thick. The soils are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. These soils are considered intergrades between Udipsamments and Paleudalfs. They are of small extent in the United States. Most of them are used as forest, but some have been cleared of trees and are used as pasture or cropland.

Rhodic Paleudalfs.—These soils are like Typic Paleudalfs, but all parts of the argillic horizon have a color value, moist, of less than 3.5 and a dry color value no more than 1 unit higher than the moist value and hue in the argillic horizon is 2.5YR or redder. In addition, the Ap horizon or the upper 18 cm after mixing normally has a color value, moist, of less than 3.5 and value, dry, no more than 1 unit higher than the moist value. These soils are of small extent in the United States. They occur in the Southeastern States. Their slopes are mainly gentle. Most of the soils have been cleared of trees and are used as cropland or pasture.

Vertic Paleudalfs.—These soils are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. They are permitted, but not required, to have redox depletions and to be saturated with water within 100 cm of the mineral soil surface for 7 or more consecutive days or 20 or more cumulative days in normal years. These soils also are permitted, but not required, to have a mollic epipedon or an Ap horizon or other subhorizons of comparable thickness that meet all of the requirements for a mollic epipedon, except for thickness, after mixing. The soils are of small extent in the United States. Most of them are used as forest or pasture, but some are used as cropland.

Rhodudalfs

Rhodudalfs are dark red Udalfs that have a thinner solum than that of Paleudalfs. Rhodudalfs do not have a kandic or natric horizon. They do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface. They do not have both a glossic horizon and discrete nodules, 2.5 to 30 cm in diameter, that are enriched with iron and cemented to indurated. Their parent materials are mostly basic. These soils are rare in the United States, and definitions of subgroups have not been developed.

Definition

Rhodudalfs are the Udalfs that:

1. Have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value;

2. Do not have a kandic or natric horizon;

3. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

4. Do not have both a glossic horizon and, in the argillic horizon, discrete nodules, 2.5 to about 30 cm in diameter, that are enriched with iron, are extremely weakly cemented to indurated, and that have exteriors with either redder hue and/or higher chroma than the interiors; *and*

5. Have either a densic, lithic, or paralithic contact within 150 cm of the soil surface; *or*

a. Within 150 cm of the mineral soil surface, have *both*:

(1) A clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content; *and*

(2) Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *or*, below that layer, a clay increase of less than 3 percent (absolute) in the fine-earth fraction.

Key to Subgroups

JEHA. All Rhodudalfs (provisionally).

Typic Rhodudalfs

Ustalfs

Ustalfs are the Alfisols of subhumid to semiarid regions. They have an ustic moisture regime and a frigid, mesic, isomesic, or warmer temperature regime. They do not have, near the soil surface, both redoximorphic features with low chroma and aquic conditions (other than anthraquic conditions) for some time in normal years. Moisture moves through most of these soils to deeper layers only in occasional years. If there are carbonates in the parent materials or in the dust that settles on the surface, the soils tend to have a Bk or calcic horizon below or in the argillic or kandic horizon. The dry season or seasons are pronounced enough that trees are either deciduous or xerophytic. Many of these soils have or have had a savanna vegetation, and some were grasslands. Most of the soils are used as cropland or for grazing. Some are used as irrigated cropland. Sorghum, wheat, and cotton are the most common crops. Droughts are common.

Ustalfs tend to form a belt between the Aridisols of arid regions and the Udalfs, Ultisols, Oxisols, and Inceptisols of humid regions. The temperature regimes of Ustalfs are mostly thermic, isothermic, or warmer. These soils are extensive in the world. In the United States, their area is moderate, but the soils are extensive in the southern part of the Great Plains.

Ustalfs may be in areas of erosional surfaces or deposits of late-Wisconsinan age, but a great many, and characteristically those of warm regions, are on old surfaces. In the Ustalfs on old surfaces, the minerals have been strongly weathered, possibly in an environment more humid than the present one. At least, the clays in many of these older soils are kaolinitic. The base saturation in them at present probably reflects additions of bases in dust and rain.

Definition

Ustalfs are the Alfisols that:

1. Have an ustic moisture regime;

2. Have chroma too high for Aqualfs or do not have aquic conditions within 50 cm of the mineral soil surface for some time in normal years; *and*

3. Have a frigid, mesic, isomesic, or warmer temperature regime.

Key to Great Groups

JCA. Ustalfs that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durustalfs, p. 230

JCB. Other Ustalfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthustalfs, p. 252

JCC. Other Ustalfs that have a natric horizon.

Natrustalfs, p. 241

JCD. Other Ustalfs that:

1. Have a kandic horizon; *and*

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. Do not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content [Clay is measured noncarbonate clay or based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiustalfs, p. 237

JCE. Other Ustalfs that have a kandic horizon.

Kanhaplustalfs, p. 240

JCF. Other Ustalfs that have *one or more* of the following:

1. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

2. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *and* an argillic horizon that has *both*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content [Clay is measured noncarbonate clay or based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

(2) 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

b. In the lower one-half of the argillic horizon, one or more subhorizons with *either or both*:

(1) Hue of 7.5YR or redder and chroma of 5 or more in 50 percent or more of the matrix; *or*

(2) Common or many coarse redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

3. No densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *and* an argillic horizon that has *both*:

a. A clayey or clayey-skeletal particle-size class throughout one or more subhorizons in its upper part; *and*

b. At its upper boundary, a clay increase (in the fine-earth fraction) of *either* 20 percent or more (absolute) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute) within a vertical distance of 2.5 cm.

Paleustalfs, p. 246

JCG. Other Ustalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodustalfs, p. 252

JCH. Other Ustalfs.

Haplustalfs, p. 230

Durustalfs

Durustalfs are the Ustalfs that have a duripan that has its upper boundary within 100 cm of the mineral soil surface. They are not known to occur in the United States, but the great group has been provided for use in other countries. Subgroups have not been developed.

Key to Subgroups

JCAA. All Durustalfs (provisionally).

Typic Durustalfs

Haplustalfs

Haplustalfs are the Ustalfs that have an argillic horizon. They do not have a kandic or natric horizon, do not have a duripan that has its upper boundary within 100 cm of the surface, do not have a petrocalcic horizon within 150 cm of the surface, and do not have much plinthite. Many of these soils are relatively thin, are reddish to yellowish brown, or have a significant clay decrease within 150 cm of the surface. They are not dark red or dusky red throughout the argillic horizon. The argillic horizon does not have both a clayey or clayey-skeletal particle-size class in some subhorizon in its upper part and an abrupt upper boundary.

Haplustalfs are commonly in areas of relatively recent erosional surfaces or deposits, most of them late Pleistocene in age. Some of the soils have a monsoon climate. Others have two more or less marked dry seasons during the year.

Definition

Haplustalfs are the Ustalfs that:

1. Have an argillic horizon but do not have a kandic or natric horizon;

2. Do not have a duripan that has an upper boundary within 100 cm of the mineral soil surface;

3. Do not have a petrocalcic horizon that has an upper boundary within 150 cm of the mineral soil surface;

4. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within any subhorizon of the argillic horizon within 125 cm of the mineral soil surface;

5. Have an argillic horizon that in some part has hue no redder than 5YR or value, moist, of 4 or more or value, dry, more than 1 unit higher than the moist value;

6. Have a densic, lithic, or paralithic contact at a depth of less than 150 cm below the mineral soil surface, *or* the argillic horizon has *either*:

a. Within 150 cm of the mineral soil surface: *either*

(1) A clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content; *or*

(2) Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *or*, below that layer, no clay increase of as much as 3 percent (absolute) in the fine-earth fraction; *or*

b. *All* of the following:

(1) In 50 percent or more of the matrix of all subhorizons in its lower one-half, hue of 10YR or yellower or chroma of 4 or less; *and*

(2) In less than one-half of the total thickness, subhorizons that have, in 50 percent or more of the matrix, hue of 7.5YR or redder, a color value, moist, of 3 or less, and a color value, dry, of 4 or less; *and*

(3) In the matrix of all subhorizons in its lower one-half, few or no coarse redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both;

7. Have a densic, lithic, or paralithic contact at a depth of less than 50 cm below the mineral soil surface, *or* the argillic horizon *either*:

a. Does not have a clayey or clayey-skeletal particle-size class in some subhorizon in its upper part; *or*

b. At its upper boundary, has a clay increase, in the fine-earth fraction, of less than 15 percent (absolute) within a vertical distance of 2.5 cm, *and* less than 20 percent (absolute) within a vertical distance of 7.5 cm.

Key to Subgroups

JCHA. Haplustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustalfs

JCHB. Other Haplustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Haplustalfs

JCHC. Other Haplustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Haplustalfs

JCHD. Other Haplustalfs that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C;

2. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haplustalfs

JCHE. Other Haplustalfs that have *both*:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Haplustalfs

JCHF. Other Haplustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustalfs

JCHG. Other Haplustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Aquic Arenic Haplustalfs

JCHH. Other Haplustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. An argillic horizon that has a base saturation (by sum of cations) of less than 75 percent throughout.

Aquultic Haplustalfs

JCHI. Other Haplustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustalfs

JCHJ. Other Haplustalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustalfs

JCHK. Other Haplustalfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustalfs

JCHL. Other Haplustalfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haplustalfs

JCHM. Other Haplustalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Haplustalfs

JCHN. Other Haplustalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Arenic Aridic Haplustalfs

JCHO. Other Haplustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Haplustalfs

JCHP. Other Haplustalfs that have *both*:

1. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Calcidic Haplustalfs

JCHQ. Other Haplustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Haplustalfs

JCHR. Other Haplustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kanhaplic Haplustalfs

JCHS. Other Haplustalfs that have:

1. An argillic, kandic, or natric horizon that is 35 cm or less thick; *and*

2. No densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haplustalfs

JCHT. Other Haplustalfs that have *both*:

1. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Calcic Udic Haplustalfs

JCHU. Other Haplustalfs that have an argillic horizon with a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Haplustalfs

JCHV. Other Haplustalfs that have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface.

Calcic Haplustalfs

JCHW. Other Haplustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Haplustalfs

JCHX. Other Haplustalfs.

Typic Haplustalfs

Definition of Typic Haplustalfs

Typic Haplustalfs are the Haplustalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

3. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

4. Do not have a lithic contact within 50 cm of the soil surface;

5. Have a CEC of 24 or more cmol(+)/kg clay (by 1N NH_4OAc pH 7) in the major part of the argillic horizon or in the major part of its upper 100 cm if the argillic horizon is more than 100 cm thick;

6. Do not have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick;

7. When neither irrigated nor fallowed to store moisture:

a. Have a frigid soil temperature regime and both are dry in some or all parts of the soil moisture control section for 105 or more cumulative days and are dry in all parts of the soil moisture control section for less than four-tenths of the cumulative days per year in normal years and during a period when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. Have a mesic or thermic soil temperature regime and both are dry for more than four-tenths of the cumulative days per year in some part of the moisture control section and are dry for less than six-tenths of the time in some part of the moisture control section (not necessarily the same part) in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

c. Have a hyperthermic, isomesic, or warmer soil temperature regime and:

(1) Are dry in some or all parts of the moisture control section for 120 or more cumulative days per year; *and*

(2) Are moist in some or all parts of the moisture control section for 90 or more consecutive days per year both in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

(3) Are moist in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C;

8. Have an argillic horizon that has a base saturation (by sum of cations) of 75 percent or more in some part;

9. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

10. Do not have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface;

11. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

12. Have an argillic horizon more than 35 cm thick; *and*

13. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Haplustalfs.—The central concept or Typic subgroup of Haplustalfs is fixed on freely drained soils that are moderately deep or deep to hard rock; that have an argillic horizon that has a loamy or clayey particle-size class, some 2:1 lattice clay, and high base saturation; that do not have deep, wide cracks in normal years; that do not have a calcic horizon at a moderate depth; and that are moist for an appreciable part of a growing season.

Soils that have redox depletions with low chroma near the surface in one or more horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Haplustalfs because these properties are shared with Aqualfs. Soils that are saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years are considered atypical and define the Oxyaquic subgroup. A thick layer, starting at the mineral soil surface, of sand or loamy sand is not considered normal and defines Arenic subgroups, a convention used elsewhere in this taxonomy. A shallow lithic contact defines the Lithic subgroup, another convention used throughout this taxonomy. Clays that have low activity suggest strong weathering and are used to define the Kanhaplic subgroup. An argillic horizon that has a texture of loamy fine sand or coarser is not considered normal and defines the Psammentic subgroup. An argillic horizon that is composed entirely of thin lamellae defines the Lamellic subgroup.

A soil moisture regime that approaches the udic regime is considered more moist than normal and defines the Udic subgroup. A moderately low base saturation throughout the argillic horizon is considered atypical and defines the Ultic subgroup.

Cracks and slickensides or wedge-shaped aggregates are properties shared with Vertisols and define Vertic subgroups. A soil moisture regime that approaches the aridic regime is considered drier than normal and defines Aridic subgroups.

Typic Haplustalfs are moderately extensive in the United States. They are used mainly for grazing or as cropland.

Aquertic Haplustalfs.—These soils have a clayey texture and have expanding clay in the argillic horizon. They also have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. These soils are in nearly level areas and may or may not have calcic horizons or relatively low base saturation. They are rare in the United States.

Aquic Arenic Haplustalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a texture of loamy fine sand or coarser. The presence or absence of a calcic horizon or of relatively low base saturation is not definitive of this subgroup. These soils are on gentle slopes and are rare in the United States.

Aquic Haplustalfs.—These soils are like Typic Haplustalfs, but they have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. These soils are in nearly level areas and may or may not have calcic horizons or relatively low base saturation. They are locally important in the central part of the Southern United States. They are used as cropland or for grazing.

Aquultic Haplustalfs.—These soils are like Typic

Haplustalfs, but they have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. These soils are in nearly level areas and have relatively low base saturation. They are rare in the United States.

Arenic Aridic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a layer, 50 cm or more thick, starting at the mineral soil surface, that has a texture of loamy fine sand or coarser throughout its thickness. In addition, they are drier than the Typic Haplustalfs and, because they have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout, they are permitted, but not required, to have a calcic horizon within the depths required for the Typic subgroup. Arenic Aridic Haplustalfs are rare in the United States.

Arenic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a layer, 50 cm or more thick, starting at the mineral soil surface, that has a texture of loamy fine sand or coarser throughout its thickness. There is no restriction on base saturation in the argillic horizon, except for the limit imposed by the definition of Alfisols. A calcic horizon may be present at any depth but is not required. These soils are of small extent but are locally important in the southern part of the Great Plains in the United States. Their slopes are gentle. Most of the soils are used as cropland.

Aridic Haplustalfs.—These soils are drier than Typic Haplustalfs. They are intergrades between Haplargids and Haplustalfs. They are extensive in the southern part of the Great Plains of the United States. Slopes generally are gentle or moderate. Many of these soils are used for grazing, and others are used as cropland. Some of the cropland is irrigated, and some is used for drought-tolerant crops.

Calcic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface. They are rare in the United States.

Calcic Udic Haplustalfs.—These soils are like Typic Haplustalfs, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 ^{o}C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 ^{o}C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils also have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface. They are rare in the United States.

Calcidic Haplustalfs.—These soils are drier than Typic Haplustalfs. They have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface. These soils are intergrades between Calcids or Calciargids and Haplustalfs. They are rare in the United States.

Inceptic Haplustalfs.—These soils have an argillic horizon 35 cm or less thick and have no densic, lithic, or paralithic contact within 100 cm of the mineral soil surface. In addition, the base saturation of all parts of the argillic horizon is permitted, but not required, to be lower than that in Typic Haplustalfs. A calcic horizon also is permitted. These soils are considered intergrades to Ustepts. They are rare in the United States.

Kanhaplic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a cation-exchange capacity (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay. They are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent in all parts of the argillic horizon and to have a calcic horizon or soft, powdery secondary lime at any depth. The upper boundary of the argillic horizon in these soils generally is gradual. Kanhaplic Haplustalfs are intergrades between Haplustalfs and Ustox. They are not known to occur on the United States mainland or in Puerto Rico, but the subgroup is provided for use in other countries.

Lamellic Haplustalfs.—These soils are like Typic Haplustalfs in defined properties, but they have an argillic horizon that consists of lamellae or partially of lamellae. Most of these soils have a sandy particle-size class, and the upper boundary of the argillic horizon or the upper lamella may be below a depth of 60 cm. The upper several lamellae are commonly broken or discontinuous horizontally. These soils are not extensive in the United States.

Lithic Haplustalfs.—These soils have a lithic contact within 50 cm of the soil surface. They are permitted to have any of the other properties allowed in Haplustalfs. They are common in the southwestern part of the United States. Their slopes are moderate or strong. Most of the soils are used for grazing.

Oxyaquic Haplustalfs.—These soils are like Typic Haplustalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, these soils are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent. They are considered intergrades to Aqualfs. These soils are rare in the United States.

Oxyaquic Vertic Haplustalfs.—These soils have a clayey texture and have expanding clay in the argillic horizon. They also have deep, wide cracks in normal years. In addition, they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are not extensive in the United States.

Psammentic Haplustalfs.—These soils have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick. In addition, the base saturation of the argillic horizon is permitted, but not required, to be lower than that in Typic Haplustalfs. A calcic horizon is permitted. These soils are considered intergrades to Ustipsamments. They are of small extent in the United States. Their slopes are mostly gentle. Most of these soils are grazed, but some are used for drought-tolerant crops.

Torrertic Haplustalfs.—These soils are drier than Typic Haplustalfs. They also have a clayey texture and have expanding clay in the argillic horizon. They have deep, wide cracks in normal years. They are not extensive in the United States.

Udertic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a clayey texture and have expanding clay in the argillic horizon. They are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 ^{o}C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 ^{o}C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Uderts and Haplustalfs. They are of small extent but are locally important in Texas and Oklahoma in the United States. Their slopes are mostly gentle. Most of these soils are used as cropland.

Udic Haplustalfs.—These soils are like Typic Haplustalfs, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 ^{o}C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 ^{o}C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Hapludalfs and Haplustalfs. They are extensive locally on the Great Plains in the United States. Their slopes range from gentle to strong. Where slopes are suitable, most of these soils are used as cropland.

Ultic Haplustalfs.—These soils are like Typic Haplustalfs, but they have a base saturation (by sum of cations) that is less than 75 percent in all parts of the argillic horizon. These soils are intergrades between Hapludults and Haplustalfs. They are moderately extensive in California and Oklahoma in the United States and are extensive in some parts of the world. Their slopes are gentle to strong in the United States. Where slopes are suitable, most of these soils are used as cropland.

Vertic Haplustalfs.—These soils have a clayey texture and have expanding clay in the argillic horizon. They also have deep, wide cracks in normal years. They are not extensive in the United States. Their slopes are gentle or moderate. Most of these soils are used for grazing.

Vitrandic Haplustalfs.—These are the Haplustalfs that have significant amounts of volcanic ash, pumice, or glass in one or more layers 18 cm or more thick within 75 cm of the mineral soil surface. These soils do not have a high shrink-swell potential and are not saturated within 100 cm of the mineral soil surface for extended periods. They occur in New Mexico and are used as rangeland or woodland.

Kandiustalfs

Kandiustalfs are the Ustalfs with thick argillic horizons that have relatively high base saturation but a low cation-exchange capacity. Many of these soils occur on the older surfaces in warm, humid or semihumid areas. Kandiustalfs occur in Africa and South America. They are commonly used as rangeland or cropland.

Definition

Kandiustalfs are the Ustalfs that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface and do not have a duripan within 100 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within 150 cm of the soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in content of clay below this layer;

4. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface; *and*

5. Do not have a natric horizon.

Key to Subgroups

JCDA. Kandiustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiustalfs

JCDB. Other Kandiustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Aquic Arenic Kandiustalfs

JCDC. Other Kandiustalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiustalfs

JCDD. Other Kandiustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustalfs

JCDE. Other Kandiustalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Arenic Aridic Kandiustalfs

JCDF. Other Kandiustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiustalfs

JCDG. Other Kandiustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Kandiustalfs

JCDH. Other Kandiustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for 135 cumulative days or less per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Kandiustalfs

JCDI. Other Kandiustalfs that have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kandiustalfs

JCDJ. Other Kandiustalfs.

Typic Kandiustalfs

Definition of Typic Kandiustalfs

Typic Kandiustalfs are the Kandiustalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

3. Have, in all horizons within 150 cm of the mineral soil surface, less than 5 percent plinthite, by volume;

4. When neither irrigated nor fallowed to store moisture:

a. Have a mesic or thermic soil temperature regime and both are dry in some part less than six-tenths of the time and are dry for more than 135 cumulative days per year in some part of the moisture control section (not necessarily the same part) in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. Have a hyperthermic, isomesic, or warmer soil temperature regime and:

(1) Are dry in some or all parts of the moisture control section for 120 or more cumulative days per year; *and*

(2) Are moist in some or all parts of the moisture control section for 90 or more consecutive days per year both in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

(3) Are moist in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C;

5. Do not have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value.

Description of Subgroups

Typic Kandiustalfs.—The central concept or Typic subgroup of Kandiustalfs is fixed on freely drained soils that are moderately deep or deep to hard rock, that have an argillic horizon that has a loamy or clayey particle-size class and high base saturation, and that are moist for an appreciable part of a growing season.

Soils that have redox depletions with low chroma near the surface in one or more horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Kandiustalfs because these properties are shared with Aqualfs. A thick layer, starting at the mineral soil surface, of sand or loamy sand is not considered normal and defines Arenic and Grossarenic subgroups, a convention used elsewhere in this taxonomy.

A soil moisture regime that approaches the udic regime is considered more moist than normal and defines the Udic subgroup.

A soil moisture regime that approaches the aridic regime is considered drier than normal and defines Aridic subgroups.

Typic Kandiustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Arenic Kandiustalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have a layer, starting at the mineral soil surface, that is 50 to 100 cm thick and has a sandy or sandy-skeletal particle-size class throughout. These soils are on gentle slopes. They are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. The soils are in nearly level areas. They are not known to occur in the United States. They are defined for use in other parts of the world.

Arenic Aridic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have a layer, 50 to 100 cm thick, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class throughout its thickness. In addition, they are drier than the Typic Kandiustalfs. Arenic Aridic Kandiustalfs are on gentle slopes. They are not known to occur in the United States. They are defined for use in other parts of the world.

Arenic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have a layer, 50 to 100 cm thick, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class throughout its thickness. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Aridic Kandiustalfs.—These soils are drier than Typic Kandiustalfs. They are intergrades between Argids and Kandiustalfs. They are not known to occur in the United States. They are defined for use in other parts of the world.

Grossarenic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have a layer, 100 cm or more thick, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class throughout its thickness. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Plinthic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they have, in all subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have hue of 2.5YR or redder, value, moist, of 3 or less, and dry value no more than 1 unit higher than the moist value. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Udic Kandiustalfs.—These soils are like Typic Kandiustalfs, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 ºC if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Kandiudalfs and Kandiustalfs. They are not known to occur in the United States. They are defined for use in other parts of the world.

Kanhaplustalfs

Kanhaplustalfs are the Ustalfs that have relatively high base saturation but have a low cation-exchange capacity. These soils do not have the thick argillic horizon characteristic of the Kandiustalfs. Kanhaplustalfs commonly occur on the older surfaces in warm, humid or semihumid areas. They are used for livestock grazing or crop production.

Definition

Kanhaplustalfs are the Ustalfs that:

1. Have a kandic horizon;

2. Are more than 150 cm deep and have a clay distribution in which the content of clay decreases from its maximum amount by 20 percent or more within 150 cm of the soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is less than a 3 percent (absolute) increase in content of clay below this layer;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the soil surface;

4. Do not have a natric horizon; *and*

5. Do not have a duripan within 100 cm of the mineral soil surface.

Key to Subgroups

JCEA. Kanhaplustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplustalfs

JCEB. Other Kanhaplustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplustalfs

JCEC. Other Kanhaplustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ºC; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC.

Aridic Kanhaplustalfs

JCED. Other Kanhaplustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for 135 cumulative days or less per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ºC.

Udic Kanhaplustalfs

JCEE. Other Kanhaplustalfs that have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Kanhaplustalfs

JCEF. Other Kanhaplustalfs.

Typic Kanhaplustalfs

Definition of Typic Kanhaplustalfs

Typic Kanhaplustalfs are the Kanhaplustalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Do not have a lithic contact within 50 cm of the soil surface;

3. When neither irrigated nor fallowed to store moisture:

a. Have a mesic or thermic soil temperature regime *and*, in one-half or more of the years, both are dry less than six-tenths of the time and are dry for more than 135 cumulative days in some part of the moisture control section (not necessarily the same part) during a period when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. Have a hyperthermic, isomesic, or warmer soil temperature regime and:

(1) Are dry in some or all parts of the moisture control section for 120 or more cumulative days per year; *and*

(2) Are moist in some or all parts of the moisture control section for 90 or more consecutive days per year both in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

(3) Are moist in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

4. Have, in *all* subhorizons in the upper 100 cm of the kandic horizon or throughout the entire kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value.

Description of Subgroups

Typic Kanhaplustalfs.—The central concept or Typic subgroup of Kanhaplustalfs is fixed on freely drained soils that are moderately deep or deep to hard rock and that are moist for an appreciable part of a growing season.

Soils that have redox depletions with low chroma near the surface in one or more horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Kanhaplustalfs because these properties are shared with Aqualfs. A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy. A soil moisture regime that approaches the udic regime is considered more moist than normal and defines the Udic subgroup. A soil moisture regime that approaches the aridic regime is considered drier than normal and defines the Aridic subgroup.

Typic Kanhaplustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Kanhaplustalfs.—These soils are like Typic Kanhaplustalfs, but they have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. The soils are in nearly level areas and may or may not have calcic horizons or relatively low base saturation. Aquic Kanhaplustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Aridic Kanhaplustalfs.—These soils are drier than Typic Kanhaplustalfs. They are intergrades between Haplargids and Kanhaplustalfs. Aridic Kanhaplustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Lithic Kanhaplustalfs.—These soils have a lithic contact within 50 cm of the soil surface. They are permitted to have any of the other properties allowed in Kanhaplustalfs. They are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodic Kanhaplustalfs.—These soils are like Typic Kanhaplustalfs, but all of the kandic horizon or the upper 100 cm of the kandic horizon has a color with hue of 2.5YR or redder, value, moist, of 3 or less, and a dry color value no more than 1 unit higher than the moist value. Rhodic Kanhaplustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Udic Kanhaplustalfs.—These soils are like Typic Kanhaplustalfs, but they are dry in some part of the moisture control section for 135 or fewer cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 120 cumulative days per year during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Kanhapludalfs and Kanhaplustalfs. Udic Kanhaplustalfs are not known to occur in the United States. They are defined for use in other parts of the world.

Natrustalfs

Natrustalfs are the Ustalfs that have a natric horizon. They do not have a duripan within 100 cm of the mineral soil surface, nor do they have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the soil surface. The epipedon is normally 10 to 20 cm thick. The natric horizon generally is underlain by a Bk or calcic horizon at a depth between about 25 and 40 cm. Natrustalfs were considered Solonetz soils, Soloth soils, and transitional forms in the 1938 classification. Except for a few parts of the Great Plains and mountain basins, they are not extensive in the United States.

Definition

Natrustalfs are the Ustalfs that:

1. Have a natric horizon;

2. Do not have a duripan within 100 cm of the mineral soil surface;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the soil surface.

Key to Subgroups

JCCA. Natrustalfs that have a salic horizon that has its upper boundary within 75 cm of the mineral soil surface.

Salidic Natrustalfs

JCCB. Other Natrustalfs that have *all* of the following:

1. Visible crystals of gypsum or other salts more soluble than gypsum, or both, within 40 cm of the soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

3. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Torrertic Natrustalfs

JCCC. Other Natrustalfs that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Natrustalfs

JCCD. Other Natrustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Natrustalfs

JCCE. Other Natrustalfs that have *both* of the following:

1. Visible crystals of gypsum or other salts more soluble than gypsum, or both, within 40 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Leptic Natrustalfs

JCCF. Other Natrustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrustalfs

JCCG. Other Natrustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Aquic Arenic Natrustalfs

JCCH. Other Natrustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Natrustalfs

JCCI. Other Natrustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Natrustalfs

JCCJ. Other Natrustalfs that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Natrustalfs

JCCK. Other Natrustalfs that have visible crystals of gypsum or other salts more soluble than gypsum, or both, within 40 cm of the mineral soil surface.

Leptic Natrustalfs

JCCL. Other Natrustalfs that have *both* of the following:

1. An exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) in 50 percent or more of the natric horizon; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90

consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Haplargidic Natrustalfs

JCCM. Other Natrustalfs that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Natrustalfs

JCCN. Other Natrustalfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Mollic Natrustalfs

JCCO. Other Natrustalfs.

Typic Natrustalfs

Definition of Typic Natrustalfs

Typic Natrustalfs are the Natrustalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Have an Ap horizon that has a color value, moist, of more than 3, or the surface soil to a depth of 18 cm, after mixing, has a color value, moist, of more than 3;

3. Do not have a salic horizon that has its upper boundary within 75 cm of the soil surface;

4. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the surface;

5. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

6. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

7. When neither irrigated nor fallowed to store moisture, meet *one* of the following:

a. Have a frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. Have a mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. Have a hyperthermic, isomesic, or warmer soil temperature regime and:

(1) Are dry in some or all parts of the moisture control section for 120 or more cumulative days per year; *and*

(2) Are moist in some or all parts of the moisture control section for 90 or more consecutive days per year both in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

(3) Are moist in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C;

8. Have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in more than 50 percent of the natric horizon; *and*

9. Do not have visible crystals of gypsum or other salts more

soluble than gypsum, or both, within 40 cm of the mineral soil surface.

Description of Subgroups

Typic Natrustalfs.—The central concept or Typic subgroup of Natrustalfs is fixed on soils that are not so well drained as most other Ustalfs because the natric horizon has virtually no hydraulic conductivity. The plow layer, if one occurs, or the equivalent subhorizons have a color value, moist, of more than 3, and there is no salic horizon within 75 cm and no petrocalcic horizon within 150 cm of the surface. A thick epipedon with a sandy or sandy-skeletal particle-size class throughout is considered atypical and is used to define Arenic subgroups. Visible crystals of gypsum or other salts more soluble than gypsum are not within 40 cm of the mineral soil surface. Surface horizons above a depth of 18 cm that, after mixing, have the color of a mollic epipedon or a plow layer that has this color is believed to indicate a transition to Mollisols and define the Mollic subgroup.

Soils that have shallow redox depletions with low chroma in horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from the Typic subgroup because these properties are shared with Aqualfs. Soils that have a shallow salic horizon are excluded because such a horizon is shared with Salids. A petrocalcic horizon is considered atypical and is the basis for defining the Petrocalcic subgroup.

The Typic Natrustalfs in the United States are most commonly in depressions or on the margins of lakes or playas. Their slopes are nearly level. Most of these soils are used for grazing.

Aquertic Natrustalfs.—These soils are like Typic Natrustalfs, but they have a clayey texture and have expanding clay in the argillic horizon. They also have redox depletions with low chroma within 75 cm of the mineral soil surface that are caused by periods of wetness. In addition, the surface soil to a depth of 18 cm after mixing or the Ap horizon is permitted, but not required, to have a color value, moist, of 3 or less. These soils are in nearly level areas. They are rare in the United States.

Aquic Arenic Natrustalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a texture of loamy fine sand or coarser. The soils in this subgroup are known to be locally extensive only in Texas in the United States. Most are used for grazing. Slopes are nearly level to gently undulating, suggesting some reworking by wind in the late Pleistocene.

Aquic Natrustalfs.—These soils are like Typic Natrustalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, the surface soil to a depth of 18 cm after mixing or the Ap horizon is permitted, but not required, to have a color value, moist, of 3 or less. These soils are rare in the United States. Most of them are used for grazing.

Arenic Natrustalfs.—These soils are like Typic Natrustalfs, but they have a layer, starting at the mineral soil surface, 50 cm or more thick, with a sandy or sandy-skeletal particle-size class throughout its thickness. These soils are not extensive in the United States. Their slopes are nearly level to gently undulating, suggesting some reworking by wind.

Aridic Leptic Natrustalfs.—These soils are drier than Typic Natrustalfs. In addition, they have visible crystals of gypsum or other salts more soluble than gypsum within 40 cm of the mineral soil surface. These soils are intergrades between Natrargids and Natrustalfs. They are rare in the United States.

Aridic Natrustalfs.—These soils are drier than Typic Natrustalfs. They are intergrades between Natrargids and Natrustalfs. They are rare in the United States.

Haplargidic Natrustalfs.—These soils are drier than Typic Natrustalfs. They also have an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) in 50 percent or more of the natric horizon. These soils are intergrades between Haplargids and Natrustalfs. They are rare in the United States.

Leptic Natrustalfs.—These soils have visible crystals of gypsum or other salts more soluble than gypsum within 40 cm of the mineral soil surface. They are rare in the United States.

Leptic Torrertic Natrustalfs.—These soils are drier than Typic Natrustalfs. They have a clayey texture and have expanding clay in the argillic horizon. They have deep, wide cracks in normal years. These soils also have visible crystals of gypsum or other salts more soluble than gypsum within 40 cm of the mineral soil surface. They are rare in the United States.

Mollic Natrustalfs.—These soils are like Typic Natrustalfs, but the Ap horizon or the upper 18 cm after mixing has a color value, moist, of 3 or less, generally 3. These soils are of small extent in the United States. Their slopes are nearly level, and most of the soils are used for grazing.

Petrocalcic Natrustalfs.—These soils have a petrocalcic horizon that is normally about 50 to 75 cm below the soil surface but is very thin, about 5 to 10 cm thick. They are rare in the United States.

Salidic Natrustalfs.—These soils are like Typic Natrustalfs, but they have a salic horizon within 75 cm of the surface but in or below the natric horizon. They are rare in the United States. Ground water in these soils is relatively shallow and is salty. The soils are used only for limited grazing.

Torrertic Natrustalfs.—These soils are drier than Typic Natrustalfs. They have a clayey texture and have expanding clay in the argillic horizon. They have deep, wide cracks in normal years. They are rare in the United States.

Vertic Natrustalfs.—These soils are like Typic Natrustalfs, but they have a clayey texture and have expanding clay in the argillic horizon. In addition, the surface soil to a depth of 18 cm after mixing or the Ap horizon is permitted, but not required, to have a color value, moist, of 3 or less. These soils are in nearly level areas. They are rare in the United States.

Paleustalfs

Paleustalfs are the reddish or red Ustalfs that are on old surfaces. Many of them have some plinthite in their lower horizons. Paleustalfs occur in relatively stable landscape positions, their slopes are mostly gentle, and their genesis began before the late Pleistocene. In the United States, they typically have a Bk or calcic horizon in or below the argillic horizon as a result of additions of atmospheric carbonates. Commonly, secondary lime coats the surfaces of peds that have noncalcareous interiors and the soils may be noncalcareous at a depth of less than 200 cm. A few of these soils, near the boundary where they join Aridisols, have received enough calcareous dust to have a petrocalcic horizon. A few others, near the boundary where they join Udults or Udalfs, do not have a Bk horizon. Before cultivation, the vegetation on the Paleustalfs in the United States included a mixture of grasses and woody plants. These soils are moderately extensive in the southern part of the Great Plains in the United States, and they probably are extensive in Africa and southern Asia.

Definition

Paleustalfs are the Ustalfs that:

1. Do not have a duripan within 100 cm of the soil surface and do not have a natric horizon;

2. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within any subhorizon of the argillic horizon within 150 cm of the soil surface; *and*

3. Meet *one or more* of the following:

a. Have a petrocalcic horizon that is in or below an argillic horizon but that has an upper boundary within 150 cm of the soil surface; *or*

b. Do not have a densic, lithic, or paralithic contact within 150 cm of the soil surface and have an argillic horizon that has:

(1) A clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent from the soil surface to a depth of 150 cm, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in content of clay below this layer; *and*

(2) *One or more* of the following:

(a) Hue of 7.5YR or redder and chroma of 5 or more in 50 percent or more of the matrix of one or more horizons in its lower one-half;

(b) In 50 percent or more of the matrix of horizons that total more than one-half the total thickness, hue of 7.5YR or redder, value, moist, of 3 or less, and value, dry, of 4 or less; *or*

(c) In one or more horizons in its lower one-half, common coarse redox concentrations that have hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

c. Do not have a densic, lithic, or paralithic contact within 50 cm of the surface and have an argillic horizon that has:

(1) A clayey or clayey-skeletal particle-size class in its upper part; *and*

(2) At its upper boundary, a clay increase of at least 20 percent (absolute) within a vertical distance of 7.5 cm or of 15 percent (absolute) within a distance of 2.5 cm, in the fine-earth fraction.

Although the restriction on depth to a densic, lithic, or paralithic contact in the Paleustalfs is only 50 cm, it is rare that such a contact is within a depth of 150 cm. A few of these soils, however, have rock at a depth of less than 100 cm.

Key to Subgroups

JCFA. Paleustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Paleustalfs

JCFB. Other Paleustalfs that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Paleustalfs

JCFC. Other Paleustalfs that have *both*:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Paleustalfs

JCFD. Other Paleustalfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleustalfs

JCFE. Other Paleustalfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Aquic Arenic Paleustalfs

JCFF. Other Paleustalfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleustalfs

JCFG. Other Paleustalfs that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleustalfs

JCFH. Other Paleustalfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleustalfs

JCFI. Other Paleustalfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleustalfs

JCFJ. Other Paleustalfs that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Arenic Aridic Paleustalfs

JCFK. Other Paleustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleustalfs

JCFL. Other Paleustalfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleustalfs

JCFM. Other Paleustalfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleustalfs

JCFN. Other Paleustalfs that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Paleustalfs

JCFO. Other Paleustalfs that have *both*:

1. When neither irrigated nor fallowed to store moisture, *either*:

a. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

(1) Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. A calcic horizon *either* within 100 cm of the mineral soil surface if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, *or* within 60 cm if it is loamy, *or* within 50 cm if it is clayey, *and* carbonates in all horizons above the calcic horizon.

Calcidic Paleustalfs

JCFP. Other Paleustalfs that, when neither irrigated nor fallowed to store moisture, have:

1. A frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for four-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for six-tenths or more of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years:

a. Is moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Paleustalfs

JCFQ. Other Paleustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kandic Paleustalfs

JCFR. Other Paleustalfs that have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodic Paleustalfs

JCFS. Other Paleustalfs that have an argillic horizon with a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Paleustalfs

JCFT. Other Paleustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Paleustalfs

JCFU. Other Paleustalfs.

Typic Paleustalfs

Definition of Typic Paleustalfs

Typic Paleustalfs are the Paleustalfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

3. Have a texture finer than loamy fine sand in one or more subhorizons within 50 cm of the mineral soil surface;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the soil surface;

5. When neither irrigated nor fallowed to store moisture:

a. Have a frigid temperature regime *and* a moisture control section that in normal years is dry in all parts for less than four-tenths of the time (cumulative) per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. Have a mesic or thermic soil temperature regime *and* a moisture control section that is dry in some part for more than four-tenths but less than six-tenths of the time (cumulative) when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

c. Have a hyperthermic, isomesic, or warmer soil temperature regime and:

(1) Are dry in some or all parts of the moisture control section for 120 or more cumulative days per year; *and*

(2) Are moist in some or all parts of the moisture control section for 90 or more consecutive days per year both in normal years and during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

(3) Are moist in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C;

6. Have an argillic horizon that has a base saturation (by sum of cations) of 75 percent or more in some part;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

8. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface;

9. Do not have a calcic horizon that has an upper boundary within 100 cm of the soil surface if the weighted average

particle-size class of the upper 50 cm of the argillic horizon is sandy, or 60 cm if it is loamy, or 50 cm if it is clayey;

10. Have a CEC of 24 or more cmol(+)/kg clay (by 1N NH_4OAc pH 7) in the major part of the argillic horizon or in the major part of its upper 100 cm if it is thicker than 100 cm;

11. Have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value;

12. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

13. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Description of Subgroups

Typic Paleustalfs.—The central concept or Typic subgroup of Paleustalfs is fixed on freely drained soils that have a thin or loamy epipedon; that do not have cracks and slickensides or wedge-shaped aggregates; that are moist for an appreciable part of the growing season; and that have an argillic horizon that contains some 2:1 lattice clays, has a loamy or clayey particle-size class and high base saturation in at least some part, and is not composed entirely of thin lamellae.

Soils that have shallow redox depletions with low chroma in horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Paleustalfs because these properties are shared with Aqualfs. A thick epipedon with a sandy or sandy-skeletal particle-size class throughout is not considered normal and defines Arenic and Grossarenic subgroups, a convention used elsewhere in this taxonomy. Soils that have an appreciable amount of plinthite are excluded because the presence of plinthite is a property of Plinthustalfs. A soil moisture regime that is ustic but borders on udic is more moist than normal and defines the Udic subgroup. A moderately low base saturation throughout the argillic horizon is considered atypical and defines the Ultic subgroup.

Cracks and slickensides or wedge-shaped aggregates are properties shared with Vertisols and define intergrades to that order. A petrocalcic horizon causes a soil to be excluded from the Typic subgroup, even though one is very common in Paleustalfs, and its presence defines the Petrocalcic subgroup. A soil moisture regime that approaches the aridic regime is considered drier than normal and defines Aridic subgroups.

Clays that have low activity are considered evidence of strong weathering, and their dominance is the basis for defining the Kandic subgroup.

Typic Paleustalfs are not the most extensive subgroup of Paleustalfs in the United States. They are mostly in Texas. Some of them are used as cropland, and many of them are used for grazing. The Typic subgroup was selected to provide a basis for defining subgroups, and it is thought to be extensive in some parts of the world.

Aquertic Paleustalfs.—These soils are like Typic Paleustalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have cracks and slickensides or wedge-shaped aggregates. The base saturation (by sum of cations) may be less than 75 percent throughout the argillic horizon. These soils are not extensive in the United States. Their slopes are gentle, and most of the soils are used as cropland.

Aquic Arenic Paleustalfs.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a sandy or sandy-skeletal particle-size class throughout its thickness. The base saturation (by sum of cations) may be less than 75 percent throughout the argillic horizon. These soils are moderately extensive in some areas in the southern part of the Great Plains in the United States. Their slopes are gentle or moderate.

Aquic Paleustalfs.—These soils are like Typic Paleustalfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Skeletans with low chroma should not be mistaken for redox depletions with low chroma, which are caused by wetness. The base saturation (by sum of cations) may be less than 75 percent throughout the argillic horizon. These soils are of moderate extent in the United States. Most of them are in Texas. Their slopes are gentle, and most of the soils are used as cropland.

Arenic Aridic Paleustalfs.—These soils have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a sandy or sandy-skeletal particle-size class throughout its thickness. They are drier than Typic Paleustalfs. Some Arenic Aridic Paleustalfs have a calcic horizon or a horizon that has identifiable secondary carbonates. Arenic Aridic Paleustalfs are of small extent in the southern part of the Great Plains in the United States. Their slopes are gentle. These soils are used mainly for grazing.

Arenic Paleustalfs.—These soils have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a sandy or sandy-skeletal particle-size class throughout its thickness. These soils are not extensive in the United States. Their slopes are mostly gentle or moderate. Some of the soils are used as cropland, but most of them are used for grazing.

Aridic Paleustalfs.—These soils are like Typic Paleustalfs, but they are drier. In addition, they do not have a calcic horizon or are noncalcareous in some subhorizon above the calcic horizon, or, if calcareous throughout, the calcic horizon is deeper than 100 cm if the weighted average particle-size class of the upper 50 cm of the argillic horizon is sandy, deeper than 60 cm if the particle-size class is loamy, or 50 cm if the particle-size class is clayey. The calcic horizon is normally in the thick argillic horizon. These soils are thought to have been recalcified since the argillic horizon formed. In the United States, dust from the Aridisols to the west is a probable source of some of the carbonates. Aridic Paleustalfs are extensive in some areas in the southern part of the Great Plains. Their slopes are gentle. Many of the soils are used as cropland. Some are used for irrigated crops, mainly cotton, sorghum, and wheat. Others are used for drought-tolerant crops or for grazing.

Calcidic Paleustalfs.—These soils are calcareous in all subhorizons; have a calcic horizon within 100 cm of the soil surface, commonly within 50 cm; and are drier than Typic Paleustalfs. The argillic horizon appears to have been largely but not entirely disrupted by the deposition of carbonates, but it is preserved in part below the calcic horizon. Calcidic Paleustalfs are not extensive in the United States. They are used mainly for grazing.

Grossarenic Paleustalfs.—These soils have an epipedon that has a sandy or sandy-skeletal particle-size class throughout and is more than 100 cm thick. The argillic horizon commonly is sandy loam or sandy clay loam. The soils of this subgroup are extensive only locally in Texas in the United States. Most of them are used for grazing. Their slopes are gentle but commonly are billowy, suggesting some reworking by wind at some time during the late Pleistocene.

Kandic Paleustalfs.—These soils have an argillic horizon that has a CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in the major part. The base saturation (by sum of cations) is less than 75 percent in all parts of the argillic horizon in some pedons. These soils are intergrades between Paleustalfs and Kandiustalfs. They are not known to occur in the United States but probably are moderately extensive in some other countries.

Lamellic Paleustalfs.—These soils are like Typic Paleustalfs in defined properties, but they have an argillic horizon that consists of lamellae or partially of lamellae. Most of these soils have a sandy particle-size class, and the upper boundary of the argillic horizon or the upper lamella may be below a depth of 60 cm. The upper several lamellae are commonly broken or discontinuous horizontally. These soils are not extensive in the United States.

Oxyaquic Paleustalfs.—These soils are like Typic Paleustalfs, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, the soils are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent. They are considered intergrades to Aqualfs. They are rare in the United States.

Oxyaquic Vertic Paleustalfs.—These soils are like Typic Paleustalfs, but they have a clayey texture and have expanding clay in the argillic horizon. They also have deep, wide cracks in normal years and are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are not extensive in the United States.

Petrocalcic Paleustalfs.—These soils have a petrocalcic horizon, most commonly at a depth about 75 cm below the surface, and are drier than Typic Paleustalfs. The upper part of the argillic horizon is noncalcareous. Petrocalcic Paleustalfs are locally extensive in the southern part of the Great Plains in the United States. Some of them are used for crops, mainly cotton, sorghum, and wheat. A few of the soils are irrigated. Many are used for grazing.

Plinthic Paleustalfs.—These soils are like Typic Paleustalfs, but they have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. In addition, the soils are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent. These soils are rare in the United States.

Psammentic Paleustalfs.—These soils are like Typic Paleustalfs, but they have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick. In addition, the epipedon is permitted to be, and generally is, more than 50 cm thick, and its texture is permitted to be loamy fine sand or coarser throughout its thickness. These soils are not extensive in the United States. Their slopes are gentle to strong. Most of the soils are used for grazing.

Rhodic Paleustalfs.—These soils are like Typic Paleustalfs, but the argillic horizon has hue of 2.5YR or redder and has a color value, moist, of 3 or less and a dry color value 1 unit or less higher than the moist value. In addition, the base saturation (by sum of cations) may be less than 75 percent throughout the argillic horizon. These soils are not extensive in the United States. Their slopes are gentle, and most of the soils are used for grazing.

Udertic Paleustalfs.—These soils are like Typic Paleustalfs, but they have cracks and slickensides or wedge-shaped aggregates and are moist for longer periods. They are intergrades between Hapluderts and Paleustalfs. They are locally extensive in some areas in the southern part of the Great Plains in the United States. Their slopes are gentle, and most of the soils are used as cropland.

Udic Paleustalfs.—These soils are like Typic Paleustalfs, but they are moist for longer periods. They are intergrades between Paleudalfs and Paleustalfs. They are extensive in parts of the United States. Their slopes are gentle, and most of the soils are used as cropland.

Ultic Paleustalfs.—These soils are like Typic Paleustalfs, but they have a base saturation (by sum of cations) that is less than 75 percent in all subhorizons of the argillic horizon. Most Ultic Paleustalfs do not have a calcic horizon or a horizon that contains identifiable secondary carbonates. Ultic Paleustalfs are intergrades between Paleudults or Paleustults and Paleustalfs. They are locally extensive in Texas and Oklahoma in the United States. Their slopes are gentle, and most of the soils are used as cropland.

Vertic Paleustalfs.—These soils are like Typic Paleustalfs, but they have cracks and slickensides or wedge-shaped aggregates. Vertic Paleustalfs are intergrades between Haplusterts and Paleustalfs. They are moderately extensive locally in some areas in the southern part of the Great Plains and in the southwestern part of the United States. Their slopes are gentle, and most of the soils are used as cropland.

Plinthustalfs

Plinthustalfs are the Ustalfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. These soils do not have a duripan that has its upper boundary within 100 cm of the soil surface. There are no soil series in the United States that are presently classified in this great group, but the group is provided for use in other parts of the world. Subgroups have not been developed.

Key to Subgroups

JCBA. All Plinthustalfs (provisionally).

Typic Plinthustalfs

Rhodustalfs

Rhodustalfs are dark red Ustalfs that have a thinner solum than that in Paleustalfs. Rhodustalfs generally formed on erosional surfaces or in deposits of late-Pleistocene age. In the United States, their vegetation was mostly grass and scattered woody shrubs and trees before the soils were cultivated. The parent materials are basic. These soils are rare in the United States.

Definition

Rhodustalfs are the Ustalfs that:

1. Have, in *all* subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. Value, moist, of 3 or less; *and*

   c. Dry value no more than 1 unit higher than the moist value;

2. Do not have a natric or kandic horizon;

3. Do not have a duripan that has an upper boundary within 100 cm of the soil surface or a petrocalcic horizon that has an upper boundary within 150 cm of the soil surface;

4. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix within any subhorizon of the argillic horizon within 150 cm of the soil surface;

5. Either have a densic, lithic, or paralithic contact within 150 cm of the soil surface or have a clay distribution in the argillic horizon in which the clay content decreases with increasing depth by 20 percent or more from its maximum within 150 cm of the soil surface and, if there is a clay increase of 3 percent or more (absolute) below that layer, less than 5 percent of the volume in the layer where the clay content decreases consists of skeletans on faces of peds; *and*

6. Have *either*:

   a. A densic, lithic, or paralithic contact within 50 cm of the soil surface; *or*

   b. A particle-size class other than fine, very-fine, or clayey-skeletal in the upper part of the argillic horizon; *or*

   c. A fine, very-fine, or clayey-skeletal particle-size class in the upper part of the argillic horizon and an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm and of less than 15 percent within 2.5 cm of the upper boundary of the argillic horizon.

Key to Subgroups

JCGA. Rhodustalfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodustalfs

JCGB. Other Rhodustalfs that have a CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more *either* of the argillic horizon if less than 100 cm thick *or* of its upper 100 cm.

Kanhaplic Rhodustalfs

JCGC. Other Rhodustalfs that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for four-tenths or less of the time (cumulative) per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Rhodustalfs

JCGD. Other Rhodustalfs.

Typic Rhodustalfs

Definition of Typic Rhodustalfs

Typic Rhodustalfs are the Rhodustalfs that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have a CEC of 24 or more cmol(+)/kg clay (by 1N NH_4OAc pH 7) in the major part of the argillic horizon or the major part of the upper 100 cm of the argillic horizon if the argillic horizon is thicker than 100 cm; *and*

3. When neither irrigated nor fallowed to store moisture, have:

a. A mesic or thermic soil temperature regime *and* a moisture control section that in normal years is dry in some part for more than four-tenths of the time (cumulative) when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime *and* a moisture control section that in normal years is dry in some or all parts for 120 or more days (cumulative) during a period when the soil temperature at a depth of 50 cm exceeds 8 °C.

Description of Subgroups

Typic Rhodustalfs.—The central concept or Typic subgroup of Rhodustalfs is fixed on soils that are deep or moderately deep to hard rock and that have some 2:1 lattice clays.

A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy. Low activity in the clay fraction is thought to indicate stronger weathering than normal and is used to define the Kanhaplic subgroup. Rhodustalfs that are moist for longer periods than are described for the Typic subgroup are assigned to the Udic subgroup.

Typic Rhodustalfs are rare in the United States. Their slopes range from gentle to strong. Most of them are used for grazing.

Kanhaplic Rhodustalfs.—These soils are like Typic Rhodustalfs, but their CEC is less than 24 cmol(+)/kg clay. They are permitted, but not required, to have a calcic or Bk horizon that contains identifiable secondary carbonates. These soils are rare in the United States and are known to occur only in Hawaii. Their slopes are strong, and most of the soils are used for grazing.

Lithic Rhodustalfs.—These soils have a lithic contact within 50 cm of the soil surface. They may have any of the other properties allowed in Rhodustalfs. Lithic Rhodustalfs are rare in the United States and are known to occur only in Texas.

Udic Rhodustalfs.—These soils are like Typic Rhodustalfs, but they are moist for longer periods. They are rare in the United States. Their slopes are moderate or strong, and most of the soils are used for grazing.

Xeralfs

Xeralfs are the Alfisols in regions that have a Mediterranean climate. As their name implies, they have a xeric moisture regime. They are dry for extended periods in summer, but in winter moisture moves through the soils to deeper layers in at least occasional years, if not in normal years. Small grain and other winter annuals are common crops where there is no irrigation. Grapes and olives also are common crops where the climate is thermic. With irrigation, a wide variety of crops can be grown.

Xeralfs formed not only in the area around the Mediterranean Sea but also in parts of South Africa, Chile, western and southern Australia, and in the Western United States. Most of these soils border the Mediterranean Sea or lie to the east of an ocean at midlatitudes. The temperature regime is thermic, mesic, or frigid. In the world as a whole, Xeralfs are not extensive soils, but in the regions where they occur, they are extensive. In the United States, they are moderately extensive. Before the soils were farmed, the vegetation was a mixture of annual grasses, forbs, and woody shrubs on the warmest and driest Xeralfs and coniferous forest on the coolest and most moist Xeralfs.

Xeralfs formed on surfaces that are of different ages. Some formed on erosional surfaces or in deposits of late-Wisconsinan age, and some, such as those in Australia, are on old surfaces and have characteristics that probably reflect an environment greatly different from the present one. In the oldest Xeralfs, the boundary between the A and B horizons commonly is very abrupt. The epipedon of some Xeralfs is hard and massive when dry.

Definition

Xeralfs are the Alfisols that:

1. Have a xeric moisture regime;

2. Have a frigid, mesic, or thermic temperature regime;

3. Have, in no horizon within 50 cm of the mineral soil surface, both aquic conditions (other than anthraquic conditions) for some time in normal years (or artificial drainage) *and either* of the following:

a. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm; *and one* of the following within the upper 12.5 cm of the argillic, kandic, natric, or glossic horizon:

(1) 50 percent or more redox depletions with chroma of 2 or less on faces of peds and redox concentrations within peds; *or*

(2) Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less in the matrix; *or*

(3) 50 percent or more redox depletions with chroma of 1 or less on faces of peds or in the matrix, or both; *or*

b. In a horizon that has aquic conditions, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

JDA. Xeralfs that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durixeralfs, p. 254

JDB. Other Xeralfs that have a natric horizon.

Natrixeralfs, p. 263

JDC. Other Xeralfs that have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Fragixeralfs, p. 256

JDD. Other Xeralfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthoxeralfs, p. 269

JDE. Other Xeralfs that have, in *all* subhorizons in the upper 100 cm of the argillic or kandic horizon or throughout the entire argillic or kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. Value, moist, of 3 or less; *and*

3. Dry value no more than 1 unit higher than the moist value.

Rhodoxeralfs, p. 269

JDF. Other Xeralfs that have *one or more* of the following:

1. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

2. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *and* an argillic or kandic horizon that has *both*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content [Clay is measured noncarbonate clay or based on the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon), whichever value is greater, but no more than 100]; *or*

(2) 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

b. A base at a depth of 150 cm or more; *or*

3. No densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *and* an argillic or kandic horizon that has within 15 cm of its upper boundary *both*:

a. A clayey, clayey-skeletal, fine, or very-fine particle-size class; *and*

b. A clay increase, in the fine-earth fraction, of *either* 20 percent or more (absolute) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute) within a vertical distance of 2.5 cm.

Palexeralfs, p. 264

JDG. Other Xeralfs.

Haploxeralfs, p. 258

Durixeralfs

Durixeralfs are the Xeralfs that have a duripan that has an upper boundary within 100 cm of the soil surface but below an argillic or natric horizon. These soils are known to have formed in California, Idaho, Nevada, Oregon, Chile, and Italy, in areas of Pleistocene or earlier vulcanism. Some of the Durixeralfs in the United States appear to be on very old surfaces and have complex horizons that indicate polygenesis. The oldest soils are commonly reddish and have kaolinitic mineralogy. Other Durixeralfs appear to have formed in late-Pleistocene sediments and are yellowish brown and have 2:1 lattice clays. The pan commonly has an upper boundary about 50 cm below the soil surface and has very coarse polyhedrons, the tops and sides of which are coated with opal or chalcedony. In undisturbed areas in the United States, a microrelief of about 10 to 100 cm or more is common. The microrelief is mainly the result of differences in the thickness of horizons that are above the duripan.

Durixeralfs are moderately extensive only in California and Idaho in the United States.

Definition

Durixeralfs are the Xeralfs that have a duripan that has an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

JDAA. Durixeralfs that have a natric horizon.

Natric Durixeralfs

JDAB. Other Durixeralfs that have, above the duripan, *one or both* of the following:

1. Cracks that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick; *or*

2. A linear extensibility of 6.0 cm or more.

Vertic Durixeralfs

JDAC. Other Durixeralfs that have, in one or more subhorizons within the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixeralfs

JDAD. Other Durixeralfs that have *both*:

1. An argillic horizon that has *both*:

a. A clayey, clayey-skeletal, fine, or very-fine particle-size class throughout some subhorizon 7.5 cm or more thick; *and*

b. At its upper boundary or within some part, a clay increase *either* of 20 percent or more (absolute) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction; *and*

2. A duripan that is strongly cemented or less cemented in all subhorizons.

Abruptic Haplic Durixeralfs

JDAE. Other Durixeralfs that have an argillic horizon that has *both*:

1. A clayey, clayey-skeletal, fine, or very-fine particle-size class throughout some subhorizon 7.5 cm or more thick; *and*

2. At its upper boundary or within some part, a clay increase *either* of 20 percent or more (absolute) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction.

Abruptic Durixeralfs

JDAF. Other Durixeralfs that have a duripan that is strongly cemented or less cemented in all subhorizons.

Haplic Durixeralfs

JDAG. Other Durixeralfs.

Typic Durixeralfs

Definition of Typic Durixeralfs

Typic Durixeralfs are the Durixeralfs that:

1. Have an argillic horizon that meets *one or more* of the following:

a. Has less than 35 percent clay in all subhorizons that are 7.5 cm or thicker; *or*

b. Has an increase in clay content that is less than 15 percent (absolute) within a vertical distance of 2.5 cm and is less than 20 percent (absolute) within a vertical distance of 7.5 cm at the upper boundary and within all parts;

2. Do not have, in any subhorizon within the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions;

3. Have a duripan that is very strongly cemented or indurated in some part;

4. Do not have a natric horizon; *and*

5. Above the duripan, do not have *either*:

a. Cracks that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick; *or*

b. A linear extensibility of 6.0 cm or more.

Description of Subgroups

Typic Durixeralfs.—The central concept or Typic subgroup is fixed on the most freely drained Durixeralfs that have a very strongly cemented or indurated duripan and do not have a natric horizon. These soils have an argillic horizon that either has less than 35 percent clay or, if it has 35 percent or more clay, has a relatively small increase in clay content or a relatively thick transitional horizon between the epipedon and the argillic horizon.

The Typic subgroup is not the most extensive subgroup, but it was selected to provide what seems the best basis for definition of the others.

An abrupt textural change at the upper boundary of the argillic horizon or within the argillic horizon is very common, and it defines Abruptic subgroups. Soils that have redox depletions with low chroma and aquic conditions for some time in normal years (or artificial drainage) in the argillic horizon are excluded from the Typic subgroup. A duripan that does not have a very strongly cemented or indurated subhorizon is considered weakly expressed and is the basis for definition of Haplic subgroups. A natric horizon is considered atypical and is used to define the Natric subgroup.

Abruptic Durixeralfs.—These soils are like Typic Durixeralfs, but the argillic horizon has a fine, very-fine, clayey, or clayey-skeletal particle-size class in some subhorizon, and at the upper boundary of the argillic horizon or within the argillic horizon, there is a marked increase in content of clay. These soils are moderately extensive in California. In many of the soils, the argillic horizon appears to have formed since the duripan developed. Slopes are gentle or moderate. Most of the soils are used for grazing or for small grain.

Abruptic Haplic Durixeralfs.—These soils have an argillic horizon that has a fine, very-fine, clayey, or clayey-skeletal particle-size class in some subhorizon and, at the upper boundary of the argillic horizon or within the argillic horizon, there is a marked increase in content of clay. In addition, the duripan is strongly cemented or less cemented in all subhorizons. It is not known whether the duripan is forming, is being destroyed, or is only weakly developed. These soils are not extensive. Their slopes are gentle. Most of the soils are used for grazing.

Aquic Durixeralfs.—These soils are like Typic Durixeralfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). These soils are not known to occur in the United States.

Haplic Durixeralfs.—These soils are like Typic Durixeralfs, but the duripan is strongly cemented or less cemented in all subhorizons. It is not known whether the duripan is forming, is being destroyed, or is only weakly developed. In the United States, Haplic Durixeralfs are not extensive, except locally in California. Their slopes are gentle or moderate. Some of the soils are used for irrigated citrus crops, some are used for small grain, and some are used as pasture.

Natric Durixeralfs.—These soils have a natric horizon. The duripan may or may not be indurated, and there may be redox depletions with low chroma in the natric horizon, which in some years may be saturated or may have ground water perched above it. In the United States, these soils are extensive only in the Central Valley of California. Commonly, they are saline. After reclamation, they may be used for cultivated crops. Otherwise, they provide only limited grazing unless irrigated.

Vertic Durixeralfs.—These soils have, above the duripan, cracks that are 5 mm or more wide through a thickness of 30 cm or more in normal years and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick or have a linear extensibility of 6.0 cm or more. These soils are not known to occur in the United States.

Fragixeralfs

Fragixeralfs are the Xeralfs that have a fragipan with an upper boundary within 100 cm below the mineral soil surface. Commonly, these soils have a brown argillic or kandic horizon and have redoximorphic features and a perched water table that is seasonally above the pan. Above the pan, some Fragixeralfs have a thin eluvial horizon with peds that have gray clay depletions.

Most Fragixeralfs in the United States are on gentle or moderate slopes and formed, at least in part, in silty or loamy late-Pleistocene deposits. Some are strongly sloping. Temperature regimes are mesic or frigid. In the United States, the native vegetation was primarily a coniferous forest. These soils are of small extent in Idaho and Oregon.

Definition

Fragixeralfs are the Xeralfs that:

1. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

2. Do not have a duripan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have a natric horizon.

Key to Subgroups

JDCA. Fragixeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragixeralfs

JDCB. Other Fragixeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragixeralfs

JDCC. Other Fragixeralfs that have an Ap horizon with a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) or materials between the soil surface and a depth of 18 cm that have these color values after mixing.

Mollic Fragixeralfs

JDCD. Other Fragixeralfs that have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragixeralfs

JDCE. Other Fragixeralfs that, above the fragipan, do not have an argillic or kandic horizon with clay films on both vertical and horizontal faces of any peds.

Inceptic Fragixeralfs

JDCF. Other Fragixeralfs.

Typic Fragixeralfs

Definition of Typic Fragixeralfs

Typic Fragixeralfs are the Fragixeralfs that:

1. Above the fragipan, have an argillic or kandic horizon that has clay films on at least some vertical and horizontal faces of primary or secondary peds, or both;

2. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus 1/2 acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Either have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more, when crushed and smoothed, or have materials to a depth of 18 cm that have these colors after mixing; *and*

4. Do not have, in any horizon within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions.

Description of Subgroups

Typic Fragixeralfs.—The central concept or Typic subgroup of Fragixeralfs is fixed on the soils of this great group that are the most freely drained, that have an argillic or kandic horizon above the fragipan, and that have a high color value in an Ap horizon or in comparable layers if the soils are undisturbed.

Typic Fragixeralfs are not the most extensive subgroup, but they furnish the best basis for definition of subgroups. No Fragixeralfs are freely drained because in all of them ground water is perched above the fragipan in many years. The perched water table is a probable cause of the very common albic materials and gray clay depletions directly above the fragipan. Soils that have these features and also redox depletions with low chroma at a shallow depth together with redox concentrations of high chroma or of reddish hue are considered to be intergrades toward Aqualfs.

Typic Fragixeralfs do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. An Ap horizon or subhorizons of comparable thickness that have the color of a mollic epipedon are considered atypical and define the Mollic subgroup.

In many Fragixeralfs the fragipan is in the argillic horizon; above the fragipan, there is a cambic horizon that is separated from the pan by an eluvial horizon. These extra horizons form the basis for defining intergrades to Fragixerepts.

Andic and Vitrandic Fragixeralfs.—These soils are like Typic Fragixeralfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. In the United States, these soils occur in Idaho. They are permitted, but not required, to have redox depletions and also color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. These soils are not extensive.

Aquic Fragixeralfs.—These soils are like Typic Fragixeralfs, but they have, in one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Fragixeralfs are intergrades between Fragiaqualfs and Fragixeralfs. They are rare in the United States.

Inceptic Fragixeralfs.—These soils are like Typic Fragixeralfs, but, above the fragipan, they do not have a distinct argillic horizon that has clay films on some vertical and horizontal faces of peds. They have, above the fragipan, a brown or strong brown, unmottled horizon that seems more like a cambic horizon than an argillic horizon. Directly above the fragipan, there may be a thin eluvial horizon. The prism faces of the fragipan have thick (more than 1 mm) clay films, or the fragipan itself also is an argillic horizon.

Mollic Fragixeralfs.—These soils have an Ap horizon that has a color value, moist, darker than 4 and a color vaue, dry, darker than 6, or they have these color values to a depth of 18 cm, after mixing. These soils are permitted, but not required, to have redox depletions that have chroma of 2 or less within 40 cm of the soil surface. The epipedon is mollic or approaches the properties of a mollic epipedon.

Haploxeralfs

These are the Xeralfs that have an argillic or kandic horizon that is relatively thin, has a clear or gradual upper boundary, or has a loamy particle-size class throughout. These soils are not dark red or dusky red throughout. They do not have a natric horizon and do not have a duripan or fragipan with an upper boundary within 100 cm of the mineral soil surface. They have neither a petrocalcic horizon nor one or more horizons in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the soil surface. Many Haploxeralfs formed in late-Pleistocene deposits or on erosional surfaces of that age. Their parent materials may be either acidic or basic. These soils are extensive in the areas of Xeralfs in the Western United States.

Definition

Haploxeralfs are the Xeralfs that:

1. Do not have a natric horizon;

2. Do not have a duripan or fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have plinthite that forms a continuous phase or that constitutes more than half the matrix within one or more horizons within 150 cm of the mineral soil surface;

4. Do not have a petrocalcic horizon with its upper boundary within 150 cm of the soil surface;

5. Have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *or* have an argillic or kandic horizon that has *either*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) A clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content; *or*

(2) Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *or*, below that layer, a clay increase of less than 3 percent (absolute) in the fine-earth fraction; *or*

b. A base at a depth of less than 150 cm;

6. Have a densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *or* have an argillic or kandic horizon that has:

a. Less than 35 percent clay in all parts; *or*

b. At its upper boundary, a clay increase, in the fine-earth fraction, of *both* less than 20 percent (absolute) within a vertical distance of 7.5 cm *and* of less than 15 percent (absolute) within a vertical distance of 2.5 cm;

7. Have, in the upper 100 cm of the argillic or kandic horizon or throughout the entire argillic or kandic horizon if less than 100 cm thick, less than 50 percent colors that have hue of 2.5YR or redder *or one* of the following:

a. Value, moist, of 4 or more; *or*

b. Dry value 2 or more units higher than the moist value.

Key to Subgroups

JDGA. Haploxeralfs that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout an Ap horizon or throughout the upper 10 cm of an A horizon.

Lithic Mollic Haploxeralfs

JDGB. Other Haploxeralfs that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. An argillic or kandic horizon that is discontinuous horizontally in each pedon.

Lithic Ruptic-Inceptic Haploxeralfs

JDGC. Other Haploxeralfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxeralfs

JDGD. Other Haploxeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or

more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxeralfs

JDGE. Other Haploxeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Haploxeralfs

JDGF. Other Haploxeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxeralfs

JDGG. Other Haploxeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxeralfs

JDGH. Other Haploxeralfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic or kandic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic or kandic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Haploxeralfs

JDGI. Other Haploxeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. An argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent in one or more subhorizons within its upper 75 cm or above a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Haploxeralfs

JDGJ. Other Haploxeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxeralfs

JDGK. Other Haploxeralfs that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in one or more subhorizons of the argillic or kandic horizon.

Natric Haploxeralfs

JDGL. Other Haploxeralfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haploxeralfs

JDGM. Other Haploxeralfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haploxeralfs

JDGN. Other Haploxeralfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Haploxeralfs

JDGO. Other Haploxeralfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haploxeralfs

JDGP. Other Haploxeralfs that have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Calcic Haploxeralfs

JDGQ. Other Haploxeralfs that have:

1. An argillic, kandic, or natric horizon that is 35 cm or less thick; *and*

2. No densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Inceptic Haploxeralfs

JDGR. Other Haploxeralfs that have an argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent in one or more subhorizons within its upper 75 cm or above a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Haploxeralfs

JDGS. Other Haploxeralfs that have a color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout an Ap horizon or throughout the upper 10 cm of an A horizon.

Mollic Haploxeralfs

JDGT. Other Haploxeralfs.

Typic Haploxeralfs

Definition of Typic Haploxeralfs

Typic Haploxeralfs are the Haploxeralfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 4 or more or has less than 0.7 percent organic carbon in some part or have an Ap horizon that has a color value, moist, of 4 or more or contains less than 0.7 percent organic carbon;

3. Do not have a lithic contact within 50 cm of the soil surface;

4. Have exchangeable sodium that is less than 15 percent of the CEC (at pH 8.2) throughout the argillic horizon;

5. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the soil surface;

6. Have an argillic or kandic horizon that has a base saturation (by sum of cations) of 75 percent or more throughout the upper 75 cm or to a densic, lithic, or paralithic contact, whichever is shallower;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

8. Have an argillic or kandic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic or kandic horizon is more than 75 cm thick or in any part if the argillic or kandic horizon is less than 75 cm thick;

9. Do not have a calcic horizon that has its upper boundary within the upper 100 cm of the mineral soil surface;

10. Have an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) in all subhorizons of the argillic or kandic horizon;

11. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

12. Do not have an argillic horizon that:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

13. Have an argillic or kandic horizon that is more than 35 cm thick; *and*

14. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Haploxeralfs.—The central concept or Typic subgroup of Haploxeralfs is fixed on freely drained soils that are deep or moderately deep to hard rock, that have high base saturation but little sodium on the exchange complex, and that have little or no plinthite. In addition, the argillic horizon is 35 cm or more thick, does not consist of lamellae, and has a particle-size class finer than sandy. Typic Haploxeralfs do not have cracks and slickensides or wedge-shaped aggregates or a linear extensibility of 6.0 cm or more.

Soils that have redox depletions with low chroma at a shallow depth and that have ground water during the growing season are excluded from Typic Haploxeralfs because these properties are shared with Aqualfs. Soils that have a large volume of fragic soil properties are excluded because they are considered intergrades to Fragixeralfs. Soils that have an Ap horizon or a moderately thick A horizon that has the color and organic-matter content of a mollic epipedon are excluded because these properties are shared with Mollisols. A shallow lithic contact defines the Lithic subgroups, a convention used throughout this taxonomy.

Soils that contain exchangeable sodium in the amount adequate for a natric horizon are excluded from Typic Haploxeralfs because this important property is shared with Natrixeralfs. Soils that contain plinthite are excluded because plinthite is a property of Plinthoxeralfs. A base saturation that is only moderately high is considered atypical and defines the Ultic subgroup. Soils that have cracks and slickensides or wedge-shaped aggregates are excluded because these properties are shared with Vertisols. An argillic horizon composed entirely of thin lamellae is considered atypical and defines the Psammentic subgroup. A moderately shallow calcic horizon also is considered atypical and defines the Calcic subgroup.

Typic Haploxeralfs are extensive in the central and coastal valleys and adjacent foothills of California in the United States. They are on late-Pleistocene terraces and fans or dissected upland surfaces. Where slopes are suitable, the soils are irrigated and intensively farmed. Other areas are used for grazing or woodland.

Andic and Vitrandic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. They are permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. In the United States, these soils occur mostly in Washington, Idaho, Oregon, and California. The temperature regimes are mostly mesic or frigid. The native vegetation was primarily a coniferous forest. These soils are moderately extensive in the United States. They are used mostly as forest, but some have been cleared and are used as cropland or pasture.

Aquandic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. They have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They are permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. Aquandic Haploxeralfs are not extensive.

Aquic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they are permitted, but not required, to have an A horizon that, throughout the upper 10 cm, has a color value, moist, of 3 or less and has more than 0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of 3 or less and has more than 0.7 percent organic carbon. These soils are not extensive. They are mostly in California and Washington. Most of them have a clayey argillic horizon that has low hydraulic conductivity. Slopes range considerably. The native vegetation was primarily a coniferous forest in Washington and grass and shrubs in California. The soils that have suitable slopes are used mainly as cropland.

Aquultic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have a base saturation (by sum of cations) that is less than 75 percent in some subhorizon within 75 cm of the upper boundary of the argillic or kandic horizon. In addition, they are permitted, but not required, to have an A horizon that, throughout the upper 10 cm, has a color value, moist, of 3 or less and has more than 0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of 3 or less and has more than 0.7 percent organic carbon. These soils are of small extent, mostly in Oregon. They are intergrades between Haploxeralfs and Aquults. Most Aquultic Haploxeralfs have a clayey argillic horizon that has low hydraulic conductivity. The native vegetation was primarily forest. Slopes are mostly gentle, and many of the soils have been cleared and are used as cropland.

Calcic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a calcic horizon that has its upper boundary within 100 cm of the soil surface. They are known to occur in Idaho and Utah in the United States. They are not extensive.

Fragiaquic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have redox depletions with low chroma and aquic conditions at a shallow depth for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Fragic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Inceptic Haploxeralfs.—These soils are like Typic Haploxeralfs in defined properties, but they have an argillic or kandic horizon that is 35 cm or less thick and have no densic, lithic, or paralithic contact within 100 cm of the soil surface. They may also have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon or an Ap horizon that has both a color value, moist, of 3 or less and 0.7 percent or more organic carbon. These soils are not extensive in the United States.

Lamellic Haploxeralfs.—These soils are like Typic Haploxeralfs in defined properties, but they have an argillic horizon that consists of lamellae or partially of lamellae. Most Lamellic Haploxeralfs have a sandy particle-size class. The upper several lamellae are commonly broken or discontinuous horizontally. Lamellic Haploxeralfs are allowed to have an Ap horizon that has a color value, moist, of 3 or less or upper horizons that have a color value, moist, of less than 4 after the surface soil has been mixed to a depth of 15 cm. These soils are not extensive in the United States.

Lithic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a lithic contact within 50 cm of the soil surface. In addition, they are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent in some subhorizon within 75 cm of the upper boundary of the argillic or kandic horizon. These soils are not extensive in the United States. They are mostly in California and Idaho. The vegetation is mostly grasses and shrubs. Some areas support widely spaced trees. These soils are used as rangeland.

Lithic Mollic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a lithic contact within 50 cm of the soil surface and also have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon; rarely, they have an Ap horizon that has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon. These soils are permitted, but not required, to have a base saturation (by sum of cations) that is less than 75 percent in some subhorizon within 75 cm of the upper boundary of the argillic or kandic horizon. They are mostly in California and Idaho in the United States. The vegetation is mostly grasses and shrubs. Some areas support widely spaced trees. These soils are used mainly as rangeland.

Lithic Ruptic-Inceptic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a lithic contact within 50 cm of the soil surface. The upper boundary of the contact is irregular. The major part of the pedon has an argillic or kandic horizon. Where the lithic contact is closest to the soil surface, however, only a cambic horizon is evident. These soils are rare in the United States.

Mollic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon; rarely, they have an Ap horizon that has both a color value, moist, of 3 or less and 0.7 percent or more organic carbon. The epipedon of these soils meets all of the requirements for a mollic epipedon as a rule, but it is both massive and hard or very hard when dry. These soils are extensive in the United States. They are intergrades between Haploxeralfs and Argixerolls. Their slopes range from nearly level to very strong. Where slopes are suitable, many of the soils are cultivated. The soils that have strong slopes are mainly under forest vegetation.

Natric Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have 15 percent or more saturation with sodium in some part of the argillic horizon. The argillic horizon would be a natric horizon if it had prismatic or columnar structure or if it had blocky structure and albic materials extending more than 2.5 cm into the horizon. These soils are not extensive in the United States.

Plinthic Haploxeralfs.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States.

Psammentic Haploxeralfs.—These soils have an argillic horizon that has a sandy particle-size class (loamy fine sand or coarser) throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick. These soils are rare in the United States. Most formed on old stabilized sand dunes, and their slopes are gentle or moderate. Most of the soils are used for grazing.

Ultic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they have a base saturation (by sum of cations) that is less than 75 percent in some subhorizon within 75 cm of the upper boundary of the argillic or kandic horizon. In addition, they are permitted, but not required, to have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon or to have an Ap horizon that has a color value, moist, of 3 or less and has 0.7 percent or more organic carbon. These soils are extensive. They are mostly in California, Oregon, Washington, and Idaho. They occur in areas where Xeralfs intergrade toward Ultisols and in areas where the parent materials have a component of volcanic ash. Slopes range from gentle to very strong. Most Ultic Haploxeralfs with strong or very strong slopes are in forests and in some areas are grazed for short periods. Many Ultic Haploxeralfs with gentle slopes have been cleared and are used as cropland, but some are used as pasture or are in forests.

Vertic Haploxeralfs.—These soils are like Typic Haploxeralfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are rare in the United States and are considered to be transitional to Vertisols.

Natrixeralfs

Natrixeralfs are the Xeralfs that have a natric horizon but do not have a duripan. They are not extensive. They support a sparse vegetation that commonly consists of salt-tolerant grasses and forbs. They were considered Solonetz soils, Soloth soils, and transitional forms in the 1938 classification.

Definition

Natrixeralfs are the Xeralfs that:

1. Have a natric horizon;

2. Do not have a duripan within 100 cm of the soil surface.

Key to Subgroups

JDBA. Natrixeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrixeralfs

JDBB. Other Natrixeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Natrixeralfs

JDBC. Other Natrixeralfs.

Typic Natrixeralfs

Definition of Typic Natrixeralfs

Typic Natrixeralfs are the Natrixeralfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions; *and*

2. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Natrixeralfs.—The central concept or Typic subgroup of Natrixeralfs is fixed on the most freely drained soils of this great group. None of these soils are freely drained because their low hydraulic conductivity results in perched ground water above the natric horizon in many years. Some Natrixeralfs have ground water below as well as above the natric horizon and have redox depletions with low chroma. These features cause the soils to be excluded from the Typic subgroup because they are properties shared with Aqualfs.

Typic Natrixeralfs are not extensive in the United States. They are mostly in California and Montana. Their slopes are mostly gentle. The soils developed under grass, shrubs, and forbs. Some of the soils, mostly those in California, are reclaimed and used as cropland. The native plants are used for grazing.

Aquic Natrixeralfs.—These soils are like Typic Natrixeralfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). These soils are rare in the United States. Their slopes are mostly nearly level. The soils developed under grass, shrubs, and forbs. Some of the soils, mostly those in California, are reclaimed and used as cropland. The native plants are used for grazing.

Vertic Natrixeralfs.—These soils are like Typic Natrixeralfs, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are rare in the United States. They are considered to be transitional to Vertisols.

Palexeralfs

Palexeralfs are the Xeralfs that have a petrocalcic horizon or an argillic or kandic horizon that is thick or that has, at its upper boundary, both a clayey, clayey-skeletal, fine, or very-fine particle-size class and a large clay increase. Many of these soils have some plinthite in their lower horizons, but this feature is rare in the United States. Palexeralfs are in relatively stable landscape positions on gentle slopes, and most began their genesis before the late Pleistocene. During pluvial periods of the Pleistocene, carbonates appear to have been almost completely removed from the argillic or kandic horizon of most of these soils, but some of the soils appear to have been recalcified later.

Most Palexeralfs formed in acid or in moderately basic parent materials, but some formed in materials as basic as basalt. The native vegetation on the warmest Palexeralfs in the United States was a mixture of annual grasses, forbs, and woody shrubs. The native vegetation on the coolest Palexeralfs was mostly a coniferous forest. Palexeralfs are moderately extensive both in the United States and in some other parts of the world.

Definition

Palexeralfs are the Xeralfs that:

1. Have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface;

2. Have no densic, lithic, or paralithic contact within 150 cm of the mineral soil surface *and* have an argillic or kandic horizon that has *both*:

a. Within 150 cm of the mineral soil surface, *either*:

(1) With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

(2) 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

b. A base at a depth of 150 cm or more;

3. Have no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface *and* have an argillic or kandic horizon that has within 15 cm of its upper boundary *both*:

a. A clayey, clayey-skeletal, fine, or very-fine particle-size class; *and*

b. A clay increase, in the fine-earth fraction, of *either* 20 percent or more (absolute) within a vertical distance of 7.5 cm *or* of 15 percent or more (absolute) within a vertical distance of 2.5 cm; *and*

4. Do not have a duripan or fragipan with an upper boundary within 100 cm of the mineral soil surface;

5. Do not have a natric horizon;

6. Do not have plinthite that forms a continuous phase or that constitutes more than one-half the matrix within one or more horizons within 150 cm of the mineral soil surface;

7. Have, in the upper 100 cm of the argillic or kandic horizon or throughout the entire argillic or kandic horizon if less than 100 cm thick, less than 50 percent colors that have hue of 2.5YR or redder *or one* of the following:

a. Value, moist, of 4 or more; *or*

b. Dry value 2 or more units higher than the moist value.

Key to Subgroups

JDFA. Palexeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Palexeralfs

JDFB. Other Palexeralfs that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Palexeralfs

JDFC. Other Palexeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palexeralfs

JDFD. Other Palexeralfs that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palexeralfs

JDFE. Other Palexeralfs that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years (or artificial drainage) *either*:

a. Within the upper 25 cm of the argillic or kandic horizon if its upper boundary is within 50 cm of the mineral soil surface; *or*

b. Within 75 cm of the mineral soil surface if the upper boundary of the argillic or kandic horizon is 50 cm or more below the mineral soil surface.

Fragiaquic Palexeralfs

JDFF. Other Palexeralfs that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexeralfs

JDFG. Other Palexeralfs that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Palexeralfs

JDFH. Other Palexeralfs that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Palexeralfs

JDFI. Other Palexeralfs that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Palexeralfs

JDFJ. Other Palexeralfs that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 cm or more.

Arenic Palexeralfs

JDFK. Other Palexeralfs that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) in one or more horizons within 100 cm of the mineral soil surface.

Natric Palexeralfs

JDFL. Other Palexeralfs that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Palexeralfs

JDFM. Other Palexeralfs that have a calcic horizon within 150 cm of the mineral soil surface.

Calcic Palexeralfs

JDFN. Other Palexeralfs that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Palexeralfs

JDFO. Other Palexeralfs that have an argillic or kandic horizon that has a base saturation (by sum of cations) of less than 75 percent throughout.

Ultic Palexeralfs

JDFP. Other Palexeralfs with an argillic or kandic horizon that has, in the fine-earth fraction, *either or both*:

1. Less than 35 percent clay throughout all subhorizons within 15 cm of its upper boundary; *or*

2. At its upper boundary, a clay increase of less than 20 percent (absolute) within a vertical distance of 7.5 cm and of less than 15 percent (absolute) within a vertical distance of 2.5 cm.

Haplic Palexeralfs

JDFQ. Other Palexeralfs that have a color value, moist, of 3 or less and 0.7 percent or more organic carbon either throughout an Ap horizon or throughout the upper 10 cm of an A horizon.

Mollic Palexeralfs

JDFR. Other Palexeralfs.

Typic Palexeralfs

Definition of Typic Palexeralfs

Typic Palexeralfs are the Palexeralfs that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Have neither a calcic nor a petrocalcic horizon within 150 cm of the soil surface;

3. Have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 4 or more or contains less than 0.7 percent organic carbon or have an Ap horizon that has a color value, moist, of 4 or more or contains less than 0.7 percent organic carbon;

4. Have an argillic or kandic horizon that has at least 75 percent base saturation (by sum of cations) in some part;

5. Have an argillic or kandic horizon in which some subhorizon in the upper 15 cm has 35 percent or more clay and there is an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of at least

15 percent clay (absolute) within 2.5 cm at the upper boundary;

6. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the soil surface;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

8. Have less than 15 percent saturation with sodium in all subhorizons within 100 cm of the soil surface;

9. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

10. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon; *and*

11. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Palexeralfs.—The central concept or Typic subgroup of Palexeralfs is fixed on moderately deep or deep, freely drained soils that have an argillic or kandic horizon that has an abrupt upper boundary, 35 percent or more clay in the upper part, and high base saturation. These soils have neither a calcic nor a petrocalcic horizon within 150 cm of the mineral soil surface. They also have little or no plinthite, and they do not have cracks and slickensides or wedge-shaped aggregates.

Soils that have redox depletions with low chroma and ground water at a moderate depth are excluded from the Typic subgroup because these properties are shared with Aqualfs. Soils that have a calcic or petrocalcic horizon are excluded because these horizons are interpreted to be evidence of recalcification of the soils. Soils that have a moderately thin A horizon or an Ap horizon that has the color and organic-matter content of a mollic epipedon are excluded because they approach the properties of Mollisols. A moderately low base saturation is associated with relatively high precipitation, either past or present, and is used to define the Ultic subgroup. A clear or gradual upper boundary of the argillic or kandic horizon is considered atypical in Palexeralfs, and a soil that has one is excluded from the Typic subgroup. Plinthite is a property shared with Plinthoxeralfs, and a soil that contains plinthite is excluded from the Typic subgroup, unless the amount is very small. Cracks and slickensides or wedge-shaped aggregates are properties shared with Vertisols and define the Vertic subgroup. A thick epipedon with a sandy or sandy-skeletal particle-size class throughout is considered atypical and causes soils to be excluded from the Typic subgroup, a convention that is used elsewhere in this taxonomy.

Typic Palexeralfs are moderately extensive. They are on old terraces and on foothills, mostly in California in the United States. Slopes are gentle to steep. Most of these soils are used as rangeland. Some are used as cropland.

Andic and Vitrandic Palexeralfs.—These soils are like Typic Palexeralfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. In the United States, these soils occur mostly in Washington and California. The temperature regimes are mostly mesic or frigid. The native vegetation was primarily a coniferous forest. These soils are moderately extensive in the United States. They are used mostly as forest, but some have been cleared and are used as cropland or pasture.

Aquandic Palexeralfs.—These soils are like Typic Palexeralfs, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They are permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. Aquandic Palexeralfs are not extensive.

Arenic Palexeralfs.—These soils have a layer, starting at the mineral soil surface, that is 50 cm or more thick and has a sandy or sandy-skeletal particle-size class throughout its thickness. These soils are not known to occur in the United States. The subgroup has been established for use in other countries.

Aquic Palexeralfs.—These soils are like Typic Palexeralfs, but they have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, they are permitted to have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon. Aquic Palexeralfs are of small extent, mostly in Washington and Oregon in the United States. Their slopes are nearly level. The native vegetation is primarily a coniferous forest.

Calcic Palexeralfs.—These soils are like Typic Palexeralfs, but they have a calcic horizon that has its upper boundary within 150 cm of the mineral soil surface. They are rare in the United States and are known to occur only in California. The subgroup may also be needed for use in other countries.

Fragiaquic Palexeralfs.—These soils are like Typic Palexeralfs, but they have redox depletions with low chroma and aquic conditions at a shallow depth for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Fragic Palexeralfs.—These soils are like Typic Palexeralfs, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Haplic Palexeralfs.—These soils are like Typic Palexeralfs, but they do not have an argillic or kandic horizon that has an abrupt upper boundary and 35 percent or more clay in the upper part. These soils are not extensive in the United States.

Lamellic Palexeralfs.—These soils are like Typic Palexeralfs, but they have an argillic horizon that consists of lamellae or partially of lamellae. Most of these soils do not have an argillic or kandic horizon that has an abrupt upper boundary and 35 percent or more clay in the upper part. The upper several lamellae are commonly broken or discontinuous horizontally. These soils are not extensive in the United States.

Mollic Palexeralfs.—These soils are like Typic Palexeralfs, but they have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon or have an Ap horizon that has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon. Mollic Palexeralfs have an argillic or kandic horizon that has an abrupt upper boundary, 35 percent or more clay in the upper part, and high base saturation. They are intergrades between Palexeralfs and Palexerolls. Their slopes are gentle or moderate. The native vegetation is primarily rangeland or savanna with widely spaced oak or coniferous trees. Mollic Palexeralfs are of moderate extent in the United States. Where slopes are suitable, some of these soils are used as cropland. Many of the soils are used for grazing.

Natric Palexeralfs.—These soils have 15 percent or more saturation with sodium in one or more horizons within 100 cm of the mineral soil surface. Some of these soils have columnar or prismatic structure in the argillic horizon, but the horizon that contains sodium is too deep in the soils to be a natric horizon. Natric Palexeralfs are rare in the United States.

Petrocalcic Palexeralfs.—These soils are like Typic Palexeralfs, but they have a petrocalcic horizon that has an upper boundary within 150 cm of the soil surface. In addition, the argillic or kandic horizon is permitted, but not required, to have less than 35 percent clay in all subhorizons, and there may be, at the upper boundary, an increase in clay content of less than 20 percent (absolute) within a vertical distance of 7.5 cm and an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm. These soils are rare in the United States. The subgroup has been established for use in other countries.

Plinthic Palexeralfs.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. They are not known to occur in the United States.

Psammentic Palexeralfs.—These soils have an argillic horizon that has a sandy particle-size class throughout the upper 75 cm or throughout the entire argillic horizon if it is less than 75 cm thick. They are rare in the United States.

Ultic Palexeralfs.—These soils are like Typic Palexeralfs, but they have a base saturation that is less than 75 percent in all parts of the argillic or kandic horizon. In addition, the argillic or kandic horizon is permitted, but not required, to have less than 35 percent clay in all subhorizons, and there may be, at the upper boundary, an increase of less than 20 percent (absolute) in clay content within a vertical distance of 7.5 cm and an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm. These soils also are permitted to have an A horizon that, throughout its upper 10 cm, has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon or to have an Ap horizon that has a color value, moist, of 3 or less and contains more than 0.7 percent organic carbon. Ultic Palexeralfs are moderately extensive in California, Oregon, and Washington in the United States. The native vegetation is primarily a coniferous forest but is rangeland or savanna with widely spaced oak or coniferous trees on the warmest and driest sites. Slopes are gentle to steep. The primary uses of these soils are timber production and grazing. Some of the soils are used as cropland, much of which is irrigated.

Vertic Palexeralfs.—These soils are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are considered to be transitional to Vertisols. They are rare in the United States. The subgroup has been established mainly for use in other countries.

Plinthoxeralfs

Plinthoxeralfs are the Xeralfs that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. There are few of these soils in the United States, but the soils are moderately extensive in other parts of the world. Subgroups have not been developed.

Definition

Plinthoxeralfs are the Xeralfs that:

1. Have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume;

2. Have neither a fragipan nor a duripan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have a natric horizon.

Key to Subgroups

JDDA. All Plinthoxeralfs (provisionally).

Typic Plinthoxeralfs

Rhodoxeralfs

Rhodoxeralfs are the more or less dark red Xeralfs that formed in areas of limestone, basalt, and other highly basic parent materials. As a group, these soils are remarkably uniform in virtually all properties, except for depth to rock. A few that are receiving carbonates may have a calcic or petrocalcic horizon below the argillic or kandic horizon. Rhodoxeralfs are rare in the United States.

Definition

Rhodoxeralfs are the Xeralfs that:

1. Have, in *all* subhorizons in the upper 100 cm of the argillic or kandic horizon or throughout the entire argillic or kandic horizon if less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. Value, moist, of 3 or less; *and*

c. Dry value no more than 1 unit higher than the moist value;

2. Have neither a fragipan nor a duripan that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a natric horizon;

4. Do not have, within 150 cm of the mineral soil surface, plinthite forming a continuous phase or constituting one-half or more of the volume.

Key to Subgroups

JDEA. Rhodoxeralfs that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodoxeralfs

JDEB. Other Rhodoxeralfs that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Rhodoxeralfs

JDEC. Other Rhodoxeralfs that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Rhodoxeralfs

JDED. Other Rhodoxeralfs that have a calcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Calcic Rhodoxeralfs

JDEE. Other Rhodoxeralfs that have an argillic or kandic horizon that is either less than 15 cm thick or is discontinuous horizontally in each pedon.

Inceptic Rhodoxeralfs

JDEF. Other Rhodoxeralfs.

Typic Rhodoxeralfs

Definition of Typic Rhodoxeralfs

Typic Rhodoxeralfs are the Rhodoxeralfs that:

1. Have an argillic or kandic horizon that is more than 15 cm thick and is horizontally continuous in each pedon;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Do not have a petrocalcic horizon that has an upper boundary within 150 cm of the mineral soil surface;

4. Do not have a calcic horizon that has an upper boundary within 150 cm of the mineral soil surface; *and*

5. Do not have *one or both* of the following:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Rhodoxeralfs.—The central concept or Typic subgroup of Rhodoxeralfs is fixed on moderately deep or deep soils that have an argillic or kandic horizon that is horizontally continuous throughout each pedon and that do not have a calcic or petrocalcic horizon shallow enough to be diagnostic.

Soils in which an argillic horizon is discontinuous horizontally are excluded from the Typic subgroup because such a horizon represents weak development. A shallow lithic contact is used to define the Lithic subgroup, a convention used throughout this taxonomy. Soils that have a calcic or petrocalcic horizon are excluded from this subgroup because these horizons are thought to indicate recalcification through addition of carbonates that originated outside of the soils.

Most of the Typic Rhodoxeralfs in the United States are moderately sloping or strongly sloping and are in forests or are used for grazing. A few are irrigated and farmed.

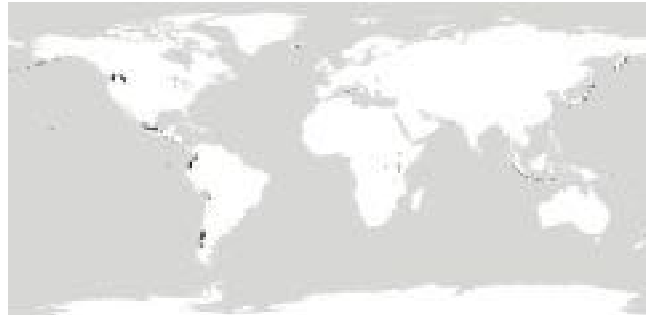
Calcic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs, but they have a calcic horizon that has an upper boundary within 150 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other countries.

Inceptic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs in defined properties, but they have an argillic or kandic horizon that is 35 cm or less thick. They are not known to occur in the United States. The subgroup is provided for use in other countries.

Lithic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs, but they have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other countries.

Petrocalcic Rhodoxeralfs.—These soils are like Typic Rhodoxeralfs, but they have a petrocalcic horizon that has an upper boundary within 150 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other countries.

Vertic Rhodoxeralfs.—These soils are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are considered to be transitional to Vertisols. They are rare in the United States. The subgroup has been established mainly for use in other countries.



CHAPTER 10

Andisols[1]

The central concept of an Andisol is that of a soil developing in volcanic ejecta (such as volcanic ash, pumice, cinders, and lava) and/or in volcaniclastic materials, the colloidal fraction of which is dominated by short-range-order minerals or Al-humus complexes. Under some environmental conditions, weathering of primary alumino-silicates in parent materials of nonvolcanic origin may also lead to the formation of short-range-order minerals. Some of these soils also are included in Andisols.

The dominant processes in most Andisols are weathering and mineral transformation. Translocation within the soils and accumulation of the translocated compounds are normally minimal. The accumulation of organic matter, complexed with aluminum, however, is characteristic of Andisols in some regimes.

Weathering of primary alumino-silicates has proceeded only to the point of formation of short-range-order minerals, such as allophane, imogolite, and ferrihydrite. Commonly, this state has been perceived as a stage in the transition from unweathered to the more weathered volcanic material characteristic of some other soil orders. Under some conditions, however, the short-range-order minerals achieve a stability that allows them to persist with little or only very slow further alteration over long periods.

Andisols may have any diagnostic epipedon, provided that the minimum requirements for the order are met in and/or below the epipedon. Andisols may also have any soil moisture regime and any soil temperature regime. They can occupy any position on the landscape and can occur at any elevation.

Andisols have andic soil properties in 60 percent of a layer in the upper part of the soils. The upper part is considered to start at the mineral soil surface or at the surface of organic soil materials with andic soil properties and end at a point 60 cm below the starting point or at a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon, whichever is shallowest. These soils may have many kinds of diagnostic horizons below this layer. The soils are considered Andisols if the criteria for thickness and position of the andic layer or layers are met, irrespective of the nature of the underlying material or horizons.

[1] This chapter builds on the preliminary Andisol Proposal (1978) by Guy D. Smith (New Zealand Soil Bureau Record 96) and represents the work of the International Committee on the Classification of Andisols (ICOMAND), chaired by Michael L. Leamy, New Zealand Soil Bureau.

Cultivation of the soils, as in puddling of the surface layer in areas used for rice paddies, may change some of the physical properties of the upper part of the soils, such as bulk density. A soil that, below this disturbed zone, has a layer, at least 36 cm thick, with andic soil properties meets the requirements for Andisols. Many Andisols, such as those that formed in some loess or alluvium, are stratified. Before the soils are considered Andisols, the layers that meet the requirements for andic soil properties must have a cumulative thickness of at least 36 cm within the upper 60 cm.

One of the outstanding features of Andisols is their high natural productivity. There are exceptions to this very general statement, but the dominance of physical properties that favor the growth of most plants, allied to the most common occurrence of the soils in areas of considerable rainfall, has resulted in volcanic soils being generally regarded as highly fertile soils.

Andisols cover more than 124 million hectares, or approximately 0.8 percent of the earth's surface. By far, the most striking pattern in the distribution of Andisols follows the circum-Pacific Ring of Fire—that concentration of active tectonic zones and volcanoes along the western coast of the American continents, both North and South, across the Aleutian Islands, down the Kamchatka peninsula of Russia, through Japan, the Philippine Islands, and Indonesia, across Papua New Guinea, the Solomon Islands, and Vanuatu and other Pacific Islands to New Zealand. Other distinctive patterns are associated with the Rift Valley of Africa, the west coast of Italy, the Hawaiian Islands, the West Indies, Iceland, the Canary Islands, and other island locations.

Definition of Andisols and Limits Between Andisols and Soils of Other Orders

Andisols are soils that:

1. Have andic soil properties in 60 percent or more of the thickness *either*:

 a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

 b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon;

2. Do not have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[2] *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact and have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more;

3. Do not have both a spodic horizon and an albic horizon in 50 percent or more of each pedon;

4. Do not have an Ap horizon containing 85 percent or more spodic materials; *and*

5. Do not have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Limits Between Andisols and Other Soil Orders

The definition of Andisols must provide criteria that separate Andisols from all other soil orders. The aggregate of these criteria defines the limits of Andisols in relation to all other known kinds of soil.

1. Unlike Andisols, Gelisols have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

2. Unlike Andisols, Histosols are soils that:

a. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

b. Have organic soil materials that meet *one or more* of the following:

(1) Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[2] *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

(2) When added with the underlying cindery, fragmental, or pumiceous material, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

(3) Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact and have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

(4) Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(a) 60 cm if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(b) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

3. Unlike Andisols, Spodosols have:

a. Both a spodic horizon and an albic horizon in 50 percent or more of each pedon; *or*

b. An Ap horizon containing 85 percent or more spodic materials.

4. Andisols differ from Alfisols, Aridisols, Entisols, Inceptisols, Mollisols, Oxisols, Ultisols, and Vertisols because they have andic soil properties in 60 percent or more of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

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[2] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Representative Pedon and Data

Following is a description of a representative Andisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Andisol."

Classification: Medial, amorphic, mesic Eutric Fulvudand
Site identification number: 83P0481
Location: Chile
Landform: Terrace
Slope: 1 percent, plane
Elevation: 17 m above m.s.l.
Annual precipitation: 205 cm
Soil moisture regime: Udic
Average annual air temperature: 13 ^{o}C
Permeability class: Moderately rapid
Drainage class: Well drained
Depth to water table: More than 200 cm
Land use: Pasture
Stoniness class: 1
Particle-size control section: 0 to 100 cm
Parent material: Ejecta ash
Diagnostic features: An umbric epipedon from a depth of 0 to 27 cm, a cambic horizon from a depth of 27 to 98 cm, and andic soil properties from a depth of 0 to 200 cm
Field moisture: From a depth of 0 to 39 cm—dry; from a depth of 39 to 200 cm—slightly moist
Described by: T. Cook, W. Luzio, R. Honorato, G. Galindo, W. Vera, and R. Grez

In the following pedon description, colors are for moist soil unless otherwise indicated. Field reaction was determined by use of paper test strips.

Ap1—0 to 4 cm; very dark grayish brown (10YR 3/2) silt loam, brown (10YR 4/3) dry; strong medium and coarse granular structure; friable, weakly smeary, slightly sticky and slightly plastic; many very fine and fine roots; many very fine and fine interstitial pores; strongly acid (pH 5.3); abrupt smooth boundary.

Ap2—4 to 27 cm; very dark brown (10YR 2/2) silt loam, brown (10YR 4/3) dry; moderate very coarse subangular blocky structure parting to weak coarse granular; friable, moderately smeary, slightly sticky and slightly plastic; many very fine and few medium roots; many very fine and fine interstitial pores; strongly acid (pH 5.3); abrupt smooth boundary.

2BA—27 to 39 cm; dark yellowish brown (10YR 3/4) silt loam, brown (10YR 5/3) dry; weak coarse prismatic structure; very friable, moderately smeary, slightly sticky and slightly plastic; common very fine and few medium roots; common coarse and common very fine tubular pores; few fine cylindrical insect casts; moderately acid (pH 5.7); 1 percent ejecta pebbles; clear smooth boundary.

2Bw1—39 to 73 cm; dark brown (7.5YR 3/4) silt loam; weak coarse prismatic structure parting to moderate medium and coarse subangular blocky; very friable, moderately smeary, slightly sticky and slightly plastic; common very fine roots; many very fine and few fine tubular pores; few fine cylindrical insect casts; moderately acid (pH 5.7); 1 percent ejecta pebbles; clear smooth boundary.

2Bw2—73 to 98 cm; dark brown (10YR 3/3) silt loam; moderate coarse prismatic structure parting to weak medium subangular blocky; friable, moderately smeary, slightly sticky and slightly plastic; few very fine roots; many fine and medium tubular pores; patchy skeletans (sand or silt) in root channels and/or pores; moderately acid (pH 5.7); 1 percent ejecta pebbles; gradual smooth boundary.

2C1—98 to 160 cm; dark yellowish brown (10YR 3/4) silt loam; massive; friable, moderately smeary, slightly sticky and slightly plastic; few very fine roots; many fine and medium tubular pores; patchy skeletans (sand or silt) in root channels and/or pores; moderately acid (pH 5.7); clear irregular boundary.

3C2—160 to 200 cm; dark yellowish brown (10YR 4/4) silt loam; massive; firm, moderately smeary, sticky and slightly plastic; few very fine roots; many very fine and fine and many medium tubular pores; a few thin seams and masses of uncoated fine sand; moderately acid (pH 5.7).

Key to Suborders

DA. Andisols that have *either*:

1. A histic epipedon; *or*

2. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallowest, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquands, p. 275

Characterization Data for an Andisol

SITE IDENTIFICATION NO.: 83P0481
CLASSIFICATION: MEDIAL, AMORPHIC, MESIC EUTRIC FULVUDAND
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO_3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	WEIGHT 2 -5	WEIGHT 5 -20	WEIGHT 20 -75	WEIGHT .1- 75	WT PCT OF WHOLE SOIL (>2mm)
			<- Pct of <2mm (3A1)											->	<- Pct of <75mm(3B1)			->	
83P2246	0- 4	Ap1	10.4	68.8	20.8			44.4	24.4	10.5	5.1	2.2	2.7	0.3	TR	--	--	10	--
83P2247	4- 27	Ap2	5.9	72.7	21.4			45.1	27.6	13.7	5.4	1.2	0.9	0.2	TR	TR	--	8	--
83P2248	27- 39	2BA	1.0	56.1	42.9			30.4	25.7	21.5	14.2	4.6	1.9	0.7	TR	--	--	21	--
83P2249	39- 73	2Bw1	--	42.7	57.3			17.7	25.0	24.9	21.7	6.7	3.1	0.9	TR	--	--	32	--
83P2250	73- 98	2Bw2	3.6	36.7	59.7			17.4	19.3	20.9	21.6	10.4	5.7	1.1	TR	TR	--	39	--
83P2251	98-129	2C1	4.7	35.0	60.3			16.7	18.3	21.8	20.8	10.9	6.2	0.6	TR	--	--	38	--
83P2252	129-160	2C1	2.2	29.0	68.8			13.5	15.5	24.9	24.3	11.6	6.6	1.4	TR	--	--	44	--
83P2253	160-200	3C2	3.7	46.9	49.4			27.7	19.2	11.4	8.9	7.0	10.1	12.0	TR	--	--	38	--

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	DITH-CIT Al 6G7a	DITH-CIT Mn 6D2a	(RATIO/CLAY) CEC 8D1	(RATIO/CLAY) 15 BAR 8D1	ATTERBERG LIMITS LL 4F1	ATTERBERG PI 4F	BULK DENSITY FIELD MOIST 4A3a	BULK DENSITY 1/3 BAR 4A1d	BULK DENSITY OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	WATER 1/10 BAR 4B1c	WATER 1/3 BAR 4B1c	WATER 15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 4	12.4	1.076			3.2	1.9		3.97	4.38										36.9	
4- 27	8.61	0.668			3.8	2.3		5.37	5.78				0.70	0.81	0.050			55.5	29.4	0.15
27- 39	4.03	0.302			4.6	2.0		22.00	44.10				0.68	0.80	0.056				27.9	
39- 73	2.43				4.9	1.8							0.87	0.87					24.9	
73- 98	1.07				5.1	1.6		3.89	12.67				0.74	0.84	0.043			54.5	24.0	0.07
98-129	0.91				4.9	1.7		2.62	9.49				0.84	0.96	0.046			54.0	22.9	0.08
129-160	0.72				4.1	1.3		5.68	21.36				0.80	0.93	0.051			57.0	21.4	0.08
160-200	1.69				4.6	1.7		6.57	16.54				0.90	1.09	0.066			60.8	26.2	

DEPTH (cm)	NH_4OAc EXTRACTABLE BASES Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9a	CEC SUM CATS 5A3a	CEC NH_4-OAc 5A8b	CEC BASES + Al 5A3b	Al SAT 5G1	BASE SAT SUM 5C3	BASE SAT NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	PH NaF 8C1d	PH $CaCl_2$ .01M 8C1f 1:2	PH H_2O 8C1f 1:1
	<- -meq / 100 g									->	<- Pct			->					
0- 4	11.4	3.0	0.8	0.6	15.8	47.5	0.3	63.3	41.3	16.1	2	25	38				10.4	5.2	5.6
4- 27	1.7	0.2	0.1	0.1	2.1	49.5	1.3	51.6	31.7	3.4	38	4	7				10.9	4.8	5.2
27- 39	0.9	0.1	0.1	--	1.1	39.7	TR	40.8	22.0			3	5				11.1	5.4	5.7
39- 73	3.4	0.4	0.1	0.1	4.0	31.2	TR	35.2	18.6			11	22				10.7	5.6	5.9
73- 98	2.5	0.7	TR	--	3.2	23.6	--	26.8	14.0			12	23				10.6	5.8	6.1
98-129	2.9	0.8	--	--	3.7	22.4	--	26.1	12.3			14	30				10.4	5.8	6.2
129-160	2.3	0.7	TR	--	3.0	23.7	TR	26.7	12.5			11	24				10.6	5.8	6.2
160-200	1.5	0.3	--	--	1.8	33.2	0.1	35.0	24.3	1.9	5	5	7				10.8	5.7	5.9

SAMPLE NO.	HZ NO	ACID OXALATE EXTRACTION OPT DEN 8J	Fe 6C9a	Si 6V2	Al 6G12	PHOSPHORUS RET 6S4	PHOSPHORUS CIT-ACID 6S5	KCl Mn 6D3	TOTAL C 6A2d	WATER CONTENT 0.06 BAR 4B1c	1- BAR 4B1a	2- BAR 4B1a	15 BAR 4B2b	PIPETTE CLAY 3A1c	PIPETTE SILT 3A1c	PIPETTE SAND 3A1c	HYDROMETER CLAY SML	HYDROMETER SILT SML	HYDROMETER SAND SML	MIN SOIL CONT 8F1	AGGRT STABL <5mm 4G1
			<- P c t o f < 2 m m ->				<- p p m ->		< - Percent of < 2 mm											>	< Pct>
83P2246	1		1.40	1.08	3.01	94							45.6								
83P2247	2		1.39	1.18	3.54	99							34.1								
83P2248	3		1.84	1.95	4.55	98							44.1								
83P2249	4		2.13	2.13	4.68	98							51.7								
83P2250	5		2.01	1.27	2.86	98							45.6								
83P2251	6		2.01	1.27	2.64	97							44.6								
83P2252	7		1.69	1.48	2.97	98							47.0								
83P2253	8		2.50	2.83	5.77	98							61.2								

Characterization Data for an Andisol--Continued

```
            -1-   -2-   -3-   -4-   -5-   -6-   -7-   -8-   -9-   -10-  -11-  -12-  -13-  -14-  -15-  -16-  -17-  -18-  -19-  -20-
------------------------------------------------------------------------------------------------------------------------------------
           < - - - - - - - - - - - - - - - - - - - - - - -  CLAY MINERALOGY (<.002mm) - - - - - - - - - - - - - - - - - - - - - - - - >
           FRAC- < - - - - - - X-RAY - - - - - ->< - - - THERMAL - - - -><  - - - - - - - - ELEMENTAL - - - - - - - - ->< - -> EGME INTER-
SAMPLE      TION <                           >< - DTA - -><  - TGA - -> SiO2 Al2O3 Fe2O3  MgO   CaO   K2O   Na2O <    > RETN PRETA-
                 < - - - - - -  7A2i - - - - - - ->< - 7A6   - >< - 7A4b - ><  - - - - - - - - - - 7C3 - - - - - - - - - -><    >  7D2  TION
NUMBER     <- - >< - - - - Peak size - - - - - ->< - - - Percent - - - ->< - - - - - - - - - Percent - - - - - - - - ->< - -><mg/g>< - ->

83P2247     TCLY  VR 1  NX 6                                                     6.3               0.2
83P2248     TCLY  GI 1  VR 1  NX 6             GI 1                              5.7
83P2250     TCLY  GI 2  KK 1  VR 1  NX 6       GI13  KK 2                       10.2               0.1
83P2253     TCLY  KK 1  GI 1  NX 6             KK 4  GI 3                        9.7               0.2
------------------------------------------------------------------------------------------------------------------------------------
           < - - - - - - - - - - - - - - - - - - - - -  SAND - SILT MINERALOGY (2.0-0.002mm) - - - - - - - - - - - - - - - - - - - - - >
           FRAC- < - - - - - - X-RAY - - -><  - - - THERMAL - - - -><  - - - - - - - -  OPTICAL - - - - - - - - - ><               >INTER-
SAMPLE      TION <                      >< - DTA - - >< - TGA - ->TOT RE< - - - - - GRAIN COUNT - - - - - ->< >PRETA-
                 < - - - - -  7A2i - - - - >< - 7A3b - >< - 7A4b - >< - - - - - - - - -  7B1a - - - - - - - - - -><               > TION
NUMBER     < - -->< - - - Peak Size - - -><  - - - Percent - - - ->< - - - - - - - - - Percent - - - - - - - - ->< - - - - - - - - -->< - ->

83P2248     VFS                                                     OT96  GS 4  GAtr
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The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm; VFS, very fine sand, 0.05-0.10 mm.
Mineral interpretation: VR, vermiculite; NX, noncrystalline; GA, glass aggregate; GI, gibbsite; OT, other; GS, glass; KK,
    kaolinite.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.
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DB. Other Andisols that have a cryic soil temperature regime.

Cryands, p. 285

DC. Other Andisols that have an aridic moisture regime.

Torrands, p. 294

DD. Other Andisols that have a xeric moisture regime.

Xerands, p. 323

DE. Other Andisols that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitrands, p. 319

DF. Other Andisols that have an ustic moisture regime.

Ustands, p. 315

DG. Other Andisols.

Udands, p. 297

Aquands

Aquands are the Andisols with aquic conditions at or near the surface. Commonly, these soils have dark colored surface horizons that meet the requirements for a histic, umbric, or mollic epipedon. They occur in the lower landscape positions and support forest or grass vegetation. Some have been drained and are used for small grain or grass for livestock. Aquands occur in the Pacific Northwest and in other areas that have a volcanic influence.

Definition

Aquands are the Andisols that have *either*:

1. A histic epipedon; *or*

2. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

DAA. Aquands that have a cryic soil temperature regime.
Cryaquands, p. 276

DAB. Other Aquands that have, in half or more of each pedon, a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Placaquands, p. 282

DAC. Other Aquands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Duraquands, p. 277

DAD. Other Aquands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact.
Vitraquands, p. 283

DAE. Other Aquands that have a melanic epipedon.
Melanaquands, p. 281

DAF. Other Aquands that have episaturation.
Epiaquands, p. 279

DAG. Other Aquands.
Endoaquands, p. 278

Cryaquands

Cryaquands are the more or less poorly drained Andisols of cold regions. They are not extensive. They formed in the western part of North America and the northeastern part of Asia above 49° north latitude and in mountains south of that latitude. Most of these soils formed under grassy meadow or coniferous forest vegetation.

Characteristically, Cryaquands have a thin O horizon, a mollic or umbric epipedon, and a cambic horizon with many redox concentrations.

The Cryaquands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Cryaquands are the Aquands that have a cryic soil temperature regime.

Key to Subgroups

DAAA. Cryaquands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Lithic Cryaquands

DAAB. Other Cryaquands that have a histic epipedon.
Histic Cryaquands

DAAC. Other Cryaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.
Thaptic Cryaquands

DAAD. Other Cryaquands.
Typic Cryaquands

Definition of Typic Cryaquands

Typic Cryaquands are the Cryaquands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a histic epipedon; *and*

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower.

Description of Subgroups

Typic Cryaquands.—The central concept or Typic subgroup of Cryaquands is fixed on soils that are moderately deep or deeper and have a mollic or umbric epipedon and a cambic horizon. Typic Cryaquands do not have a histic epipedon; a lithic contact within a depth of 50 cm; or, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick.

These soils commonly support wet meadow vegetation, but some support coniferous forest vegetation. Some forests have widely spaced trees. Typic Cryaquands are not extensive in the United States.

Histic Cryaquands.—These soils are like Typic Cryaquands, but they have a histic epipedon. They are considered intergrades to Histosols. They are rare in the United States.

Lithic Cryaquands.—These soils are like Typic Cryaquands, but they have a lithic contact within a depth of 50 cm. They are rare in the United States.

Thaptic Cryaquands.—These soils are like Typic Cryaquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons, 10 cm or more thick, with a lower content of organic carbon. Thaptic Cryaquands are rare in the United States.

Duraquands

Duraquands are the more or less poorly drained Andisols that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Duraquands are not known to occur in the United States. They are established for use in other countries.

Definition

Duraquands are the Aquands that:

1. In 75 percent or more of each pedon, have a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower;

2. Do not have a cryic soil temperature regime; *and*

3. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DACA. Duraquands that have a histic epipedon.

Histic Duraquands

DACB. Other Duraquands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acraquoxic Duraquands

DACC. Other Duraquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Duraquands

DACD. Other Duraquands.

Typic Duraquands

Definition of Typic Duraquands

Typic Duraquands are the Duraquands that:

1. Do not have a histic epipedon;

2. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower; *and*

3. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm.

Description of Subgroups

Typic Duraquands.—The central concept or Typic subgroup of Duraquands is fixed on soils that do not have a histic epipedon, have extractable bases plus 1N KCl-extractable Al^{3+} totaling 2.0 or more cmol(+)/kg, and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon.

These soils are not known to occur in the United States. They are established for use in other countries.

Acraquoxic Duraquands.—These soils are like Typic Duraquands, but they have very low extractable bases plus 1N KCl-extractable Al^{3+} in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. Acraquoxic Duraquands are not known to occur in the United States. They are established for use in other countries.

Histic Duraquands.—These soils are like Typic

Duraquands, but they have a histic epipedon. They are not known to occur in the United States. They are established for use in other countries.

Thaptic Duraquands.—These soils are like Typic Duraquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Thaptic Duraquands are not known to occur in the United States. They are established for use in other countries.

Endoaquands

Endoaquands are the more or less poorly drained Andisols with no slowly permeable layers that cause unsaturated layers to underlie saturated layers within 200 cm of the mineral soil surface. Most of these soils formed under grassy meadow vegetation, but some formed under coniferous forest vegetation.

Characteristically, Endoaquands have a thin O horizon, a mollic or umbric epipedon, and a cambic horizon with many redox concentrations.

The Endoaquands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Endoaquands are the Aquands that:

1. Do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have, in half or more of each pedon, a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have a melanic epipedon;

4. Do not have a cryic soil temperature regime;

5. Have a 1500 kPa water retention either of 15 percent or more on air-dried samples or of 30 percent or more on undried samples throughout one or more layers with a total thickness of more than 25 cm within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

6. Have endosaturation.

Key to Subgroups

DAGA. Endoaquands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Endoaquands

DAGB. Other Endoaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Endoaquands

DAGC. Other Endoaquands that have a histic epipedon.

Histic Endoaquands

DAGD. Other Endoaquands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Endoaquands

DAGE. Other Endoaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Endoaquands

DAGF. Other Endoaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Endoaquands

DAGG. Other Endoaquands.

Typic Endoaquands

Definition of Typic Endoaquands

Typic Endoaquands are the Endoaquands that:

1. Do not have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have a horizon with an upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, that is more than 15 cm thick and has 20 percent or more (by volume) cemented soil material;

3. Do not have a histic epipedon;

4. Do not have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with

andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower;

5. Have 2.0 cmol(+)/kg or less Al^{3+} (by 1N KCl) in the fine-earth fraction throughout a layer 10 cm or more thick at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

6. Have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Endoaquands.—The central concept or Typic subgroup of Endoaquands is fixed on soils that do not have a histic epipedon, that are moderately deep or deeper, and that do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Soils that have a horizon 15 cm or more thick with 20 percent or more cemented soil material also are excluded.

Endoaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick in the upper part are assigned to the Hydric subgroup. Soils with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more also are excluded from the Typic subgroup. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have a histic epipedon are excluded from the Typic subgroup because they are considered intergrades to Histosols.

Typic Endoaquands are not extensive in the United States. They commonly support wet meadow vegetation, but some support coniferous forest vegetation. Most Typic Endoaquands are used as rangeland, but some have been drained and are used as cropland or pasture.

Alic Endoaquands.—These soils are like Typic Endoaquands, but they have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States.

Duric Endoaquands.—These soils are like Typic Endoaquands, but they have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Histic Endoaquands.—These soils are like Typic Endoaquands, but they have a histic epipedon. They have not been recognized in the United States.

Hydric Endoaquands.—These soils are like Typic Endoaquands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Lithic Endoaquands.—These soils are like Typic Endoaquands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Thaptic Endoaquands.—These soils are like Typic Endoaquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils are rare in the United States.

Epiaquands

Epiaquands are the more or less poorly drained Andisols with a slowly permeable layer that causes unsaturated layers to underlie saturated layers within 200 cm of the mineral soil surface. Most of these soils formed under grassy meadow vegetation, but some formed under coniferous forest vegetation.

Characteristically, Epiaquands have a thin O horizon, a mollic or umbric epipedon, and a cambic horizon with many redox concentrations.

The Epiaquands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Epiaquands are the Aquands that:

1. Do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have, in half or more of each pedon, a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have a melanic epipedon;

4. Do not have a cryic soil temperature regime;

5. Have a 1500 kPa water retention either of 15 percent or more on air-dried samples or of 30 percent or more on undried samples throughout one or more layers with a total thickness of more

than 25 cm within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

6. Have episaturation.

Key to Subgroups

DAFA. Epiaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Epiaquands

DAFB. Other Epiaquands that have a histic epipedon.

Histic Epiaquands

DAFC. Other Epiaquands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Epiaquands

DAFD. Other Epiaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Epiaquands

DAFE. Other Epiaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Epiaquands

DAFF. Other Epiaquands.

Typic Epiaquands

Definition of Typic Epiaquands

Typic Epiaquands are the Epiaquands that:

1. Do not have a horizon with an upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, that is more than 15 cm thick and has 20 percent or more (by volume) cemented soil material;

2. Do not have a histic epipedon;

3. Do not have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower;

4. Have 2.0 cmol(+)/kg or less Al^{3+} (by 1N KCl) in the fine-earth fraction throughout a layer 10 cm or more thick at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

5. Have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Epiaquands.—The central concept or Typic subgroup of Epiaquands is fixed on moderately deep or deeper soils that do not have a histic epipedon and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Soils that have a horizon 15 cm or more thick with 20 percent or more cemented soil material also are excluded.

Epiaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick in the upper part are assigned to the Hydric subgroup. Soils with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more also are excluded from the Typic subgroup. Soils that have a histic epipedon are excluded from the Typic subgroup because they are considered intergrades to Histosols.

Typic Epiaquands are rare in the United States. They commonly support wet meadow vegetation, but some support coniferous forest vegetation.

Alic Epiaquands.—These soils are like Typic Epiaquands, but they have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States.

Duric Epiaquands.—These soils are like Typic Epiaquands, but they have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Histic Epiaquands.—These soils are like Typic Epiaquands, but they have a histic epipedon. They have not been recognized in the United States.

Hydric Epiaquands.—These soils are like Typic Epiaquands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Thaptic Epiaquands.—These soils are like Typic Epiaquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils are rare in the United States.

Melanaquands

Melanaquands are the more or less poorly drained Andisols with a melanic epipedon. Most of these soils formed under forest vegetation.

Characteristically, Melanaquands have a thin O horizon, a thick melanic epipedon, and a cambic horizon with many redox concentrations.

Definition

Melanaquands are the Aquands that:

1. Have a melanic epipedon;

2. Do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

3. Do not have a cryic soil temperature regime;

4. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

5. Have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples throughout a thickness of more than 25 cm within 60 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower.

Key to Subgroups

DAEA. Melanaquands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Melanaquands

DAEB. Other Melanaquands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acraquoxic Melanaquands

DAEC. Other Melanaquands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Pachic Melanaquands

DAED. Other Melanaquands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Melanaquands

DAEE. Other Melanaquands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanaquands

DAEF. Other Melanaquands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Melanaquands

DAEG. Other Melanaquands.

Typic Melanaquands

Definition of Typic Melanaquands

Typic Melanaquands are the Melanaquands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. On undried samples, have a 1500 kPa water retention of less than 70 percent throughout any continuous thickness of 35 cm or more within the upper 100 cm;

3. Do not have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm;

4. Do not have, between depths of 40 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower; *and*

5. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm.

Description of Subgroups

Typic Melanaquands.—The central concept or Typic subgroup of Melanaquands is fixed on soils that have a melanic epipedon less than 50 cm thick, are moderately deep or deeper, and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Soils that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick in the upper part are assigned to the Hydric subgroup. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Melanaquands are not extensive in the United States. They commonly support coniferous forest vegetation. Most of these soils are used as woodland or have been drained and are used as cropland or pasture.

Acraquoxic Melanaquands.—These soils are like Typic Melanaquands, but they have very low extractable bases plus 1N KCl-extractable Al^{3+} in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Hydric Melanaquands.—These soils are like Typic Melanaquands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Hydric Pachic Melanaquands.—These soils are like Typic Melanaquands, but they have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm of the andic materials and, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Hydric Pachic Melanaquands have not been recognized in the United States.

Lithic Melanaquands.—These soils are like Typic Melanaquands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Pachic Melanaquands.—These soils are like Typic Melanaquands, but they have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm below the mineral soil surface or below the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Thaptic Melanaquands.—These soils are like Typic Melanaquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Placaquands

Placaquands are the more or less poorly drained Andisols that have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. Most of these soils formed under coniferous forest vegetation.

Characteristically, Placaquands have a thin O horizon and an umbric or histic epipedon above the placic horizon. They are rare in the United States.

Definition

Placaquands are the Aquands that:

1. In half or more of each pedon, have a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

2. Do not have a cryic soil temperature regime.

Key to Subgroups

DABA. Placaquands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Placaquands

DABB. Other Placaquands that have *both*:

1. A histic epipedon; *and*

2. A horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Histic Placaquands

DABC. Other Placaquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Placaquands

DABD. Other Placaquands that have a histic epipedon.

Histic Placaquands

DABE. Other Placaquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Placaquands

DABF. Other Placaquands.

Typic Placaquands

Definition of Typic Placaquands

Typic Placaquands are the Placaquands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower, that is more than 15 cm thick and that has 20 percent or more (by volume) cemented soil material;

3. Do not have a histic epipedon; *and*

4. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower.

Description of Subgroups

Typic Placaquands.—The central concept or Typic subgroup of Placaquands is fixed on soils that do not have a histic epipedon, are moderately deep or deeper, and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Soils that average 20 percent or more (by volume) cemented soil material in a layer 15 cm or more thick are assigned to the Duric subgroup. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Typic Placaquands have not been recognized in the United States.

Duric Histic Placaquands.—These soils are like Typic Placaquands, but they have both a histic epipedon and a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Duric Placaquands.—These soils are like Typic Placaquands, but they have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Histic Placaquands.—These soils are like Typic Placaquands, but they have a histic epipedon. They are rare in the United States.

Lithic Placaquands.—These soils are like Typic Placaquands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Thaptic Placaquands.—These soils are like Typic Placaquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Vitraquands

Vitraquands are the more or less poorly drained Andisols with relatively coarse textures. Most of these soils have no slowly permeable layer that causes unsaturated layers to underlie saturated layers within 200 cm of the mineral soil surface. Many of the soils formed under grassy or brushy meadow vegetation, but some formed under coniferous forest vegetation.

Characteristically, Vitraquands have a thin O horizon, a mollic or umbric epipedon, and a cambic horizon with many redox concentrations.

Most Vitraquands in the United States developed in Holocene deposits.

Definition

Vitraquands are the Aquands that:

1. Have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

   a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no lithic or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

   b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon;

2. Do not have a cryic soil temperature regime;

3. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

4. Do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DADA. Vitraquands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Vitraquands

DADB. Other Vitraquands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Vitraquands

DADC. Other Vitraquands that have a histic epipedon.

Histic Vitraquands

DADD. Other Vitraquands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Vitraquands

DADE. Other Vitraquands.

Typic Vitraquands

Definition of Typic Vitraquands

Typic Vitraquands are the Vitraquands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower, that is more than 15 cm thick and that has 20 percent or more (by volume) cemented soil material;

3. Do not have a histic epipedon; *and*

4. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower.

Description of Subgroups

Typic Vitraquands.—The central concept or Typic subgroup of Vitraquands is fixed on soils that do not have a histic epipedon, are moderately deep or deeper, and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. Soils that average 20 percent or more (by volume) cemented soil material in a layer 15 cm or more thick are assigned to the Duric subgroup. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Typic Vitraquands are of small extent in the United States.

Duric Vitraquands.—These soils are like Typic Vitraquands, but they have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Histic Vitraquands.—These soils are like Typic Vitraquands, but they have a histic epipedon. They are of small extent in the United States.

Lithic Vitraquands.—These soils are like Typic

Vitraquands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Thaptic Vitraquands.—These soils are like Typic Vitraquands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Cryands

Cryands are the more or less well drained Andisols of cold regions. These soils are moderately extensive. They formed in the western part of North America and the northeastern part of Asia above 49° north latitude and in mountains south of that latitude. Most of the soils formed under coniferous forest vegetation.

Characteristically, Cryands have a thin O horizon and a cambic horizon. The epipedon ranges from ochric to melanic.

The Cryands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Cryands are the Andisols that:

1. Have a cryic soil temperature regime; *and*

2. Do not have a histic epipedon or the aquic conditions characteristic of Aquands.

Key to Great Groups

DBA. Cryands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

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DBB. Other Cryands that have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

1. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Hydrocryands, p. 289

DBC. Other Cryands that have a melanic epipedon.

Melanocryands, p. 291

DBD. Other Cryands that have a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon.

Fulvicryands, p. 286

DBE. Other Cryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitricryands, p. 292

DBF. Other Cryands.

Haplocryands, p. 287

Duricryands

Duricryands are the Cryands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Characteristically, Duricryands have a thin O horizon and a cambic horizon above the cemented horizon.

The Duricryands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous forest vegetation.

Definition

Duricryands are the Cryands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Key to Subgroups

DBAA. Duricryands that have, in some subhorizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Duricryands

DBAB. Other Duricryands.

Typic Duricryands

Definition of Typic Duricryands

Typic Duricryands are the Duricryands that do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Description of Subgroups

Typic Duricryands.—The central concept or Typic subgroup of Duricryands is fixed on soils that have relatively high amounts of aluminum and low cation-exchange capacities and do not have both aquic conditions and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

These soils are not extensive in the United States. They commonly support coniferous forest vegetation. Most of the soils are used for timber production, but some are used as recreational areas.

Aquic Duricryands.—These soils are like Typic Duricryands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States. Most are used for timber production, but some are used as recreational areas.

Fulvicryands

Fulvicryands are the Cryands that do not have a melanic epipedon but have a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon. They do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Characteristically, Fulvicryands have a thin O horizon, an umbric epipedon, and a cambic horizon.

The Fulvicryands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous forest vegetation.

Definition

Fulvicryands are the Cryands that:

1. Have, in less than 75 percent of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have a melanic epipedon but have a layer that meets the depth, thickness, and organic carbon requirements for a melanic epipedon; *and*

3. Do not have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

a. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DBDA. Fulvicryands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Fulvicryands

DBDB. Other Fulvicryands that have, throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

1. More than 6.0 percent organic carbon, by weighted average; *and*

2. More than 4.0 percent organic carbon in all parts.

Pachic Fulvicryands

DBDC. Other Fulvicryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Fulvicryands

DBDD. Other Fulvicryands.

Typic Fulvicryands

Definition of Typic Fulvicryands

Typic Fulvicryands are the Fulvicryands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

3. Do not have throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

a. More than 6.0 percent organic carbon, by weighted average; *and*

b. More than 4.0 percent organic carbon in all parts.

Description of Subgroups

Typic Fulvicryands.—The central concept or Typic subgroup of Fulvicryands is fixed on moderately deep or deeper, more or less well drained soils that have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Typic Fulvicryands commonly have relatively high amounts of aluminum and low cation-exchange capacities. These soils are not extensive in the United States. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Lithic Fulvicryands.—These soils are like Typic Fulvicryands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Pachic Fulvicryands.—These soils are like Typic Fulvicryands, but they have thicker, darker layers or horizons at or near the surface. These soils are not extensive in the United States. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Vitric Fulvicryands.—These soils are like Typic Fulvicryands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. These soils are rare in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Haplocryands

Haplocryands are the Cryands that do not have a melanic epipedon or a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon. They do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. They have, on undried samples, a 1500 kPa water retention of less than 100 percent, by weighted average, throughout 60 percent or more of the upper 60 cm of the andic materials. They also have a 1500 kPa water retention of 30 percent or more on undried samples or of 15 percent or more on air-dried samples, by weighted average, throughout 60 percent or more of the upper 60 cm of the andic materials.

Characteristically, Haplocryands have a thin O horizon, an umbric epipedon, and a cambic horizon.

The Haplocryands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous forest vegetation.

Definition

Haplocryands are the Cryands that:

1. Have, in less than 75 percent of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have a melanic epipedon or an epipedon meeting the depth, thickness, and organic-carbon requirements for a melanic epipedon;

3. Have, on undried samples, a 1500 kPa water retention of

less than 100 percent, by weighted average, throughout more than 40 percent of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, a petrocalcic horizon, or a depth of 60 cm, whichever is shallowest; *and*

4. Have a 1500 kPa water retention of 30 percent or more on undried samples or 15 percent or more on air-dried samples in all subhorizons that meet the requirements for andic soil properties and that are at least 25 cm thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DBFA. Haplocryands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haplocryands

DBFB. Other Haplocryands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Haplocryands

DBFC. Other Haplocryands that have, in some subhorizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haplocryands

DBFD. Other Haplocryands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Haplocryands

DBFE. Other Haplocryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Haplocryands

DBFF. Other Haplocryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Haplocryands

DBFG. Other Haplocryands that have a xeric moisture regime.

Xeric Haplocryands

DBFH. Other Haplocryands.

Typic Haplocryands

Definition of Typic Haplocryands

Typic Haplocryands are the Haplocryands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Have, on undried samples, 30 percent or more 1500 kPa water retention in all subhorizons that meet the requirements for andic soil properties and that are at least 25 cm thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

4. Have 1N KCl-extractable Al^{3+} of 2.0 or less cmol(+) kg^{-1} in

the fine-earth fraction throughout all layers 10 cm or more thick between depths of 25 and 50 cm;

5. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower;

6. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm; *and*

7. Do not have a xeric soil moisture regime.

Description of Subgroups

Typic Haplocryands.—The central concept or Typic subgroup of Haplocryands is fixed on moderately deep or deep soils that have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Soils with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more are excluded from the Typic subgroup. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands.

Typic Haplocryands are moderately extensive in the United States. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Acrudoxic Haplocryands.—These soils are like Typic Haplocryands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Alic Haplocryands.—These soils are like Typic Haplocryands, but they have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are mostly in Oregon and Washington and are of small extent in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Aquic Haplocryands.—These soils are like Typic Haplocryands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Lithic Haplocryands.—These soils are like Typic Haplocryands, but they have a lithic contact within a depth of 50 cm. They are mostly in Oregon and Washington and are of small extent in the United States. Most of the soils are used for timber production or as recreational areas.

Thaptic Haplocryands.—These soils are like Typic Haplocryands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Vitric Haplocryands.—These soils are like Typic Haplocryands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples in some subhorizon that meets the requirements for andic soil properties and that is 25 cm or more thick and is within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. These soils are mostly in Idaho, Oregon, and Washington and are of small extent in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Xeric Haplocryands.—These soils are like Typic Haplocryands, but they have a xeric moisture regime. They are mostly in California and Idaho and are of small extent in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Hydrocryands

Hydrocryands have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout 60 percent or more of the upper part of the pedon. They do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydrocryands have not been recognized in the United States. Most formed under coniferous forest vegetation.

Definition

Hydrocryands are the Cryands that:

1. Have, in less than 75 percent of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. Have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

a. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DBBA. Hydrocryands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hydrocryands

DBBB. Other Hydrocryands that have a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Placic Hydrocryands

DBBC. Other Hydrocryands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hydrocryands

DBBD. Other Hydrocryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Hydrocryands

DBBE. Other Hydrocryands.

Typic Hydrocryands

Definition of Typic Hydrocryands

Typic Hydrocryands are the Hydrocryands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have a placic horizon within 100 cm of the soil surface; *and*

4. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower.

Description of Subgroups

Typic Hydrocryands.—The central concept or Typic subgroup of Hydrocryands is fixed on moderately deep or deep soils that do not have a placic horizon within a depth of 100 cm and do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon.

Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands.

Typic Hydrocryands are not known to occur in the United States.

Aquic Hydrocryands.—These soils are like Typic Hydrocryands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Lithic Hydrocryands.—These soils are like Typic Hydrocryands, but they have a lithic contact within a depth of 50 cm. They are not known to occur in the United States.

Placic Hydrocryands.—These soils are like Typic Hydrocryands, but they have a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Thaptic Hydrocryands.—These soils are like Typic Hydrocryands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Melanocryands

Melanocryands are the Cryands that have a melanic epipedon but do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils also do not have the high water retention associated with Hydrocryands. Melanocryands have not been recognized in the United States.

Definition

Melanocryands are the Cryands that:

1. Have, in less than 75 percent of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Have a melanic epipedon; *and*

3. Do not have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

a. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DBCA. Melanocryands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Melanocryands

DBCB. Other Melanocryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Melanocryands

DBCC. Other Melanocryands.

Typic Melanocryands

Definition of Typic Melanocryands

Typic Melanocryands are the Melanocryands that:

1. Do not have a lithic contact within 50 cm of the soil surface; *and*

2. Have, on undried samples, 30 percent or more 1500 kPa water retention in all subhorizons that meet the requirements for andic soil properties and that are at least 25 cm thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Description of Subgroups

Typic Melanocryands.—The central concept or Typic subgroup of Melanocryands is fixed on moderately deep or deeper soils that have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Typic Melanocryands commonly have relatively high amounts of aluminum. They have been recognized in the Pacific Northwest.

Lithic Melanocryands.—These soils are like Typic

Melanocryands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Vitric Melanocryands.—These soils are like Typic Melanocryands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples in all subhorizons that meet the requirements for andic soil properties and that are 25 cm or more thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. Vitric Melanocryands have not been recognized in the United States.

Vitricryands

Vitricryands are the Cryands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the upper 60 cm of the andic materials. These soils do not have a melanic epipedon or a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon. They do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Characteristically, Vitricryands have a thin O horizon; an ochric, mollic, or umbric epipedon; and a cambic horizon.

The Vitricryands in the United States generally developed in Holocene deposits. Most formed under coniferous forest vegetation.

Definition

Vitricryands are the Cryands that:

1. Have, in less than 75 percent of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have a melanic epipedon or an epipedon meeting the depth, thickness, and organic-carbon requirements for a melanic epipedon; *and*

3. Have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DBEA. Vitricryands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Vitricryands

DBEB. Other Vitricryands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitricryands

DBEC. Other Vitricryands that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Vitricryands

DBED. Other Vitricryands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Vitricryands

DBEE. Other Vitricryands that have a xeric moisture regime and a mollic or umbric epipedon.

Humic Xeric Vitricryands

DBEF. Other Vitricryands that have a xeric moisture regime.

Xeric Vitricryands

DBEG. Other Vitricryands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Vitricryands

DBEH. Other Vitricryands that have an argillic or kandic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Vitricryands

DBEI. Other Vitricryands that have a mollic or umbric epipedon.

Humic Vitricryands

DBEJ. Other Vitricryands.

Typic Vitricryands

Definition of Typic Vitricryands

Typic Vitricryands are the Vitricryands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Do not have a xeric moisture regime;

5. Do not have an argillic or kandic horizon with its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

6. Do not have a mollic or umbric epipedon; *and*

7. Are not saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years.

Description of Subgroups

Typic Vitricryands.—The central concept or Typic subgroup of Vitricryands is fixed on moderately deep or deep, more or less well drained soils that have an ochric epipedon and a udic moisture regime. These soils do not have an argillic horizon. They do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon.

Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that are saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, also are excluded from the Typic subgroup and are considered intergrades to Aquands.

Typic Vitricryands are moderately extensive in the United States. They are mainly in Washington, Oregon, and Idaho. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Alfic Vitricryands.—These soils are like Typic Vitricryands, but they have both an argillic or kandic horizon within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the argillic or kandic horizon. These soils are of small extent in the United States. They are mainly in Washington, Oregon, and Idaho. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Aquic Vitricryands.—These soils are like Typic Vitricryands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States. Most are used for timber production, but some are used as recreational areas.

Humic Vitricryands.—These soils are like Typic Vitricryands, but they have a mollic or umbric epipedon. They are of small extent in the United States. They are mainly in Alaska, Idaho, and Washington. They commonly support grassy vegetation in Alaska and coniferous forest vegetation elsewhere. Most of the soils are used as recreational areas or for timber production.

Humic Xeric Vitricryands.—These soils are like Typic Vitricryands, but they have both a mollic or umbric epipedon and a xeric moisture regime. These soils are of small extent in the United States. They are mainly in Washington. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Lithic Vitricryands.—These soils are like Typic Vitricryands, but they have a lithic contact within a depth of 50 cm. They are mostly in Alaska and Washington and are of small extent in the United States. They commonly support grassy vegetation in Alaska and coniferous forest vegetation elsewhere. Most of the soils are used as recreational areas or for timber production.

Oxyaquic Vitricryands.—These soils are like Typic Vitricryands, but they are saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are rare in the United States.

Thaptic Vitricryands.—These soils are like Typic Vitricryands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Ultic Vitricryands.—These soils are like Typic Vitricryands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils have not been recognized in the United States.

Xeric Vitricryands.—These soils are like Typic Vitricryands, but they have a xeric moisture regime. They are moderately extensive in the United States. They are mainly in Washington and Oregon. They commonly support coniferous forest vegetation. Most are used for timber production, but some are used as recreational areas.

Torrands

Torrands are the more or less well drained Andisols of dry regions. These soils are not extensive. Some formed in the western part of North America, and some are known to occur in Hawaii and other Pacific islands. Most of the soils formed under grassy or shrub vegetation.

Characteristically, Torrands have an ochric or mollic epipedon and a cambic horizon. Some have a duripan or a petrocalcic horizon.

The Torrands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Torrands are the Andisols that:

1. Have an aridic soil moisture regime;

2. Have a frigid or warmer soil temperature regime; *and*

3. Do not have a histic epipedon or the aquic conditions characteristic of Aquands.

Key to Great Groups

DCA. Torrands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duritorrands, p. 294

DCB. Other Torrands that have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitritorrands, p. 296

DCC. Other Torrands.

Haplotorrands, p. 295

Duritorrands

Duritorrands are the Torrands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Characteristically, these soils have an ochric or mollic epipedon and a cambic horizon above the cemented horizon.

The Duritorrands in the United States generally developed in late-Pleistocene deposits. Most formed under grass or shrub vegetation, and some have widely spaced trees.

Definition

Duritorrands are the Torrands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm of either the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Key to Subgroups

DCAA. Duritorrands that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Petrocalcic Duritorrands

DCAB. Other Duritorrands that have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

1. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, if there is no paralithic contact or duripan within that depth, and a point 60 cm below that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a paralithic contact or a duripan.
Vitric Duritorrands

DCAC. Other Duritorrands.
Typic Duritorrands

Definition of Typic Duritorrands

Typic Duritorrands are the Duritorrands that:

1. Do not have a petrocalcic horizon with its upper boundary within 100 cm of the mineral soil surface;

2. Do not have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

a. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, if there is no paralithic contact or duripan within that depth, and a point 60 cm below that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a paralithic contact or a duripan.

Description of Subgroups

Typic Duritorrands.—The central concept or Typic subgroup of Duritorrands is fixed on soils that have a cemented horizon, other than a petrocalcic horizon, that has its upper boundary within 100 cm of the mineral soil surface. Commonly, the cemented horizon is a duripan. These soils do not have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties and a point 60 cm below that depth, a paralithic contact, or a duripan, whichever is shallowest.

These soils are known to occur only in Hawaii and are of small extent in the United States. They commonly support grassy or shrub vegetation. Most are used as rangeland, but some are used as recreational areas.

Petrocalcic Duritorrands.—These soils are like Typic Duritorrands, but they have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface. These soils are known to occur only in Hawaii and are of small extent in the United States. They commonly support grassy or shrub vegetation. Most are used as rangeland, but some are used as recreational areas.

Vitric Duritorrands.—These soils are like Typic Duritorrands, but they have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties and a point 60 cm below that depth, a paralithic contact, or a duripan, whichever is shallowest.

These soils are known to occur only in Oregon and are of small extent in the United States. They support grassy or shrub vegetation, and some have widely spaced trees. Most of the soils are used as rangeland, but some are used as recreational areas.

Haplotorrands

Haplotorrands are the Torrands that do not have a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have, on air-dried samples, a 1500 kPa water retention of 15 percent or more throughout less than 60 percent of the thickness between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a point 60 cm below the starting point or a densic, lithic, or paralithic contact, whichever is shallower.

Characteristically, Haplotorrands have an ochric or mollic epipedon and a cambic horizon.

The Haplotorrands in the United States generally developed in late-Pleistocene deposits. Most formed under grass or shrub vegetation, and some have widely spaced trees.

Definition

Haplotorrands are the Torrands that:

1. Do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Have, on air-dried samples, a 1500 kPa water retention of 15 percent or more throughout less than 60 percent of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DCCA. Haplotorrands that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplotorrands

DCCB. Other Haplotorrands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm of the mineral soil surface.

Duric Haplotorrands

DCCC. Other Haplotorrands that have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface.

Calcic Haplotorrands

DCCD. Other Haplotorrands.

Typic Haplotorrands

Definition of Typic Haplotorrands

Typic Haplotorrands are the Haplotorrands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have 20 percent or more (by volume) cemented soil material in a horizon that has its upper boundary within 100 cm of the mineral soil surface and is more than 15 cm thick;

3. Do not have a calcic horizon with its upper boundary within 125 cm of the mineral soil surface.

Description of Subgroups

Typic Haplotorrands.—The central concept or Typic subgroup of Haplotorrands is fixed on moderately deep or deep soils that have no horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm of the mineral soil surface. These soils do not have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Haplotorrands are known to occur only in Hawaii and are of small extent in the United States. They commonly support grassy or shrub vegetation. Most are used as rangeland, but some are used as recreational areas.

Calcic Haplotorrands.—These soils are like Typic Haplotorrands, but they have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface. They are known to occur only in Hawaii and are of small extent in the United States. They commonly support grassy or shrub vegetation. Most of the soils are used as rangeland, but some are used as recreational areas.

Duric Haplotorrands.—These soils are like Typic Haplotorrands, but they have 20 percent or more (by volume) cemented soil material in a horizon that has its upper boundary within 100 cm of the mineral soil surface and is more than 15 cm thick. These soils are known to occur only in Hawaii and are of small extent in the United States. They commonly support grassy or shrub vegetation. Most of the soils are used as rangeland, but some are used as recreational areas.

Lithic Haplotorrands.—These soils are like Typic Haplotorrands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Vitritorrands

Vitritorrands are the Torrands that do not have a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. They have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a point 60 cm below the starting point or a densic, lithic, or paralithic contact, whichever is shallower.

Characteristically, Vitritorrands have an ochric or mollic epipedon and a cambic horizon.

The Vitritorrands in the United States generally developed in Holocene deposits. Most formed under grass or shrub vegetation, and some have widely spaced trees.

Definition

Vitritorrands are the Torrands that:

1. Have, on air-dried samples, a 1500 kPa water retention of less than 15 percent throughout 60 percent or more of the thickness *either*:

a. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, if there is no paralithic contact or duripan within that depth, and a point 60 cm below that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a paralithic contact or a duripan; *and*

2. Do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Key to Subgroups

DCBA. Vitritorrands that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vitritorrands

DCBB. Other Vitritorrands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm of the mineral soil surface.

Duric Vitritorrands

DCBC. Other Vitritorrands that have, in one or more horizons at a depth between 50 and 100 cm from the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitritorrands

DCBD. Other Vitritorrands that have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface.

Calcic Vitritorrands

DCBE. Other Vitritorrands.

Typic Vitritorrands

Definition of Typic Vitritorrands

Typic Vitritorrands are the Vitritorrands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have 20 percent or more (by volume) cemented soil material in a horizon that has its upper boundary within 100 cm of the mineral soil surface and is more than 15 cm thick;

3. Do not have, in any horizon at a depth between 50 and 100 cm from the mineral soil surface, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *and*

4. Do not have a calcic horizon with its upper boundary within 125 cm of the mineral soil surface.

Description of Subgroups

Typic Vitritorrands.—The central concept or Typic subgroup of Vitritorrands is fixed on moderately deep or deep soils that have no horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm of the mineral soil surface. These soils do not have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Vitritorrands are known to occur only in Oregon and are of small extent in the United States. They commonly support grassy or shrub vegetation and some widely spaced trees. Most of the soils are used as rangeland, but some are used as recreational areas.

Aquic Vitritorrands.—These soils are like Typic Vitritorrands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Calcic Vitritorrands.—These soils are like Typic Vitritorrands, but they have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Duric Vitritorrands.—These soils are like Typic Vitritorrands, but they have 20 percent or more (by volume) cemented soil material in a horizon that has its upper boundary within 100 cm of the mineral soil surface and is more than 15 cm thick. These soils are not known to occur in the United States.

Lithic Vitritorrands.—These soils are like Typic Vitritorrands, but they have a lithic contact within a depth of 50 cm. They have not been recognized in the United States.

Udands

Udands are the more or less well drained Andisols of moist regions. These soils are moderately extensive. They are mostly on the Pacific rim, mainly in the western part of North America and in Japan, New Zealand, the Philippines, and Indonesia. Most of the Udands in the United States are in Washington and Oregon, but some are in Hawaii. Most Udands formed under forest vegetation.

Characteristically, Udands have an ochric or umbric epipedon and a cambic horizon. Some have a duripan.

Most of the Udands in the United States developed in late-Pleistocene or Holocene deposits.

Definition

Udands are the Andisols that:

1. Have a udic soil moisture regime;

2. Have a frigid or warmer soil temperature regime;

3. Do not have a histic epipedon or the aquic conditions characteristic of Aquands; *and*

4. Have a 1500 kPa water retention of 15 percent or more on air-dried samples and 30 percent or more on undried samples throughout more than 40 percent of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Great Groups

DGA. Udands that have, in half or more of each pedon, a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Placudands, p. 314

DGB. Other Udands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Durudands, p. 298

DGC. Other Udands that have a melanic epipedon.

Melanudands, p. 310

DGD. Other Udands that have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

1. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Hydrudands, p. 308

DGE. Other Udands that have a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon.

Fulvudands, p. 300

DGF. Other Udands.

Hapludands, p. 303

Durudands

Durudands are moderately deep or shallow Udands that do not have a placic horizon. In 75 percent or more of each pedon, they have a cemented horizon that has its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Characteristically, Durudands have a thin O horizon, an ochric or umbric epipedon, a cambic horizon, and a cemented horizon.

The Durudands in the United States generally developed in late-Pleistocene deposits. Most formed under coniferous forest vegetation.

Definition

Durudands are the Udands that:

1. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

2. Have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DGBA. Durudands that have, in one or more horizons above the cemented horizon, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to

alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durudands

DGBB. Other Durudands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the cemented horizon.

Acrudoxic Durudands

DGBC. Other Durudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick above the cemented horizon.

Hydric Durudands

DGBD. Other Durudands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Durudands

DGBE. Other Durudands.

Typic Durudands

Definition of Typic Durudands

Typic Durudands are the Durudands that:

1. Do not have, in any horizon at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the cemented horizon, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

2. Do not have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a continuous thickness of 35 cm or more above the cemented horizon;

3. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick at a depth between either 25 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the cemented horizon; *and*

4. Do not have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Durudands.—The central concept or Typic subgroup of Durudands is fixed on moderately deep or shallow soils that have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick above the cemented horizon.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, also are excluded.

Typic Durudands are moderately extensive in the United States. They commonly support coniferous forest vegetation. Most of these soils are used for timber production, but some are used as recreational areas.

Acrudoxic Durudands.—These soils are like Typic Durudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the cemented horizon. These soils have not been recognized in the United States.

Aquic Durudands.—These soils are like Typic Durudands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the cemented horizon. These soils are of small extent in the State of Washington. Most of the soils are used for timber production.

Hydric Durudands.—These soils are like Typic Durudands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick above the cemented horizon. These soils are rare and are known to occur only in Hawaii.

Pachic Durudands.—These soils are like Typic Durudands, but they have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Fulvudands

Fulvudands are the Udands that do not have a melanic epipedon but have a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon. These soils can have a lithic contact. In 75 percent or more of each pedon, however, they do not have a placic horizon or any other cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. The soils have, on undried samples, a 1500 kPa water retention of less than 100 percent, by weighted average, throughout the major part of the andic materials.

Characteristically, Fulvudands have a thin O horizon, an umbric epipedon, and a cambic horizon.

The Fulvudands in the United States generally developed in late-Pleistocene deposits. Most formed under coniferous forest vegetation.

Definition

Fulvudands are the Udands that:

1. Do not have, within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower, the upper boundary of a placic horizon that occurs in half or more of each pedon and can have a lithic contact but do not have any other cemented horizon that occurs in 75 percent or more of each pedon within these depths;

2. Do not have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

a. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon; *and*

3. Do not have a melanic epipedon but have a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon.

Key to Subgroups

DGEA. Fulvudands that have *both*:

1. A lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the lithic contact.

Eutric Lithic Fulvudands

DGEB. Other Fulvudands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Fulvudands

DGEC. Other Fulvudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Fulvudands

DGED. Other Fulvudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Fulvudands

DGEE. Other Fulvudands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Fulvudands

DGEF. Other Fulvudands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Ultic Fulvudands

DGEG. Other Fulvudands that have *both*:

1. No horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. Throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

a. More than 6.0 percent organic carbon, by weighted average; *and*

b. More than 4.0 percent organic carbon in all parts.

Eutric Pachic Fulvudands

DGEH. Other Fulvudands that have no horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Fulvudands

DGEI. Other Fulvudands that have, throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower:

1. More than 6.0 percent organic carbon, by weighted average; *and*

2. More than 4.0 percent organic carbon in all parts.

Pachic Fulvudands

DGEJ. Other Fulvudands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Fulvudands

DGEK. Other Fulvudands.

Typic Fulvudands

Definition of Typic Fulvudands

Typic Fulvudands are the Fulvudands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, *both*:

a. More than 6.0 percent organic carbon, by weighted average; *and*

b. More than 4.0 percent organic carbon in all parts;

4. On undried samples, have a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick within the upper 100 cm;

5. Do not have, between depths of 40 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value 1 unit or more higher and an organic-carbon content 1 percent or more lower;

6. Have an Al^{3+} (1N KCl extractable) of 2.0 cmol(+)/kg in the fine-earth fraction throughout all layers 10 cm or more thick between depths of 25 and 50 cm;

7. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm; *and*

8. Do not have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower, and base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of that horizon.

Description of Subgroups

Typic Fulvudands.—The central concept or Typic subgroup of Fulvudands is fixed on moderately deep or deep soils that have a relatively high amount of aluminum. These soils have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup. The upper part of Typic Fulvudands has extractable bases plus 1N KCl-extractable Al^{3+} that total more than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that average more than 6.0 percent organic carbon throughout a layer 50 cm or more thick in the upper part also are excluded.

Typic Fulvudands are moderately extensive in the United States. They commonly support coniferous forest vegetation. Most of these soils are used for timber production, but some are used as cropland.

Acrudoxic Fulvudands.—These soils are like Typic Fulvudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Fulvudands.—These soils are like Typic Fulvudands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and are known to occur only in the State of Washington in the United States. Most of the soils are used for timber production.

Eutric Fulvudands.—These soils are like Typic Fulvudands, but they do not have one or more horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Eutric Lithic Fulvudands.—These soils are like Typic Fulvudands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. They do not have one or more horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and are known to occur only in the State of Washington in the United States. Most of the soils are used for timber production, but some are used as recreational areas.

Eutric Pachic Fulvudands.—These soils are like Typic Fulvudands, but they do not have horizons with more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction and with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They have, throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, both more than 6.0 percent organic carbon, by weighted average, and more than 4.0 percent organic carbon in all parts.

Hydric Fulvudands.—These soils are like Typic Fulvudands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Lithic Fulvudands.—These soils are like Typic Fulvudands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and are known to occur only in the State of Washington. Most of the soils are used for timber production, but some are used as recreational areas.

Pachic Fulvudands.—These soils are like Typic Fulvudands, but they have, throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, both more than 6.0 percent organic carbon, by weighted average, and more than 4.0 percent organic carbon in all parts. These soils are not known to occur in the United States.

Thaptic Fulvudands.—These soils are like Typic Fulvudands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Ultic Fulvudands.—These are the Fulvudands that have an argillic or kandic horizon with a base saturation of less than 35 percent throughout the upper 50 cm. These soils do not have a lithic contact within 50 cm of the mineral soil surface or aquic conditions within 100 cm of the mineral soil surface. They occur in the Pacific Northwest, where they formed under forest vegetation.

Hapludands

Hapludands are the Udands that do not have a melanic epipedon or a layer that meets the depth, thickness, and organic-carbon requirements for a melanic epipedon. They do not have a placic horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower. They can have a lithic contact but do not have any other cemented horizon in 75 percent or more of each pedon within these depths. They have, on undried samples, a 1500 kPa water retention of less than 100 percent, by weighted average, throughout the major part of the andic materials.

Commonly, Hapludands have a thin O horizon, an ochric or umbric epipedon, and a cambic horizon.

Most of the Hapludands in the United States developed in late-Pleistocene or Holocene deposits. Most formed under coniferous forest vegetation.

Definition

Hapludands are the Udands that:

1. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

2. Do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

3. Do not have a melanic epipedon or an epipedon meeting the depth, thickness, and organic-carbon requirements for a melanic epipedon; *and*

4. Have, on undried samples, a 1500 kPa water retention of less than 100 percent, by weighted average, throughout all layers 35 cm or more thick within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DGFA. Hapludands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hapludands

DGFB. Other Hapludands that have anthraquic conditions.

Anthraquic Hapludands

DGFC. Other Hapludands that have *both*:

1. A horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. In one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Duric Hapludands

DGFD. Other Hapludands that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Hapludands

DGFE. Other Hapludands that have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Alic Hapludands

DGFF. Other Hapludands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hapludands

DGFG. Other Hapludands that have *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hydric Hapludands

DGFH. Other Hapludands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more; *and*

2. A layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Acrudoxic Thaptic Hapludands

DGFI. Other Hapludands that have *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. An argillic or kandic horizon that has *both*:

a. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

b. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Acrudoxic Ultic Hapludands

DGFJ. Other Hapludands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hapludands

DGFK. Other Hapludands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Hapludands

DGFL. Other Hapludands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. At a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Hydric Thaptic Hapludands

DGFM. Other Hapludands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Hapludands

DGFN. Other Hapludands that have *both*:

1. A sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. At a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or

more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Eutric Thaptic Hapludands

DGFO. Other Hapludands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Hapludands

DGFP. Other Hapludands that have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Hapludands

DGFQ. Other Hapludands that have an oxic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Oxic Hapludands

DGFR. Other Hapludands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Ultic Hapludands

DGFS. Other Hapludands that have an argillic or kandic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Hapludands

DGFT. Other Hapludands.

Typic Hapludands

Definition of Typic Hapludands

Typic Hapludands are the Hapludands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower, that is more than 15 cm thick and that has 20 percent or more (by volume) cemented soil material;

3. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

   a. 2 percent or more redox concentrations; *or*

   b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

   c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

4. Do not have anthraquic conditions;

5. Have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

6. Have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples throughout all layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

7. Have 1N KCl-extractable Al^{3+} of 2.0 or less cmol(+) kg^{-1} in the fine-earth fraction throughout all layers 10 cm or more thick between depths of 25 and 50 cm;

8. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

9. Have a sum of bases of 25.0 or less cmol(+) kg^{-1} in the fine-earth fraction of one or more subhorizons 35 cm or more thick between depths of 25 and 75 cm;

10. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm; *and*

11. Do not have an argillic, kandic, or oxic horizon with its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Description of Subgroups

Typic Hapludands.—The central concept or Typic subgroup of Hapludands is fixed on moderately deep or deep soils that have 2.0 or less cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of a layer 10 cm or more thick at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils have, within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, a 1500 kPa water retention of 15 percent or more on air-dried samples throughout all layers 25 cm or more thick and between 30 and 70 percent on undried samples throughout all layers 35 cm or more thick. The sum of extractable bases is 25.0 cmol(+)/kg or less throughout horizons with a total thickness of 15 cm or more in the upper part of the soils.

Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup. Typic Hapludands do not have a horizon 15 cm or more thick with 20 percent or more (by volume) cemented soil material in the upper part. Extractable bases plus 1N KCl-extractable Al^{3+} total more than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more in the upper part of these soils.

Soils that have anthraquic conditions and soils with both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Hapludands are moderately extensive in the United States. They commonly support coniferous forest vegetation. Most of these soils are used for timber production, but some have been cleared and are used as cropland.

Acrudoxic Hapludands.—These soils are like Typic Hapludands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Hydric Hapludands.—These soils are like Typic Hapludands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They also have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Thaptic Hapludands.—These soils are like Typic Hapludands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. They also have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Ultic Hapludands.—These soils are like Typic Hapludands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They also have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Alfic Hapludands.—These soils are like Typic Hapludands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Alic Hapludands.—These soils are like Typic Hapludands, but they have more than 2.0 cmol(+)/kg Al^{3+} (by 1N KCl) in the fine-earth fraction of one or more horizons with a total thickness of 10 cm or more at a depth between 25 and 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are moderately extensive in the United States. They commonly support coniferous forest vegetation. Most of the soils are used for timber production, but some have been cleared and are used as cropland.

Anthraquic Hapludands.—These soils are like Typic Hapludands, but they have anthraquic conditions. They are used for the production of paddy rice. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Duric Hapludands.—These soils are like Typic Hapludands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Hapludands.—These soils are like Typic Hapludands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and are known to occur only in the State of Washington. Most of the soils are used for timber production.

Duric Hapludands.—These soils are like Typic Hapludands, but they have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Eutric Hapludands.—These soils are like Typic Hapludands, but they have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Eutric Thaptic Hapludands.—These Hapludands have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils also have a buried mineral layer. They do not have aquic conditions within a depth of 100 cm or high amounts of aluminum. They are not known to occur in the United States. They are established for use in other countries.

Hydric Hapludands.—These soils are like Typic Hapludands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. They also have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils are rare and are known to occur only in Hawaii in the United States.

Hydric Thaptic Hapludands.—These soils are like Typic Hapludands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Lithic Hapludands.—These soils are like Typic Hapludands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in Washington and Oregon in the United States. Most are used for timber production, but some are used as recreational areas.

Oxic Hapludands.—These soils are like Typic Hapludands, but they have an oxic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Thaptic Hapludands.—These soils are like Typic Hapludands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Ultic Hapludands.—These soils are like Typic Hapludands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Vitric Hapludands.—These soils are like Typic Hapludands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in Washington and Oregon in the United States. Most are used for timber production. Some have been cleared and are used as cropland, and some are used as recreational areas.

Hydrudands

Hydrudands are the Udands that have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout the major part of the andic materials. These soils do not have, in 75 percent or more of each pedon, a melanic epipedon or a placic horizon or any other cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Commonly, Hydrudands have a thin O horizon, an ochric or umbric epipedon, and a cambic horizon.

Most of the Hydrudands in the United States developed in late-Pleistocene deposits and formed under forest vegetation.

Definition

Hydrudands are the Udands that:

1. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

2. Do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

3. Do not have a melanic epipedon; *and*

4. Have, on undried samples, a 1500 kPa water retention of 100 percent or more, by weighted average, throughout *either*:

a. One or more layers with a total thickness of 35 cm between the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. 60 percent or more of the horizon thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DGDA. Hydrudands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Hydrudands

DGDB. Other Hydrudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hydrudands

DGDC. Other Hydrudands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more; *and*

2. A layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Acrudoxic Thaptic Hydrudands

DGDD. Other Hydrudands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hydrudands

DGDE. Other Hydrudands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Hydrudands

DGDF. Other Hydrudands that have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Hydrudands

DGDG. Other Hydrudands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Ultic Hydrudands

DGDH. Other Hydrudands.

Typic Hydrudands

Definition of Typic Hydrudands

Typic Hydrudands are the Hydrudands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Have a sum of bases of 25.0 or less cmol(+) kg^{-1} in the fine-earth fraction of one or more subhorizons 35 cm or more thick at a depth between 25 and 75 cm from the mineral soil surface or from the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

5. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick between depths of 25 and 100 cm; *and*6. Do not have an argillic or kandic horizon with its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Description of Subgroups

Typic Hydrudands.—The central concept or Typic subgroup of Hydrudands is fixed on more or less well drained, moderately deep or deep soils that have extractable bases plus 1N KCl-extractable Al^{3+} totaling 2.0 or more cmol(+)/kg in the fine-earth fraction of horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils do not have an argillic horizon with a base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm. The sum of extractable bases is 25.0 cmol(+)/kg or less throughout horizons with a total thickness of 15 cm or more in the upper part of the soils.

Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Hydrudands are of moderate extent in Hawaii in the United States. They supported forest vegetation. Most of these soils have been cleared and are used as cropland or pasture.

Acrudoxic Hydrudands.—These soils are like Typic Hydrudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Thaptic Hydrudands.—These soils are like Typic Hydrudands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. They also have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Hydrudands.—These soils are like Typic Hydrudands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and are known to occur only in Hawaii in the United States. Most of the soils have been cleared and are used as cropland or pasture.

Eutric Hydrudands.—These soils are like Typic Hydrudands, but they have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 35 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Lithic Hydrudands.—These soils are like Typic Hydrudands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in Hawaii in the United States. Most have been cleared and are used as cropland or pasture, but some are used as recreational areas.

Thaptic Hydrudands.—These soils are like Typic Hydrudands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States. They are established for use in other countries.

Ultic Hydrudands.—These soils are like Typic Hydrudands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Melanudands

These are the Udands that have a melanic epipedon. They can have a lithic contact but do not have, in 75 percent or more of each pedon, a placic horizon or any other cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower. Characteristically, Melanudands have a melanic epipedon and a cambic horizon.

The Melanudands in the United States generally developed in late-Pleistocene deposits. Most formed under forest or savanna vegetation.

Definition

Melanudands are the Udands that:

1. Do not have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

2. Do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

3. Have a melanic epipedon.

Key to Subgroups

DGCA. Melanudands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Melanudands

DGCB. Other Melanudands that have anthraquic conditions.

Anthraquic Melanudands

DGCC. Other Melanudands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Melanudands

DGCD. Other Melanudands that have *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on

air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Vitric Melanudands

DGCE. Other Melanudands that have *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Hydric Melanudands

DGCF. Other Melanudands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Acrudoxic Melanudands

DGCG. Other Melanudands that have *both*:

1. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Vitric Melanudands

DGCH. Other Melanudands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Melanudands

DGCI. Other Melanudands that have *both*:

1. On undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. More than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Pachic Melanudands

DGCJ. Other Melanudands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanudands

DGCK. Other Melanudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Melanudands

DGCL. Other Melanudands that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Melanudands

DGCM. Other Melanudands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Ultic Melanudands

DGCN. Other Melanudands that have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 15 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower.

Eutric Melanudands

DGCO. Other Melanudands.

Typic Melanudands

Definition of Typic Melanudands

Typic Melanudands are the Melanudands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

   a. 2 percent or more redox concentrations; *or*

   b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

   c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

4. Have a 1500 kPa water retention of 15 percent or more on air-dried samples or 30 percent or more on undried samples throughout all layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

5. Do not have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm, excluding any overlying layers that do not have andic soil properties;

6. Do not have a sum of bases of more than 25.0 cmol(+) kg^{-1} in the fine-earth fraction throughout some subhorizon 15 cm or more thick at a depth between 25 and 75 cm either from mineral soil surface or from the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

7. Do not have, between depths of 40 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

8. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick at a depth between 25 and 100 cm from the mineral soil surface or from the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

9. Do not have an argillic or kandic horizon with a base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm and its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

10. Do not have anthraquic conditions.

Description of Subgroups

Typic Melanudands.—The central concept or Typic subgroup of Melanudands is fixed on moderately deep or deeper soils that commonly have relatively high amounts of aluminum. These soils have, within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, a 1500 kPa water retention of 15 percent or more on air-dried samples throughout all layers 25 cm or more thick and between 30 and 70 percent on undried samples throughout all layers 35 cm or more thick. The sum of extractable bases is 25.0 cmol(+)/kg or less throughout horizons with a total thickness of 15 cm or more in the upper part of the soils.

Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup. Extractable bases plus 1N-KCl-extractable Al^{3+} total more than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more in the upper part of the Typic Melanudands.

Soils that have anthraquic conditions and soils with both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Melanudands are not known to occur in the Pacific Northwest.

Acrudoxic Hydric Melanudands.—These soils are like Typic

Melanudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They also have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Melanudands.—These soils are like Typic Melanudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Acrudoxic Vitric Melanudands.—These soils are like Typic Melanudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They also have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Anthraquic Melanudands.—These soils are like Typic Melanudands, but they have anthraquic conditions. They are used for the production of paddy rice. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Melanudands.—These soils are like Typic Melanudands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Eutric Melanudands.—These soils are like Typic Melanudands, but they have a sum of extractable bases of more than 25.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 35 cm or more at a depth between 25 and 75 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Hydric Melanudands.—These soils are like Typic Melanudands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Hydric Pachic Melanudands.—These soils are like Typic Melanudands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils also have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm of the andic materials and have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. The soils have not been recognized in the United States. They are established for use in other countries.

Lithic Melanudands.—These soils are like Typic Melanudands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Pachic Melanudands.—These soils are like Typic Melanudands, but they have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm of the andic materials and have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Pachic Vitric Melanudands.—These soils are like Typic Melanudands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils also have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm of the andic materials and have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. The soils have not been recognized in the United States. They are established for use in other countries.

Thaptic Melanudands.—These soils are like Typic Melanudands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States. They are established for use in other countries.

Ultic Melanudands.—These soils are like Typic Melanudands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Vitric Melanudands.—These soils are like Typic Melanudands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Placudands

Placudands are the more or less well drained Udands that have, in half or more of each pedon, a placic horizon within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Characteristically, Placudands have a thin O horizon and an ochric or umbric epipedon above the placic horizon.

Placudands are rare in the United States. Most formed under forest vegetation.

Definition

Placudands are the Udands that have, in half or more of each pedon, a placic horizon within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower.

Key to Subgroups

DGAA. Placudands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer that has andic soil properties, whichever is shallower.

Lithic Placudands

DGAB. Other Placudands that have, in one or more horizons at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Placudands

DGAC. Other Placudands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon.

Acrudoxic Placudands

DGAD. Other Placudands that have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Hydric Placudands

DGAE. Other Placudands.

Typic Placudands

Definition of Typic Placudands

Typic Placudands are the Placudands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 2.0 or more cmol(+) kg^{-1} in the fine-earth fraction of all subhorizons 30 cm or more thick at a depth between 25 cm from the mineral soil surface or from the upper boundary of an organic layer that has andic soil properties, whichever is shallower, and the placic horizon; *and*

4. Do not have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Placudands.—The central concept or Typic subgroup of Placudands is fixed on moderately deep or shallow soils that have, on undried samples, a 1500 kPa water retention of less than 70 percent throughout all layers 35 cm or more thick above the cemented horizon.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon also are excluded.

Typic Placudands are of very small extent in the United States.

Acrudoxic Placudands.—These soils are like Typic Placudands, but they have extractable bases plus 1N KCl-extractable Al^{3+} totaling less than 2.0 cmol(+)/kg in the fine-earth fraction of one or more horizons with a total thickness of 30 cm or more at a depth between 25 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon. These soils have not been recognized in the United States.

Aquic Placudands.—These soils are like Typic Placudands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, and the placic horizon. These soils have not been recognized in the United States.

Hydric Placudands.—These soils are like Typic Placudands, but they have, on undried samples, a 1500 kPa water retention of 70 percent or more throughout a layer 35 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Lithic Placudands.—These soils are like Typic Placudands, but they have a lithic contact within 50 cm of the mineral soil surface.

Ustands

Ustands are the more or less well drained Andisols of subhumid to semiarid regions. These soils are of relatively small extent. They are mostly in Mexico, the western part of the United States, the Pacific Islands, and the eastern part of Africa. Most Ustands in the United States are in Hawaii, Arizona, and New Mexico. Most formed under grass, shrub, or forest vegetation.

Characteristically, Ustands have an ochric or mollic epipedon and a cambic horizon. Some have a duripan.

The Ustands in the United States generally developed in late-Pleistocene or Holocene deposits.

Definition

Ustands are the Andisols that:

1. Have an ustic soil moisture regime;

2. Have a frigid or warmer soil temperature regime;

3. Do not have a histic epipedon or the periods of saturation and reduction that are defined for Aquands; *and*

4. Do not have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, to a point 60 cm below the starting point or to any densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth.

Key to Great Groups

DFA. Ustands that have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Durustands, p. 316

DFB. Other Ustands.

Haplustands, p. 317

Durustands

Durustands are the Ustands that have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Characteristically, Durustands have an ochric epipedon and a cambic horizon above the cemented horizon.

The Durustands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous/grass or shrub vegetation.

Definition

Durustands are the Ustands that have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

DFAA. Durustands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durustands

DFAB. Other Durustands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Durustands

DFAC. Other Durustands that have a melanic, mollic, or umbric epipedon.

Humic Durustands

DFAD. Other Durustands.

Typic Durustands

Definition of Typic Durustands

Typic Durustands are the Durustands that:

1. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

   a. 2 percent or more redox concentrations; *or*

   b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

   c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

2. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower; *and*

3. Do not have a melanic, mollic, or umbric epipedon.

Description of Subgroups

Typic Durustands.—The central concept or Typic subgroup of Durustands is fixed on moderately deep or shallow soils with an ochric epipedon. These soils do not have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. They do not have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Durustands.—These soils are like Typic Durustands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Humic Durustands.—These soils are like Typic Durustands, but they have a melanic, mollic, or umbric epipedon. They are rare in the United States. Most of these soils are used as rangeland, but some are used for timber production or as recreational areas.

Thaptic Durustands.—These soils are like Typic Durustands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils are not known to occur in the United States. They are established for use in other countries.

Haplustands

Haplustands are the Ustands that do not have, in 75 percent or more of each pedon, a cemented horizon that has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Characteristically, Haplustands have an ochric epipedon and a cambic horizon above the cemented horizon.

The Haplustands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous/grass or shrub vegetation.

Definition

Haplustands are the Ustands that do not have, in 75 percent or more of each pedon, a cemented horizon with its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

DFBA. Haplustands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haplustands

DFBB. Other Haplustands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haplustands

DFBC. Other Haplustands that have *both*:

1. Extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Dystric Vitric Haplustands

DFBD. Other Haplustands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Vitric Haplustands

DFBE. Other Haplustands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Haplustands

DFBF. Other Haplustands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Haplustands

DFBG. Other Haplustands that have a calcic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Calcic Haplustands

DFBH. Other Haplustands that have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} totaling less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Dystric Haplustands

DFBI. Other Haplustands that have an oxic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Oxic Haplustands

DFBJ. Other Haplustands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Haplustands

DFBK. Other Haplustands that have an argillic or kandic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Haplustands

DFBL. Other Haplustands that have a melanic, mollic, or umbric epipedon.

Humic Haplustands

DFBM. Other Haplustands.

Typic Haplustands

Definition of Typic Haplustands

Typic Haplustands are the Haplustands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Have, on undried samples, 30 percent or more 1500 kPa water retention in all subhorizons that meet the requirements for andic soil properties and that are at least 25 cm thick and are within 100 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower;

4. Do not have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm, excluding any overlying layers that do not have andic soil properties;

5. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

6. Do not have a calcic horizon with its upper boundary within 125 cm of the mineral soil surface;

7. Have extractable bases (by NH_4OAc) plus 1N KCl-extractable Al^{3+} of 15.0 or more cmol(+) kg^{-1} in the fine-earth fraction throughout at least 60 cm of the upper 75 cm;

8. Do not have an oxic horizon with its upper boundary within 125 cm of the mineral soil surface;

9. Do not have an argillic or kandic horizon with its upper boundary within 125 cm of the mineral soil surface; *and*

10. Do not have a melanic, mollic, or umbric epipedon.

Description of Subgroups

Typic Haplustands.—The central concept or Typic subgroup of Haplustands is fixed on moderately deep or deeper soils that have an ochric epipedon and do not have a calcic, argillic, or oxic horizon. These soils have extractable bases plus 1N KCl-extractable Al^{3+} of 15.0 or more cmol(+) kg^{-1} in the fine-earth fraction throughout at least 60 cm of the upper 75 cm. They have a 1500 kPa water retention of 15 percent or more on air-dried samples and 30 percent or more on undried samples throughout all layers 25 cm or more thick within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Haplustands are of small extent in the United States. They commonly support grassland or forest vegetation. Most are used as rangeland or for timber production, but some have been cleared and are used as cropland.

Alfic Haplustands.—These soils are like Typic Haplustands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Aquic Haplustands.—These soils are like Typic Haplustands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Calcic Haplustands.—These soils are like Typic Haplustands, but they have a calcic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Dystric Haplustands.—These soils are like Typic Haplustands, but they have a sum of extractable bases plus aluminum of less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Dystric Vitric Haplustands.—These soils are like Typic Haplustands, but they have a sum of extractable bases plus aluminum of less than 15.0 cmol(+)/kg in the fine-earth fraction throughout one or more horizons with a total thickness of 60 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. They also have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Humic Haplustands.—These soils are like Typic Haplustands, but they have a melanic, mollic, or umbric epipedon. They are rare and are known to occur only in Hawaii and Arizona in the United States.

Lithic Haplustands.—These soils are like Typic Haplustands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and occur mostly in Hawaii in the United States. Most of the soils are used as cropland or as recreational areas.

Oxic Haplustands.—These soils are like Typic Haplustands, but they have an oxic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States.

Pachic Haplustands.—These soils are like Typic Haplustands, but they have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States.

Thaptic Haplustands.—These soils are like Typic Haplustands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Ultic Haplustands.—These soils are like Typic Haplustands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Vitric Haplustands.—These soils are like Typic Haplustands, but they have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout one or more layers that have andic soil properties and have a total thickness of 25 cm or more within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in Washington and Oregon. Most are used for timber production. Some have been cleared and are used as cropland, and some are used as recreational areas.

Vitrands

Vitrands are the more or less well drained, coarse textured Andisols. These are relatively young soils that occur mostly near volcanoes. Most of the Vitrands in the United States are in Oregon, Washington, and Idaho. Vitrands formed mainly under coniferous forest vegetation.

Characteristically, Vitrands have an ochric or mollic epipedon and a cambic horizon.

Most of the Vitrands in the United States developed in Holocene deposits.

Definition

Vitrands are the Andisols that:

1. Have a frigid or warmer soil temperature regime;

2. Do not have a histic epipedon or the periods of saturation and reduction that are defined for Aquands;

3. Have an ustic or udic moisture regime; *and*

4. Have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Great Groups

DEA. Vitrands that have an ustic moisture regime.

Ustivitrands, p. 322

DEB. Other Vitrands.

Udivitrands, p. 320

Udivitrands

Udivitrands are the more or less well drained Vitrands that have a udic moisture regime. Characteristically, these soils have an ochric epipedon and a cambic horizon. Some have an argillic horizon.

Most of the Udivitrands in the United States developed in Holocene deposits under coniferous forest vegetation.

Definition

Udivitrands are the Vitrands that have a udic soil moisture regime.

Key to Subgroups

DEBA. Udivitrands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Udivitrands

DEBB. Other Udivitrands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Udivitrands

DEBC. Other Udivitrands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Udivitrands

DEBD. Other Udivitrands that have *both*:

1. An argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm of the argillic or kandic horizon.

Ultic Udivitrands

DEBE. Other Udivitrands that have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower.

Alfic Udivitrands

DEBF. Other Udivitrands that have a melanic, mollic, or umbric epipedon.

Humic Udivitrands

DEBG. Other Udivitrands.

Typic Udivitrands

Definition of Typic Udivitrands

Typic Udivitrands are the Udivitrands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Do not have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower; *and*

5. Do not have a melanic, mollic, or umbric epipedon.

Description of Subgroups

Typic Udivitrands.—The central concept or Typic subgroup of Udivitrands is fixed on moderately deep or deeper soils that have an ochric epipedon and do not have an argillic horizon.

Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, also are excluded. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Udivitrands are moderately extensive in the States of Washington and Idaho. They commonly support coniferous forest vegetation. Most of these soils are used for timber production, but some have been cleared and are used as cropland.

Alfic Udivitrands.—These soils are like Typic Udivitrands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. These soils are moderately extensive in Idaho and Oregon. They commonly support coniferous forest vegetation. Most of the soils are used for timber production, but some have been cleared and are used as cropland.

Aquic Udivitrands.—These soils are like Typic Udivitrands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Humic Udivitrands.—These soils are like Typic Udivitrands, but they have a melanic, mollic, or umbric epipedon. They are of small extent and are known to occur only in the State of Washington. They commonly support coniferous forest vegetation. Most of the soils are used for timber production, but some have been cleared and are used as cropland.

Lithic Udivitrands.—These soils are like Typic Udivitrands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent and occur mostly in Oregon, Montana, and Washington. They commonly support coniferous forest vegetation. Most of the soils are used for timber production, but some are used as recreational areas.

Thaptic Udivitrands.—These soils are like Typic Udivitrands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States.

Ultic Udivitrands.—These soils are like Typic Udivitrands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are not known to occur in the United States. They are established for use in other countries.

Ustivitrands

Ustivitrands are the more or less well drained Vitrands that have an ustic moisture regime. Characteristically, Ustivitrands have an ochric epipedon and a cambic horizon.

Ustivitrands are rare in the United States.

Definition

Ustivitrands are the Vitrands that have an ustic soil moisture regime.

Key to Subgroups

DEAA. Ustivitrands that have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Ustivitrands

DEAB. Other Ustivitrands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Ustivitrands

DEAC. Other Ustivitrands that have, at a depth between 25 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Ustivitrands

DEAD. Other Ustivitrands that have a calcic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Calcic Ustivitrands

DEAE. Other Ustivitrands that have a melanic, mollic, or umbric epipedon.

Humic Ustivitrands

DEAF. Other Ustivitrands.

Typic Ustivitrands

Definition of Typic Ustivitrands

Typic Ustivitrands are the Ustivitrands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

   a. 2 percent or more redox concentrations; *or*

   b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

   c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Do not have a calcic horizon with its upper boundary within 125 cm of the mineral soil surface; *and*

5. Do not have a melanic, mollic, or umbric epipedon.

Description of Subgroups

Typic Ustivitrands.—The central concept or Typic subgroup of Ustivitrands is fixed on moderately deep or deep soils that have an ochric epipedon and do not have an argillic or calcic horizon. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup.

Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands.

Typic Ustivitrands are of moderate extent. They are mostly in California and Washington.

Aquic Ustivitrands.—These soils are like Typic Ustivitrands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Calcic Ustivitrands.—These soils are like Typic Ustivitrands, but they have a calcic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Humic Ustivitrands.—These soils are like Typic Ustivitrands, but they have a melanic, mollic, or umbric epipedon. They are not known to occur in the United States. They are established for use in other countries.

Lithic Ustivitrands.—These soils are like Typic Ustivitrands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are not known to occur in the United States. They are established for use in other countries.

Thaptic Ustivitrands.—These soils are like Typic Ustivitrands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States. They are established for use in other countries.

Xerands

Xerands are the more or less well drained Andisols that have a xeric moisture regime and a frigid, mesic, or thermic temperature regime. Most of the Xerands in the United States are in Oregon, Washington, Idaho, and California. Most Xerands have a frigid or mesic temperature regime and formed under coniferous forest vegetation. Some formed under grass or shrub vegetation.

Characteristically, Xerands have an ochric or mollic epipedon and a cambic horizon.

Most of the Xerands in the United States developed in late-Pleistocene or Holocene deposits.

Definition

Xerands are the Andisols that:

1. Have a xeric soil moisture regime;

2. Have a frigid, mesic, or thermic soil temperature regime; *and*

3. Do not have a histic epipedon or the aquic conditions characteristic of Aquands.

Key to Great Groups

DDA. Xerands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Vitrixerands, p. 326

DDB. Other Xerands that have a melanic epipedon.

Melanoxerands, p. 325

DDC. Other Xerands.

Haploxerands, p. 323

Haploxerands

Haploxerands are the more or less well drained Xerands that do not have a melanic epipedon. These soils have a 1500 kPa water retention of 15 percent or more on air-dried samples and 30 percent or more on undried samples throughout more than 30 percent of the upper part.

Characteristically, Haploxerands have a thin O horizon, an ochric or mollic epipedon, and a cambic horizon.

The Haploxerands in the United States generally developed in late-Pleistocene or Holocene deposits. Most formed under coniferous forest vegetation, but some formed under grass or shrub vegetation.

Definition

Haploxerands are the Xerands that:

1. Do not have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon; *and*

2. Do not have a melanic epipedon.

Key to Subgroups

DDCA. Haploxerands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Haploxerands

DDCB. Other Haploxerands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haploxerands

DDCC. Other Haploxerands that have, at a depth between 25 and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Haploxerands

DDCD. Other Haploxerands that have a calcic horizon that has its upper boundary within 125 cm of the mineral soil surface.

Calcic Haploxerands

DDCE. Other Haploxerands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout its upper 50 cm.

Ultic Haploxerands

DDCF. Other Haploxerands that have *both*:

1. A mollic or umbric epipedon; *and*

2. An argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Humic Haploxerands

DDCG. Other Haploxerands that have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Haploxerands

DDCH. Other Haploxerands that have a mollic or umbric epipedon.

Humic Haploxerands

DDCI. Other Haploxerands.

Typic Haploxerands

Definition of Typic Haploxerands

Typic Haploxerands are the Haploxerands that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, between depths of 25 and 100 cm, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Do not have a calcic horizon with its upper boundary within 125 cm of the mineral soil surface;

5. Do not have an argillic or kandic horizon with its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer that has andic soil properties, whichever is shallower; *and*

6. Do not have either a mollic or umbric epipedon.

Description of Subgroups

Typic Haploxerands.—The central concept or Typic subgroup of Haploxerands is fixed on moderately deep or deep soils that have an ochric epipedon and do not have an argillic horizon. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, also are excluded. Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup.

Typic Haploxerands commonly support coniferous forest vegetation. Most of these soils are used for timber production, but some have been cleared and are used as cropland.

Alfic Haploxerands.—These soils are like Typic Haploxerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. These soils are rare in the United States.

Alfic Humic Haploxerands.—These soils are like Typic Haploxerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. They also have a melanic, mollic, or umbric epipedon. They are rare in the United States.

Aquic Haploxerands.—These soils are like Typic Haploxerands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States. They are known to occur in Washington and Oregon.

Calcic Haploxerands.—These soils are like Typic Haploxerands, but they have a calcic horizon that has its upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils have not been recognized in the United States. They are established for use in other countries.

Humic Haploxerands.—These soils are like Typic Haploxerands, but they have a melanic, mollic, or umbric epipedon. They are of small extent in the United States. They are known to occur in California and Washington.

Lithic Haploxerands.—These soils are like Typic Haploxerands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in the United States. They are known to occur in California and Oregon.

Thaptic Haploxerands.—These soils are like Typic Haploxerands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States. They are established for use in other countries.

Ultic Haploxerands.—These soils are like Typic Haploxerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are of small extent in the United States. They are known to occur in California.

Melanoxerands

Melanoxerands are the Xerands that have a melanic epipedon and a 1500 kPa water retention of 15 percent or more on air-dried samples and 30 percent or more on undried samples throughout more than 30 percent of the upper part.

Melanoxerands have a melanic epipedon and commonly have a cambic horizon.

Most of the Melanoxerands in the United States developed in late-Pleistocene or Holocene deposits. Most formed under forest or savanna vegetation.

Definition

Melanoxerands are the Xerands that:

1. Have a melanic epipedon; *and*

2. Do not have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

   a. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

   b. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DDBA. Melanoxerands that have more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout a layer 50 cm or more thick within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Pachic Melanoxerands

DDBB. Other Melanoxerands.

Typic Melanoxerands

Definition of Typic Melanoxerands

Typic Melanoxerands are the Melanoxerands that do not have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm, excluding any overlying layers that do not have andic soil properties.

Description of Subgroups

Typic Melanoxerands.—The central concept or Typic subgroup of Melanoxerands is fixed on soils that have a melanic epipedon and do not have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm below the mineral soil surface or below the top of an organic layer with andic soil properties, whichever is shallower.

These soils commonly support coniferous forest vegetation. They are not extensive in the United States. They are known to occur in Washington and California. Most of the soils are used as woodland or have been cleared and are used as cropland or pasture.

Pachic Melanoxerands.—These soils are like Typic Melanoxerands, but they have both more than 6.0 percent organic carbon and the colors of a mollic epipedon throughout at least 50 cm of the upper 60 cm below the mineral soil surface or below the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in the United States. They are known to occur in Washington and California.

Vitrixerands

Vitrixerands are the relatively coarse textured Xerands. These are relatively young soils that in many areas occur near volcanoes. The soils are moderately extensive in the United States. They are mostly in Oregon, Washington, and Idaho. These soils formed mainly under coniferous forest vegetation.

Commonly, Vitrixerands have an ochric or mollic epipedon and a cambic horizon.

Most of the Vitrixerands in the United States developed in Holocene or late-Pleistocene deposits.

Definition

Vitrixerands are the Xerands that have a 1500 kPa water retention of less than 15 percent on air-dried samples and less than 30 percent on undried samples throughout 60 percent or more of the thickness *either*:

1. Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

2. Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Key to Subgroups

DDAA. Vitrixerands that have a lithic contact within 50 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Lithic Vitrixerands

DDAB. Other Vitrixerands that have, in one or more horizons at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. 2 percent or more redox concentrations; *or*

2. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

3. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Vitrixerands

DDAC. Other Vitrixerands that have, at a depth between 25 and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, underlying one or more horizons with a total thickness of 10 cm or more that have a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more (absolute) lower.

Thaptic Vitrixerands

DDAD. Other Vitrixerands that have *both*:

1. A melanic, mollic, or umbric epipedon; *and*

2. An argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Humic Vitrixerands

DDAE. Other Vitrixerands that have an argillic or kandic horizon that has *both*:

1. An upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. A base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire argillic or kandic horizon if it is less than 50 cm thick.

Ultic Vitrixerands

DDAF. Other Vitrixerands that have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Alfic Vitrixerands

DDAG. Other Vitrixerands that have a melanic, mollic, or umbric epipedon.

Humic Vitrixerands

DDAH. Other Vitrixerands.

Typic Vitrixerands

Definition of Typic Vitrixerands

Typic Vitrixerands are the Vitrixerands that:

1. Do not have a lithic contact within 50 cm of the soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have, in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, both aquic conditions and *any* of the following:

a. 2 percent or more redox concentrations; *or*

b. A color value, moist, of 4 or more and 50 percent or more chroma of 2 or less either in redox depletions on faces of peds or in the matrix if peds are absent; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have, at a depth between 25 and 100 cm from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a layer 10 cm or more thick with more than 3.0 percent organic carbon and the colors of a mollic epipedon throughout, occurring below a horizon or horizons 10 cm or more thick with a color value, moist, 1 unit or more higher and an organic-carbon content 1 percent or more lower;

4. Do not have an argillic or kandic horizon that has its upper boundary within 125 cm of the mineral soil surface or of the upper boundary of an organic layer with andic soil properties, whichever is shallower; *and*

5. Do not have a melanic, mollic, or umbric epipedon.

Description of Subgroups

Typic Vitrixerands.—The central concept or Typic subgroup of Vitrixerands is fixed on moderately deep or deep soils that have an ochric epipedon and do not have an argillic horizon. Soils that have, at a depth between 40 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, a dark colored layer 10 cm or more thick with more than 3.0 percent organic carbon, underlying one or more lighter colored horizons with a total thickness of 10 cm or more and a lower content of organic carbon, are excluded from the Typic subgroup.

Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have both aquic conditions (or artificial drainage) and redox features in any horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower, are excluded from the Typic subgroup and are considered intergrades to Aquands.

Typic Vitrixerands commonly support coniferous forest vegetation. Most are used for timber production, but some have been cleared and are used as cropland.

Alfic Vitrixerands.—These soils are like Typic Vitrixerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. These soils are rare in the United States.

Alfic Humic Vitrixerands.—These soils are like Typic Vitrixerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of 35 percent or more in some part of the upper 50 cm or in the entire horizon if it is less than 50 cm thick. They also have a melanic, mollic, or umbric epipedon. These soils are rare in the United States.

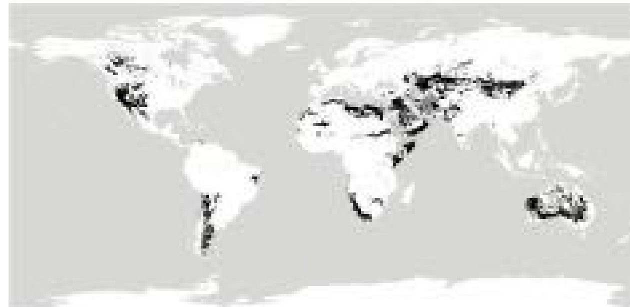
Aquic Vitrixerands.—These soils are like Typic Vitrixerands, but they have both aquic conditions (or artificial drainage) and redox features in a horizon at a depth between 50 and 100 cm either from the mineral soil surface or from the top of an organic layer with andic soil properties, whichever is shallower. These soils are rare in the United States. They are known to occur in Washington and Oregon.

Humic Vitrixerands.—These soils are like Typic Vitrixerands, but they have a melanic, mollic, or umbric epipedon. They are moderately extensive in the United States. They are known to occur in Oregon, California, and Washington.

Lithic Vitrixerands.—These soils are like Typic Vitrixerands, but they have a lithic contact within 50 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower. These soils are of small extent in the United States. They are known to occur in California and Oregon.

Thaptic Vitrixerands.—These soils are like Typic Vitrixerands, but they have, between depths of 25 and 100 cm, a buried, dark colored layer 10 cm or more thick below a lighter colored horizon or horizons 10 cm or more thick with a lower content of organic carbon. These soils have not been recognized in the United States. They are established for use in other countries.

Ultic Vitrixerands.—These soils are like Typic Vitrixerands, but they have an argillic or kandic horizon that has both an upper boundary within 125 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, and a base saturation (by sum of cations) of less than 35 percent throughout the upper 50 cm or throughout the entire horizon if it is less than 50 cm thick. These soils are of small extent in the United States. They are known to occur in California.



CHAPTER 11

Aridisols[1]

Aridisols, as their name implies, are soils in which water is not available to mesophytic plants for long periods. During most of the time when the soils are warm enough for plants to grow, soil water is held at potentials less than the permanent wilting point or has a content of soluble salts great enough to limit the growth of plants other than halophytes, or both. There is no period of 90 consecutive days when moisture is continuously available for plant growth.

The concept of Aridisols is based on limited soil moisture available for the growth of most plants. In areas bordering deserts, the absolute precipitation may be sufficient for the growth of some plants. Because of runoff or a very low storage capacity of the soils, or both, however, the actual soil moisture regime is aridic.

Soil moisture and to a lesser extent soil temperature regimes control processes in soils. In the other soil orders, soil moisture regimes are used at the suborder level or the lower categories, but in the Aridisols they are used to define the order category. The result is a rather homogeneous class in the sense that additions, removals, transfers, and transformations within the soils are strongly influenced by the lack of moisture. Aridisols require a minimum degree of soil formation. This is commonly expressed as a cambic horizon. Because the soil moisture regime is the single most important constraint in the utilization of these soils, this order delineates geographic areas that have relatively uniform use.

Because of an extreme imbalance between evapotranspiration and precipitation, many Aridisols contain salts. The dominant process is one of accumulation and concentration of weathering products. The accumulation of salts is the second most important constraint to land use. Many soluble precipitates may be eliminated or changed in concentration through irrigation. In Aridisols, however, the availability of adequate quality irrigation water is a fundamental problem. Together with irrigation, a mechanism for evacuation of the soluble precipitates must be provided or there is a rapid buildup of salinity and/or sodicity. Irrigation and drainage systems must be well maintained to keep the soils from reverting to their original state.

The classification of Aridisols must include consideration of these constraints or performance restrictive qualities at a high categoric level. Some Aridisols are also situated on geologic evaporites. It is frequently difficult to bring these substratum conditions into a classification system, but care must be taken to evaluate these deep-seated salt accumulations, particularly in irrigation projects.

Some Aridisols have inherited features, such as an argillic horizon, that may be attributed to past wetter paleoclimatic conditions. There is evidence, however, that clay illuviation has also occurred during the Holocene. These attributes, and specifically an argillic horizon, significantly affect the use and management of the soils.

In the definition of suborders, emphasis is given to the redistribution of soluble materials and their accumulation. Four of the seven suborders are defined on the basis of the composition and accumulation of the soluble fraction. Weathering and clay translocation also take place in Aridisols. Two suborders reflect these processes. The seven suborders are:

1. Cryids—Aridisols in cold areas
2. Salids—accumulation of salts more soluble than gypsum
3. Durids—accumulation of silica
4. Gypsids—accumulation of gypsum
5. Argids—accumulation of clay
6. Calcids—accumulation of carbonates
7. Cambids—translocation and/or transformation of material

The great group level reflects the degree of expression of the horizons of accumulation and/or the results of other processes that are considered subordinate to the particular suborder. The defining element is the degree of expression of the diagnostic horizon.

Definition of Aridisols and Limits Between Aridisols and Soils of Other Orders

1. Unlike Inceptisols and Entisols, Aridisols have:

   a. An aridic soil moisture regime; *and*

   b. An ochric or anthropic epipedon; *and*

   c. One or more of the following with the upper boundary within 100 cm of the soil surface: a cambic horizon with its lower boundary at a depth of 25 cm or more; a cryic

[1] This chapter was rewritten in 1994 following recommendations of the International Committee on Aridisols (ICOMID), chaired by Dr. A. Osman. Major contributions were made by Dr. H. Eswaran, J. Nichols, and Dr. Mohammad Ilaiwi.

temperature regime and a cambic horizon; a calcic, gypsic, petrocalcic, petrogypsic, or salic horizon; or a duripan; *or*

d. An argillic or natric horizon; *or*

e. A salic horizon; *and*

(1) Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

(2) A moisture control section that is dry in some or all parts at some time in normal years; *and*

(3) No sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface;

2. Unlike Histosols, Aridisols do not have organic soil materials that meet one or more of following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more;

3. Unlike Gelisols, Aridisols do not have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

4. Unlike Spodosols, Aridisols do not have *either*:

a. A spodic horizon and an albic horizon in 50 percent or more of each pedon; *or*

b. An Ap horizon containing 85 percent or more spodic materials;

5. Unlike Andisols, Aridisols do not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a depth of 60 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon, whichever is shallower;

6. Unlike Oxisols, Aridisols do not have within 150 cm of the mineral soil surface either an oxic horizon or a kandic horizon that meets the weatherable-mineral requirements for an oxic horizon and also do not have 40 percent or more clay in the surface 18 cm after mixing;

7. Unlike Vertisols, Aridisols do not have all of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically;

8. Unlike Alfisols and Ultisols, Aridisols have an aridic soil moisture regime;

9. Unlike Mollisols, Aridisols do not have a mollic epipedon.

Representative Pedon and Data

Following is a description of a representative Aridisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Aridisol."

Classification: Coarse-loamy, carbonatic, thermic Ustic Haplocalcid
Site identification number: 40A3562
Location: Cochise County, Arizona; 5.6 km east and 22.5 km south of Willcox, Arizona; 320 m north and 180 m east of the S1/4 corner of sec. 11, T. 16 S., R. 24 E.
Slope: 3 percent
Elevation: 1,293 m above m.s.l.
Annual precipitation: 280 mm
Soil moisture regime: Aridic
Air temperature: Average annual—14 ^{o}C; summer—17 ^{o}C; winter—12 ^{o}C
Drainage class: Well drained
Land use: Cropland
Runoff class: Low
Particle-size control section: 56 to 100 cm
Parent material: Mixed alluvium derived from andesite, limestone, and quartzite

Diagnostic horizons: An ochric epipedon from a depth of 0 to 56 cm and a calcic horizon from a depth of 56 to 269 cm
Described by: J. Jay and M.L. Richardson

In the following pedon description, colors are for dry soil unless otherwise indicated. Field determination of pH was made by a colormetric method.

Ap1—0 to 33 cm; light brownish gray (10YR 6/2) loam, brown (10YR 4/3) moist; moderate fine granular structure; slightly hard, friable, slightly plastic; many fine to coarse roots; many fine interstitial pores; continuous violent effervescence; moderately alkaline (pH 8.2); gradual smooth boundary.

Ap2—33 to 56 cm; light brownish gray (10YR 6/2) loam, brown (10YR 4/3) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; many fine to coarse roots; many fine interstitial pores; continuous violent effervescence; moderately alkaline (pH 8.2); abrupt irregular boundary.

Bk1—56 to 81 cm; pale brown (10YR 6/3) and white (10YR 8/2) loam, brown (10YR 5/3) and 1 percent pale brown (10YR 6/3) moist; massive; extremely hard, firm, nonsticky and slightly plastic; many fine to coarse roots; many very fine and fine tubular pores; continuous violent effervescence; 50 to 60 percent medium and large carbonate masses that are extremely hard and slightly rigid; strongly alkaline (pH 8.8); gradual smooth boundary.

Bk2—81 to 107 cm; white (10YR 8/2) and pinkish gray (7.5YR 7/2) clay loam, light brown (7.5YR 6/4) moist; weak fine subangular blocky structure; very hard, friable, slightly sticky and slightly plastic; many fine to coarse roots; many very fine and fine tubular pores; continuous violent effervescence; approximately 9 percent carbonate masses that are extremely hard and slightly rigid; strongly alkaline (pH 8.6); gradual smooth boundary.

Bk3—107 to 135 cm; pinkish white (7.5YR 8/2) loam, light brown (7.5YR 6/4) and pink (7.5YR 7/4) moist; weak fine subangular blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; many fine to coarse roots; many very fine and fine tubular pores; continuous violent effervescence; 50 to 60 percent 5- to 25-mm, rounded and irregularly shaped carbonate masses; strongly alkaline (pH 8.6); clear smooth boundary.

Bk4—135 to 269 cm; white (10YR 8/2) and pink (7.5YR 7/4) clay loam, light brown (7.5YR 6/4) moist; weak fine subangular blocky structure; very hard, extremely firm, slightly sticky and plastic; many fine to coarse roots; many very fine to medium tubular pores; continuous violent effervescence; 10 to 15 percent 6- to 30-mm carbonate masses; strongly alkaline (pH 8.8); clear irregular boundary.

2C—269 to 279 cm; light brown (7.5YR 6/4) clay, brown (7.5YR 4/4) moist; common coarse distinct pink (7.5YR 7/4) mottles; weak fine and medium subangular blocky structure; hard, very firm, very plastic; many fine to coarse roots; common medium and many very fine and fine tubular pores; continuous violent effervescence; strongly alkaline (pH 8.6).

Key to Suborders

GA. Aridisols that have a cryic soil temperature regime.
Cryids, p. 365

GB. Other Aridisols that have a salic horizon that has its upper boundary within 100 cm of the soil surface.
Salids, p. 387

GC. Other Aridisols that have a duripan that has its upper boundary within 100 cm of the soil surface.
Durids, p. 372

GD. Other Aridisols that have a gypsic or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface and do not have a petrocalcic horizon overlying these horizons.
Gypsids, p. 379

GE. Other Aridisols that have an argillic or natric horizon (deleted text) and do not have a petrocalcic horizon than has an upper boundary within 100 cm of the soil surface.
Argids, p. 331

GF. Other Aridisols that have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.
Calcids, p. 351

GG. Other Aridisols.
Cambids, p. 357

Argids

These are the Aridisols that have an argillic or natric horizon but do not have a duripan or a gypsic, petrocalcic, petrogypsic, or salic horizon within 100 cm of the soil surface. The low water flux and high concentration of salts in many Aridisols hinder clay illuviation. The presence of an argillic horizon commonly is attributed to a moister paleoclimate, although there is evidence that clay illuviation occurred during the Holocene in arid soils. Where the soil moisture regime grades to ustic or xeric, evidence of clay translocation commonly is more readily established. Most of the Argids occur in North America. A few have been recognized in the deserts of North Africa or the Near East.

Characterization Data for an Aridisol

SITE IDENTIFICATION NO.: 40A3562
CLASSIFICATION: COARSE-LOAMY, CARBONATIC, THERMIC USTIC HAPLOCALCID
GENERAL METHODS: 1B1A, 2A1, 2B

-1- -2- -3- -4- -5- -6- -7- -8- -9- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (cm)	HORIZON	(- - -TOTAL - - -) CLAY LT .002	SILT .002 -.05	SAND .05 -2	(- -CLAY- -) FINE LT .0002	CO_3 LT .002	(- -SILT- -) FINE .002 -.02	COARSE .02 -.05	(- - - - -SAND- - - - -) VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	(-COARSE FRACTIONS(mm)-) - - WEIGHT - - 2 -5	5 -20	20 -75	.1- 75	(>2mm) WT PCT OF WHOLE SOIL
			<- - - - Pct of <2mm (3A1)											- - - ->	<- Pct of <75mm(3B1)->				SOIL
4027472	0- 33	Ap1	17.2	32.4	50.4		5.0	17.9	14.5	10.9	17.2	8.4	9.8	4.1	--	--	--	39	--
4027473	33- 56	Ap2	18.3	34.5	47.2		6.0	17.9	16.6	11.9	16.3	7.5	8.1	3.4	--	--	--	35	--
4027474	56- 81	Bk1	29.2	32.9	37.9		15.0	19.8	13.1	9.2	11.6	5.5	7.5	4.1	--	--	--	29	--
4027475	81-107	Bk2	38.1	36.2	25.7		24.0	23.7	12.5	7.3	8.4	3.5	4.1	2.4	--	--	--	18	--
4027476	107-135	Bk3	45.1	31.6	23.3		29.0	20.4	11.2	6.1	8.8	3.2	3.4	1.8	--	--	--	17	--
4027477	135-269	Bk4	50.2	29.4	20.4		33.0	21.1	8.3	5.9	6.6	2.7	3.5	1.7	--	--	--	14	--
4027478	269-279	2C	40.2	34.1	25.7		13.0	24.6	9.5	10.3	9.3	2.8	2.3	1.0	--	--	2	17	2

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B4a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3b <- Percent	(- - DITH-CIT - -) EXTRACTABLE Fe 6C2b of	Al 6G7a <2mm	Mn 6D2a -->	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG - LIMITS -) LL 4F1 Pct	PI 4F <0.4mm	(- BULK DENSITY -) FIELD MOIST 4A5 <- -	1/3 BAR 4A1d g/cc	OVEN DRY 4A1h - - ->	COLE WHOLE SOIL 4D1 cm/cm	(- - -WATER CONTENT - -) FIELD MOIST 4B4 <- - -Pct	1/10 BAR 4B1c of	1/3 BAR 4B1c <2mm	15 BAR 4B2a - ->	WRD WHOLE SOIL 4C1 cm/cm
0- 33	0.90	0.093						0.88	0.86										14.8	
33- 56	0.60	0.067						0.79	0.85										15.6	
56- 81	0.34							0.32	0.52	58	28								15.3	
81-107	0.18							0.29	0.40	45	23								15.3	
107-135	0.16							0.26	0.33										14.7	
135-269	0.11							0.19	0.32										16.3	
269-279	0.03							0.38	0.36										14.6	

DEPTH (cm)	(- NH_4OAc EXTRACTABLE BASES -) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	(- -CEC- -) SUM CATS 5A3a	NH_4-OAc 5A8b	EXCH Na 55D2 Pct	SAR 5E	BASE SATURATION SUM 5C3	NH_4OAc 5C1	CARBONATE AS $CaCO_3$ <2mm 6E1g	<20mm 6E4	$CaSO_4$ AS GYPSUM <2mm 6F1a	<20mm 6F4	SAT PASTE 8C1b	(- - - -PH - - -) $CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- - - - - - - - - - -meq / 100 g - - - - - - - - - - ->								Pct		<- -Pct- >		<- -Pct ->		<- -Pct ->				
0- 33		3.2	1.0	1.7				15.1	4	2	100	100	27						7.8
33- 56		3.3	0.8	2.0				14.5	4	2	100	100	29						8.0
56- 81		3.9	0.8	1.6				9.4	7	2	100	100	46						8.1
81-107		3.6	1.0	1.3				10.9	8	2	100	100	60						8.1
107-135		3.9	1.1	1.5				11.5	7	2	100	100	55						8.1
135-269		4.7	0.9	1.5				9.6	7	2	100	100	58						8.1
269-279		4.7	0.9	2.0				15.4	5	2	100	100	29						8.0

DEPTH (cm)	(- - -WATER EXTRACTED FROM SATURATED PASTE- - -) Ca 6N1b	Mg 6O1b	Na 6P1b	K 6Q1b	CO_3 6I1b	HCO_3 6J1b	F 6U1a	Cl 6K1c	SO_4 6L1c	NO_2 6W1a	NO_3 6M1c	H_2O 8A	TOTAL SALTS EST. 8D5	PRED. ELEC. COND. 8A3a mmhos /cm	ELEC. COND. 8I mmhos /cm
	< - - - - - - - - - - - - - - -meq / liter - - - - - - - - - - - - ->											<- -Pct- ->			
0- 33	18.6	4.0	6.9	0.8	--	2.2		5.0				51.8	0.1	2.83	
33- 56	6.4	1.5	3.4	0.4	--	2.3		2.5				54.3	TR	1.17	
56- 81	5.4	2.0	3.2	0.8	--	2.8		2.2				53.8	TR	1.13	
81-107	2.8	2.2	3.4	0.8	--	2.0		2.2				49.2	TR	1.13	
107-135	5.5	2.6	5.0	1.0	--	2.2		2.2				49.6	TR	1.40	
135-269	5.6	2.2	4.4	1.2	--	2.2		2.1				52.3	TR	1.37	
269-279	4.9	2.0	3.2	0.8	--	1.8		1.7				59.9	TR	1.09	

The chemical data are based on the fraction less than 2 mm in size.

Definition

Argids are the Aridisols that:

1. Have a natric or argillic horizon (deleted text);

2. Have a soil temperature regime warmer than cryic;

3. Do not have a duripan or a gypsic, petrocalcic, petrogypsic, or salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Great Groups

GEA. Argids that have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Petroargids, p. 350

GEB. Other Argids that have a natric horizon.

Natrargids, p. 343

GEC. Other Argids that do not have a densic, lithic, or paralithic contact within 50 cm of the soil surface and have *either*:

1. A clay increase of 15 percent or more (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

2. An argillic horizon that extends to 150 cm or more from the soil surface, that does not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content, and that has, in 50 percent or more of the matrix in some part between 100 and 150 cm, *either*:

a. Hue of 7.5YR or redder and chroma of 5 or more; *or*

b. Hue of 7.5YR or redder and value, moist, of 3 or less and value, dry, of 4 or less.

Paleargids, p. 346

GED. Other Argids that have a gypsic horizon that has its upper boundary within 150 cm of the soil surface.

Gypsiargids, p. 337

GEE. Other Argids that have a calcic horizon that has its upper boundary within 150 cm of the soil surface.

Calciargids, p. 333

GEF. Other Argids.

Haplargids, p. 339

Calciargids

These are the Argids that, below the argillic horizon, have a calcic horizon within 150 cm of the soil surface. These soils have been recharged with calcium carbonate from dust. Calciargids are commonly on late-Pleistocene erosional surfaces or on gentle to steep slopes. Before the International Committee on Aridisols (ICOMID) was established, these soils were classified as Haplargids.

Definition

Calciargids are the Argids that:

1. Have a calcic horizon that has its upper boundary within 150 cm of the soil surface;

2. Do not have a natric horizon;

3. Do not have a duripan or a gypsic, petrocalcic, or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface;

4. Have a densic, lithic, or paralithic contact within 50 cm of the soil surface; *or*

a. A clay increase of less than 15 percent (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

b. An argillic horizon that does not extend to 150 cm from the soil surface, has a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content, or has *either*:

(1) Hue of 10YR or yellower or chroma of 4 or less in the matrix of all horizons between depths of 100 and 150 cm; *or*

(2) Hue of 10YR or yellower and value, moist, of 4 or more or value, dry, of 4 or less in less than 50 percent of the matrix.

Key to Subgroups

GEEA. Calciargids that have a lithic contact within 50 cm of the soil surface.

Lithic Calciargids

GEEB. Other Calciargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the

soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Xerertic Calciargids

GEEC. Other Calciargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Ustertic Calciargids

GEED. Other Calciargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower.

Vertic Calciargids

GEEE. Other Calciargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Calciargids

GEEF. Other Calciargids that have:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and a soil moisture regime that borders on ustic.

Arenic Ustic Calciargids

GEEG. Other Calciargids that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Calciargids

GEEH. Other Calciargids that have the following combination of characteristics:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Durinodic Xeric Calciargids

GEEI. Other Calciargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Calciargids

GEEJ. Other Calciargids that:

1. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric; *and*

2. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Xeric Calciargids

GEEK. Other Calciargids that:

1. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic; *and*

2. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more,

that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Ustic Calciargids

GEEL. Other Calciargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Calciargids

GEEM. Other Calciargids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calciargids

GEEN. Other Calciargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calciargids

GEEO. Other Calciargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Calciargids

GEEP. Other Calciargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Calciargids

GEEQ. Other Calciargids.

Typic Calciargids

Definition of Typic Calciargids

Typic Calciargids are the Calciargids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

3. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

4. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

5. Do not have a sandy or sandy-skeletal particle-size class in all layers extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more;

6. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

7. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Calciargids.—These soils are among the driest of the Calciargids. Soils in which the soil moisture regime borders on ustic or xeric are more moist and are the basis for the Ustic and Xeric subgroups. Typic Calciargids do not have a high shrink-swell potential or a lithic contact within 50 cm of the soil surface. They do not have a significant amount of durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments. They do not have a layer that is partially cemented by silica. They do not have a thick sandy surface horizon and are not saturated for 1 month in normal years. These soils occur in the deserts of the western part of the United States and are used for grazing.

Aquic Calciargids.—These are the Calciargids that are saturated within 100 cm of the soil surface for short periods but are dry enough to meet the requirements of an aridic soil moisture regime. These soils do not have a high shrink-swell potential or a lithic contact within 50 cm of the soil surface. They are rare in the world.

Arenic Calciargids.—These are the Calciargids that have a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more and have a soil moisture regime that does not border on ustic. These soils do not have a lithic contact within 50 cm of the surface and are not saturated within 100 cm of the soil surface. They are known to occur in the desert of California.

Arenic Ustic Calciargids.—These are the Calciargids that have a sandy or sandy-skeletal particle-size class from the surface to a depth of 50 cm or more and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or aquic conditions for more than 1 month per year within 100 cm of the soil surface.

Durinodic Calciargids.—These are the Calciargids that have a horizon with 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils do not have a lithic contact within 50 cm of the soil surface and are not saturated within 100 cm of the soil surface for 1 month or more in normal years. Durinodic Calciargids do not have thick sandy horizons from the surface to a depth of 50 cm or more, nor do they have a high shrink-swell potential. These soils occur in Nevada and Idaho and are used primarily for grazing by livestock.

Durinodic Xeric Calciargids.—These are the Calciargids that have a horizon with 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils have a soil moisture regime that borders on xeric. They do not have a lithic contact within 50 cm of the soil surface and are not saturated within 100 cm of the soil surface for 1 month or more in normal years. Durinodic Xeric Calciargids do not have thick sandy horizons from the surface to a depth of 50 cm or more, nor do they have a high shrink-swell potential. These soils occur in Nevada and Idaho and are used primarily for grazing by livestock.

Lithic Calciargids.—These are the Calciargids that have a lithic contact within 50 cm of the soil surface. These soils occur in several States in the southwestern part of the United States. They are commonly used for grazing by livestock.

Petronodic Calciargids.—These are the Calciargids that have one or more horizons, 15 cm or more thick, that have 20 percent or more (by volume) nodules or concretions. The nodules and concretions are not cemented by silica (durinodes). These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated within 100 cm of the soil surface, nor do they have thick sandy layers starting at the soil surface. Petronodic Calciargids do not have a soil moisture regime that borders on ustic or xeric. These soils occur in California, Arizona, and New Mexico and are used as rangeland.

Petronodic Ustic Calciargids.—These are the Calciargids that have, in one or more horizons with a combined thickness of 15 cm or more, 20 percent or more (by volume) nodules or concretions and that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface, or durinodes or brittleness. Petronodic Ustic Calciargids occur in Arizona and New Mexico.

Petronodic Xeric Calciargids.—These are the Calciargids that have a soil moisture regime that borders on xeric and have one or more horizons, 15 cm or more thick, that have 20 percent or more (by volume) nodules or concretions. The nodules and concretions are not cemented by silica (durinodes). These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. Petronodic Xeric Calciargids are not saturated within 100 cm of the soil surface, nor do they have thick sandy layers starting at the soil surface. These soils are moderately extensive in Idaho and are used as irrigated cropland, pasture, or rangeland.

Ustertic Calciargids.—These are the Calciargids that have a high shrink-swell potential and a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in the southwestern part of the United States and are commonly used as rangeland.

Ustic Calciargids.—These are the Calciargids that have a soil moisture regime that borders on ustic. These soils do not have many other distinguishing characteristics, such as a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an accumulation of durinodes, concretions, or nodules; or a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments near the surface. These soils occur in various States throughout the southwestern part of the United States. They are extensive and are used as irrigated cropland, pasture, or rangeland.

Vertic Calciargids.—These are the Calciargids that have a high shrink-swell potential but do not have a soil moisture regime that borders on ustic or xeric. These soils also do not have a lithic contact within 50 cm of the soil surface. Vertic

Calciargids occur in the southwestern part of the United States.

Vitrandic Calciargids.—These are the Calciargids that have a layer 18 cm or more thick in the upper 75 cm with a significant amount of volcanic glass, pumice, cinders, and pumicelike fragments. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an accumulation of nodules, concretions, or durinodes; or a soil moisture regime that borders on xeric. These soils occur in the southwestern part of the United States, in areas that have a volcanic influence.

Vitrixerandic Calciargids.—These are the Calciargids that have a layer 18 cm or more thick in the upper 75 cm with a significant amount of volcanic glass, pumice, cinders, and pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or an accumulation of nodules, concretions, or durinodes. They occur in the southwestern part of the United States, in areas that have a volcanic influence.

Xerertic Calciargids.—These are the Calciargids that have a high shrink-swell potential and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface.

Xeric Calciargids.—These are the Calciargids that have a soil moisture regime that borders on xeric. These soils do not have many other distinguishing characteristics, such as a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an accumulation of durinodes, concretions, or nodules; or a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments near the surface. These soils occur in various States throughout the western part of the United States. They are extensive and are used as irrigated cropland, pasture, or rangeland.

Gypsiargids

Gypsiargids are the Argids that have a gypsic horizon within 150 cm of the soil surface. Most of these soils are on late-Pleistocene surfaces. In the United States, they are of minor extent and are known to occur in northwestern New Mexico and possibly in other States in the Four Corners area.

Definition

Gypsiargids are the Argids that:

1. Have a gypsic horizon that has its upper boundary within 150 cm of the soil surface;

2. Do not have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface;

3. Do not have a natric horizon;

4. Have a densic, lithic, or paralithic contact within 50 cm of the soil surface; *or*

a. A clay increase of less than 15 percent (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

b. An argillic horizon that does not extend to 150 cm from the soil surface, has a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content, or has *either*:

(1) Hue of 10YR or yellower or chroma of 4 or less in the matrix of all horizons between depths of 100 and 150 cm; *or*

(2) Hue of 10YR or yellower and value, moist, of 4 or more or value, dry, of 4 or less in less than 50 percent of the matrix.

Key to Subgroups

GEDA. Gypsiargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Are saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Gypsiargids

GEDB. Other Gypsiargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that either contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Gypsiargids

GEDC. Other Gypsiargids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Gypsiargids

GEDD. Other Gypsiargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Gypsiargids

GEDE. Other Gypsiargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Gypsiargids

GEDF. Other Gypsiargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Gypsiargids

GEDG. Other Gypsiargids.

Typic Gypsiargids

Definition of Typic Gypsiargids

Typic Gypsiargids are the Gypsiargids that:

1. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

2. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist;

3. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Gypsiargids.—The Typic subgroup is centered on the soils that are not saturated for 1 month or more within 100 cm of the soil surface in normal years, that do not have a soil moisture regime that borders on ustic or xeric, that do not have durinodes or brittleness, and that do not have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments close to the surface.

Aquic Gypsiargids.—These are the Gypsiargids that are saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils are very rare in the world.

Durinodic Gypsiargids.—These are the Gypsiargids that have one or more horizons, 15 cm or more thick, that have 20 percent or more durinodes or are brittle and firm when moist. The brittleness and firm rupture-resistance class in these soils are attributed to partial cementation by silica.

Ustic Gypsiargids.—These are the Gypsiargids that have a soil moisture regime that borders on ustic. Because of the added moisture, these soils are more productive than soils in the Typic subgroup. Ustic Gypsiargids do not have an accumulation of durinodes or brittleness; a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments near the surface; or saturation for 1 month or more within 100 cm of the soil surface in normal years.

Vitrandic Gypsiargids.—These are the Gypsiargids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years and do not have brittleness or an accumulation of durinodes.

Vitrixerandic Gypsiargids.—These are the Gypsiargids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years and do not have brittleness or durinodes.

Xeric Gypsiargids.—These are the Gypsiargids that have a soil moisture regime that borders on xeric. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years and do not have brittleness or an accumulation of durinodes. They also do not have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Haplargids

These are the Argids that have an argillic horizon but do not have a duripan or a petrocalcic, petrogypsic, calcic, gypsic, or natric horizon. These soils commonly have calcium carbonate accumulations within or below the argillic horizon. Haplargids commonly occur on late-Pleistocene surfaces or sediments.

Definition

Haplargids are the Argids that:

1. Do not have a duripan or a petrocalcic, petrogypsic, gypsic, or calcic horizon that has an upper boundary within 150 cm of the soil surface;

2. Do not have a natric horizon;

3. Have a densic, lithic, or paralithic contact within 50 cm of the soil surface; *or*

a. A clay increase of less than 15 percent (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

b. An argillic horizon that does not extend to 150 cm from the soil surface, has a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content, or has *either*:

(1) Hue of 10YR or yellower or chroma of 4 or less in the matrix of all horizons between depths of 100 and 150 cm; *or*

(2) Hue of 10YR or yellower and value, moist, of 4 or more or value, dry, of 4 or less in less than 50 percent of the matrix.

Key to Subgroups

GEFA. Haplargids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. An argillic horizon that is discontinuous throughout each pedon.

Lithic Ruptic-Entic Haplargids

GEFB. Other Haplargids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Lithic Xeric Haplargids

GEFC. Other Haplargids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Lithic Ustic Haplargids

GEFD. Other Haplargids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplargids

GEFE. Other Haplargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Xerertic Haplargids

GEFF. Other Haplargids that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Ustertic Haplargids

GEFG. Other Haplargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm

or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower.

Vertic Haplargids

GEFH. Other Haplargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplargids

GEFI. Other Haplargids that have:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher and a soil moisture regime that borders on ustic.

Arenic Ustic Haplargids

GEFJ. Other Haplargids that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Haplargids

GEFK. Other Haplargids that have:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ^{o}C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Durinodic Xeric Haplargids

GEFL. Other Haplargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplargids

GEFM. Other Haplargids that:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher and have a soil moisture regime that borders on ustic.

Petronodic Ustic Haplargids

GEFN. Other Haplargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplargids

GEFO. Other Haplargids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ^{o}C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplargids

GEFP. Other Haplargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplargids

GEFQ. Other Haplargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Haplargids

GEFR. Other Haplargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Haplargids

GEFS. Other Haplargids.

Typic Haplargids

Definition of Typic Haplargids

Typic Haplargids are the Haplargids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have an argillic horizon that is continuous throughout each pedon;

3. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

4. Have:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *and*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower;

5. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

6. Do not have a sandy or sandy-skeletal particle-size class in all layers extending from the soil surface to the top of an argillic horizon at a depth of 50 cm or more;

7. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

8. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Haplargids.—The Typic subgroup is centered on soils that are moderately deep or deeper and have a soil moisture regime that borders on neither ustic nor xeric. These soils do not have a high shrink-swell potential; saturation within 100 cm of the soil surface for 1 month or more in normal years; horizons with a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm; or horizons with significant accumulations of durinodes, concretions, nodules, volcanic glass, pumice, cinders, or pumicelike fragments.

Aquic Haplargids.—These are the Haplargids that are saturated within 100 cm of the soil surface for 1 month or more in normal years but are dry for most of the year. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur on stream terraces in Idaho and California.

Arenic Haplargids.—These are the Haplargids that have a sandy or sandy-skeletal particle-size class from the surface to a depth of 50 cm or more and do not have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in California and are used as rangeland.

Arenic Ustic Haplargids.—These are the Haplargids that have a sandy or sandy-skeletal particle-size class from the surface to a depth of 50 cm or more and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Texas, New Mexico, and Colorado and are used as rangeland.

Durinodic Haplargids.—These are the Haplargids that have one or more horizons, at least 15 cm thick, that have 20 percent or more durinodes or are brittle and at least firm when moist. These soils do not have a soil moisture regime that borders on xeric and do not have a high shrink-swell potential. They do not have a lithic contact within 50 cm of the soil surface or thick sandy horizons from the soil surface to a depth of 50 cm or more. They are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Nevada and California. They are used primarily as rangeland, but in some areas they are used for urban development or irrigated cropland.

Durinodic Xeric Haplargids.—These are the Haplargids that have one or more horizons, at least 15 cm thick, that have 20 percent or more durinodes or are brittle and at least firm when moist. These soils have a soil moisture regime that borders on xeric. They do not have a lithic contact within 50 cm of the soil surface; thick sandy horizons from the soil surface to a depth of 50 cm or more; or a high shrink-swell potential. They are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Nevada, Idaho, and California. They are used primarily as rangeland, but in some areas they are used for urban development or irrigated cropland.

Lithic Haplargids.—These are the Haplargids that have a lithic contact within 50 cm of the soil surface. These soils have a continuous argillic horizon and do not have a soil moisture regime that borders on ustic or xeric. They occur in the hot to cool deserts in the western part of the United States and are used primarily as rangeland.

Lithic Ruptic-Entic Haplargids.—These are the Haplargids that have a lithic contact within 50 cm of the soil surface and have a discontinuous argillic horizon. These soils occur in Nevada and are used primarily as rangeland.

Lithic Ustic Haplargids.—These are the Haplargids that have a lithic contact within 50 cm of the soil surface, a continuous argillic horizon, and a soil moisture regime that borders on ustic. These soils occur in the deserts of the southwestern part of the United States and are used primarily as rangeland.

Lithic Xeric Haplargids.—These are the Haplargids that have a lithic contact within 50 cm of the soil surface, a continuous argillic horizon, and a soil moisture regime that borders on xeric. These soils occur in Nevada, California, and Idaho and are used primarily as rangeland.

Petronodic Haplargids.—These are the Haplargids that have one or more horizons, 15 cm or more thick, that have 20 percent or more, by volume, nodules and concretions. These soils do not have durinodes or brittleness and at least a firm rupture-resistance class when moist. They do not have a lithic contact within 50 cm of the surface or a high shrink-swell potential. They are not sandy or sandy-skeletal from the soil surface to a depth of 50 cm or more, do not have a soil moisture regime that borders on ustic, and are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Arizona and New Mexico and are used primarily as rangeland.

Petronodic Ustic Haplargids.—These are the Haplargids that have, in one or more horizons with a total thickness of 15 cm or more, 20 percent or more nodules and concretions and that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the mineral soil surface, are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years, and do not have durinodes or brittleness. They occur in Arizona and New Mexico.

Ustertic Haplargids.—These are the Haplargids that have a high shrink-swell potential and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in the deserts of the southwestern part of the United States and are used primarily as rangeland.

Ustic Haplargids.—These are the Haplargids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of volcanic glass, cinders, pumice, pumicelike fragments, durinodes, concretions, or nodules. Ustic Haplargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils are extensive in the southwestern part of the United States.

Vertic Haplargids.—These are the Haplargids that have a high shrink-swell potential but do not have a soil moisture regime that borders on xeric or ustic. These soils also do not have a lithic contact within 50 cm of the soil surface. They occur in the western part of the United States.

Vitrandic Haplargids.—These are the Haplargids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons with a total thickness of 18 cm within 75 cm of the soil surface. These soils do not have a soil moisture regime that borders on xeric; a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a significant amount of durinodes, nodules, or concretions; or a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more. These soils are rare but occur in the western part of the United States, in areas with a volcanic influence.

Vitrixerandic Haplargids.—These are the Haplargids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons with a total thickness of 18 cm within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a significant amount of durinodes, nodules, or concretions; or a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more. They are rare but occur in the western part of the United States, in areas with a volcanic influence.

Xerertic Haplargids.—These are the Haplargids that have a high shrink-swell potential and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in Nevada and Idaho and are used primarily as rangeland.

Xeric Haplargids.—These are the Haplargids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of volcanic glass, durinodes, concretions, or nodules. Xeric Haplargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They are extensive in Oregon, Nevada, and Idaho.

Natrargids

These are the Argids that have a natric horizon but do not have a duripan or a petrocalcic or petrogypsic horizon within 150 cm of the soil surface. Commonly, the natric horizon has prismatic or columnar structure. Natrargids commonly contain carbonates, soluble salts, or both. These soils formed in sediments that range in age from Holocene to late-Pleistocene. Most of them are nearly level to gently sloping. These soils occur in the western part of the United States and on the western edge of the Great Plains.

Definition

Natrargids are the Argids that:

1. Have a natric horizon;

2. Do not have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Key to Subgroups

GEBA. Natrargids that have *both* of the following:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Lithic Xeric Natrargids

GEBB. Other Natrargids that have *both* of the following:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Lithic Ustic Natrargids

GEBC. Other Natrargids that have a lithic contact within 50 cm of the soil surface.

Lithic Natrargids

GEBD. Other Natrargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrargids

GEBE. Other Natrargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natrargids

GEBF. Other Natrargids that meet *both* of the following:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Durinodic Xeric Natrargids

GEBG. Other Natrargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Natrargids

GEBH. Other Natrargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Natrargids

GEBI. Other Natrargids that have:

1. Skeletans covering 10 percent or more of the surfaces of

peds at a depth 2.5 cm or more below the upper boundary of the natric horizon; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Glossic Ustic Natrargids

GEBJ. Other Natrargids that have:

1. An exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Haplic Ustic Natrargids

GEBK. Other Natrargids that have:

1. An exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Haploxeralfic Natrargids

GEBL. Other Natrargids that have an exchangeable sodium percentage of less than 15 (or an SAR of less than 13) in 50 percent or more of the natric horizon.

Haplic Natrargids

GEBM. Other Natrargids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natrargids

GEBN. Other Natrargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natrargids

GEBO. Other Natrargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Natrargids

GEBP. Other Natrargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Natrargids

GEBQ. Other Natrargids that have skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon.

Glossic Natrargids

GEBR. Other Natrargids.

Typic Natrargids

Definition of Typic Natrargids

Typic Natrargids are the Natrargids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with

water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

4. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

5. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm;

6. Have skeletans covering less than 10 percent of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon;

7. Have an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) in more than 50 percent of the natric horizon;

8. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Natrargids.—The Typic subgroup is centered on soils that are moderately deep or deeper and have a soil moisture regime that borders on neither ustic nor xeric. These soils have an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon but do not have more than 10 percent skeletans at a depth 2.5 cm or more below the upper boundary of the natric horizon. They also do not have a high shrink-swell potential; saturation within 100 cm of the soil surface for 1 month or more in normal years; or horizons with significant accumulations of durinodes, concretions, nodules, volcanic glass, pumice, cinders, or pumicelike fragments. These soils occur in the southwestern part of the United States as well as southern Argentina.

Aquic Natrargids.—These are the Natrargids that are saturated within 100 cm of the soil surface for 1 month or more in normal years but are dry for most of the year. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur on stream terraces in Nevada, Oregon, Colorado, Montana, Utah, and California.

Durinodic Natrargids.—These are the Natrargids that have one or more horizons, at least 15 cm thick, that have 20 percent or more durinodes or are brittle and at least firm when moist. These soils do not have a soil moisture regime that borders on xeric and do not have a high shrink-swell potential. They do not have a lithic contact within 50 cm of the soil surface. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada and California. They are used primarily as rangeland, but in some areas they are used for urban development or irrigated cropland.

Durinodic Xeric Natrargids.—These are the Natrargids that have one or more horizons, at least 15 cm thick, that have 20 percent or more durinodes or are brittle and at least firm when moist. These soils have a soil moisture regime that borders on xeric but do not have a high shrink-swell potential. They do not have a lithic contact within 50 cm of the soil surface. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada, Idaho, and California. They are used primarily as rangeland, but in some areas they are used for urban development or irrigated cropland.

Glossic Natrargids.—These are the Natrargids that have skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon and have an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon. These soils do not have a soil moisture regime that borders on ustic or xeric. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils do not have a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, nodules, or concretions.

Glossic Ustic Natrargids.—These are the Natrargids that have skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils do not have a significant amount of durinodes, nodules, or concretions. They occur in Montana. They are used as rangeland or irrigated cropland.

Haplic Natrargids.—These are the Natrargids that have an exchangeable sodium percentage of less than 15 in 50 percent or more of the natric horizon but do not have a soil moisture regime that borders on ustic or xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated for 1 month or more within 100 cm of the soil surface. These soils do not have a significant amount of durinodes, nodules, or concretions. They occur in Nevada, New Mexico, and Arizona. They are used primarily as rangeland.

Haplic Ustic Natrargids.—These are the Natrargids that have an exchangeable sodium percentage of less than 15 in 50 percent or more of the natric horizon and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon. Haplic Ustic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface. These soils do not have a significant amount of durinodes, nodules, or concretions. They occur in Wyoming and the Four Corners area of northwestern New Mexico, northeastern Arizona, southeastern Utah, and southwestern Colorado. They are used primarily as rangeland.

Haploxeralfic Natrargids.—These are the Natrargids that have an exchangeable sodium percentage of less than 15 in 50 percent or more of the natric horizon and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon. Haploxeralfic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface. They do not have a significant amount of durinodes, nodules, or concretions. They occur in California and possibly in Nevada. They are used primarily as rangeland.

Lithic Natrargids.—These are the Natrargids that have a lithic contact within 50 cm of the soil surface. These soils do not have a soil moisture regime that borders on ustic or xeric. They occur in the hot to cool deserts in the western part of the United States and are used primarily as rangeland.

Lithic Ustic Natrargids.—These are the Natrargids that have a lithic contact within 50 cm of the soil surface and have a soil moisture regime that borders on ustic. These soils occur in the deserts of the southwestern part of the United States and are used primarily as rangeland.

Lithic Xeric Natrargids.—These are the Natrargids that have a lithic contact within 50 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils occur in Nevada, California, and Idaho and are used primarily as rangeland.

Petronodic Natrargids.—These are the Natrargids that have one or more horizons, 15 cm or more thick, that have 20 percent or more, by volume, nodules and concretions. These soils do not have durinodes or brittleness and at least a firm rupture-resistance class when moist. They do not have a lithic contact within 50 cm of the surface or a high shrink-swell potential. Petronodic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Arizona and New Mexico and are used primarily as rangeland.

Ustic Natrargids.—These are the Natrargids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; skeletans covering 10 percent or more of the surfaces of peds at a depth 2.5 cm or more below the upper boundary of the natric horizon; an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, concretions, or nodules. Ustic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in the southwestern part of the United States as well as southern Argentina.

Vertic Natrargids.—These are the Natrargids that have a high shrink-swell potential. These soils do not have a lithic contact within 50 cm of the soil surface. Because of a high percentage of clay and sodium, these soils are difficult to reclaim and manage. Most of the soils are used as rangeland.

Vitrandic Natrargids.—These are the Natrargids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments in one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface. These soils do not have a soil moisture regime that borders on xeric; a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon; or a significant amount of durinodes, concretions, or nodules. Vitrandic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years.

Vitrixerandic Natrargids.—These are the Natrargids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments in one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon; or a significant amount of durinodes, concretions, or nodules. Vitrixerandic Natrargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years.

Xeric Natrargids.—These are the Natrargids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; an exchangeable sodium percentage of 15 or more in more than 50 percent of the natric horizon; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, concretions, or nodules. Xeric Natrargids are not saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Nevada, Utah, and Idaho and in southern Argentina.

Paleargids

These are the Argids that are on stable land surfaces and have an abrupt textural change or a clay distribution that does not decrease significantly. Most of these soils formed in sediments appreciably older than the late-Pleistocene. If calcareous dust is present, some of these soils may be calcareous in all horizons. Slopes are normally gentle.

Definition

Paleargids are the Argids that:

1. Do not have a densic, lithic, or paralithic contact within 50 cm of the soil surface and that have *either*:

a. A clay increase of 15 percent or more (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

b. An argillic horizon that extends to 150 cm or more from the soil surface, that does not have a clay decrease with increasing depth of 20 percent or more (relative) from the maximum clay content and has, in 50 percent or more of the matrix in some part between depths of 100 and 150 cm, *either*:

(1) Hue of 7.5YR or redder and chroma of 5 or more; *or*

(2) Hue of 7.5YR or redder and value, moist, of 3 or less and value, dry, of 4 or less; *and*

2. Do not have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface; *and*

3. Do not have a natric horizon.

Key to Subgroups

GECA. Paleargids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleargids

GECB. Other Paleargids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Paleargids

GECC. Other Paleargids that have:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Arenic Ustic Paleargids

GECD. Other Paleargids that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Paleargids

GECE. Other Paleargids that have a calcic horizon that has its upper boundary within 150 cm of the soil surface.

Calcic Paleargids

GECF. Other Paleargids that have:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Durinodic Xeric Paleargids

GECG. Other Paleargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Paleargids

GECH. Other Paleargids that:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Petronodic Ustic Paleargids

GECI. Other Paleargids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Paleargids

GECJ. Other Paleargids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Paleargids

GECK. Other Paleargids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Paleargids

GECL. Other Paleargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Paleargids

GECM. Other Paleargids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Paleargids

GECN. Other Paleargids.

Typic Paleargids

Definition of Typic Paleargids

Typic Paleargids are the Paleargids that:

1. Have *both* of the following:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *and*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

3. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

4. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

5. Do not have a calcic horizon that has its upper boundary within 150 cm of the soil surface;

6. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

7. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Paleargids.—The Typic subgroup is centered on the concept of dry soils that do not have a soil moisture regime that borders on ustic or xeric. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm; a calcic horizon; or a significant amount of durinodes, nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments. These soils are not the dominant subgroup of Paleargids. They occur in the deserts of the southwestern part of the United States and in southern Argentina.

Aquic Paleargids.—These are the Paleargids that are saturated for 1 month or more within 100 cm of the soil surface in normal years. These soils do not have a high shrink-swell potential. They commonly have some sodium associated with them. They are rare in the world.

Arenic Paleargids.—These are the Paleargids that have a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more. These soils do not have a soil moisture regime that borders on ustic, do not have a high shrink-swell potential, and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They are rare in the world.

Arenic Ustic Paleargids.—These are the Paleargids that have a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more and have a soil moisture regime that borders on ustic. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They are rare in the world.

Calcic Paleargids.—These are the Paleargids with a calcic horizon that has its upper boundary within 150 cm of the soil surface. These soils do not have a high shrink-swell potential, a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more, or saturation with water for 1 month or more within 100 cm of the soil surface in normal years. These soils occur in Arizona, New Mexico, and Texas.

Durinodic Paleargids.—These are the Paleargids that have one or more horizons, with a combined thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils do not have a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, a calcic horizon, a soil moisture regime that borders on xeric, or a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more.

Durinodic Xeric Paleargids.—These are the Paleargids that have one or more horizons, with a combined thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils also have a soil moisture regime that borders on xeric. They do not have a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, a calcic horizon, or a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more. These soils occur in Oregon.

Petronodic Paleargids.—These are the Paleargids that have one or more horizons, with a combined thickness of 15 cm or more, that contain 20 percent or more nodules or concretions but do not have durinodes. These soils do not have a high shrink-swell potential, a soil moisture regime that borders on ustic, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, a calcic horizon, or a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more. These soils occur in Arizona.

Petronodic Ustic Paleargids.—These are the Paleargids that have, in one or more horizons with a combined thickness of 15 cm or more, 20 percent or more nodules or concretions and that have a soil moisture regime that borders on ustic. These soils do not have a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, a calcic horizon within 150 cm of the soil surface, or durinodes or brittleness within 100 cm of the soil surface. The soils occur mostly in Arizona and New Mexico.

Ustic Paleargids.—These are the Paleargids that have a soil moisture regime that borders on ustic. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a calcic horizon; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, nodules, and concretions. These soils occur in desert areas of the United States and Argentina.

Vertic Paleargids.—These are the Paleargids that have a high shrink-swell potential. They are known to occur in California, Arizona, Nevada, Oregon, and Colorado.

Vitrandic Paleargids.—These are the Paleargids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons with a total thickness of 18 cm within 75 cm of the soil surface. These soils do not have a soil moisture regime that borders on xeric; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a calcic horizon; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of durinodes, nodules, and concretions.

Vitrixerandic Paleargids.—These are the Paleargids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons with a total thickness of 18 cm within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a calcic horizon; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of durinodes, nodules, and concretions.

Xeric Paleargids.—These are the Paleargids that have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a calcic horizon; a sandy or sandy-skeletal particle-size class from the soil surface to a depth of 50 cm or more; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, nodules, and concretions.

These soils occur in desert areas of the United States and Argentina.

Petroargids

These are the Argids that have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary at a depth between 100 and 150 cm from the soil surface. These soils occur on stable landscapes in the western part of the United States and in southern Argentina and western South Africa.

Definition

These are the Argids that have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Key to Subgroups

GEAA. Petroargids that meet *both* of the following:

1. Have a petrogypsic horizon that has its upper boundary within 150 cm of the soil surface; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Petrogypsic Ustic Petroargids

GEAB. Other Petroargids that have a petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Petrogypsic Petroargids

GEAC. Other Petroargids that have:

1. A duripan that has its upper boundary within 150 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Duric Xeric Petroargids

GEAD. Other Petroargids that have a duripan that has its upper boundary within 150 cm of the soil surface.

Duric Petroargids

GEAE. Other Petroargids that have a natric horizon.

Natric Petroargids

GEAF. Other Petroargids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Petroargids

GEAG. Other Petroargids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Petroargids

GEAH. Other Petroargids.

Typic Petroargids

Definition of Typic Petroargids

Typic Petroargids are the Petroargids that:

1. Have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface;

2. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

3. Do not have a duripan or a petrogypsic horizon that has its upper boundary within 150 cm of the soil surface;

4. Do not have a natric horizon.

Description of Subgroups

Typic Petroargids.—These are the Petroargids that have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface. These soils do not have a soil moisture regime that borders on ustic or xeric. They occur in the southwestern part of the United States and in South Africa and Argentina.

Duric Petroargids.—These are the Petroargids that have a duripan. These soils do not have a soil moisture regime that borders on xeric. Many of the soils occur in areas that have a volcanic influence. Duric Petroargids occur in Nevada, New Mexico, and Arizona in the United States and in Australia and South Africa.

Duric Xeric Petroargids.—These are the Petroargids that have a duripan and a soil moisture regime that borders on xeric. Many of these soils occur in areas that have a volcanic influence. Duric Xeric Petroargids occur in Nevada and Idaho.

Natric Petroargids.—These are the Petroargids that have natric and petrocalcic horizons. These soils occur in Argentina and are used mostly for grazing by livestock.

Petrogypsic Petroargids.—These are the Petroargids that have a petrogypsic horizon but do not have a soil moisture regime that borders on ustic. These soils occur in very dry parts of the world where the parent materials are rich in gypsum. They are known to occur in New Mexico as well as Iran and Iraq.

Petrogypsic Ustic Petroargids.—These are the Petroargids that have a petrogypsic horizon and have a soil moisture regime that borders on ustic. These soils are rare in the world.

Ustic Petroargids.—These are the Petroargids that have a petrocalcic horizon and have a soil moisture regime that borders on ustic. These soils occur in Arizona and New Mexico as well as Argentina.

Xeric Petroargids.—These are the Petroargids that have a petrocalcic horizon and have a soil moisture regime that borders on xeric. They are known to occur in Idaho.

Calcids

Calcids are the Aridisols with calcium carbonate that was in the parent materials or was added as dust, or both. Precipitation is insufficient to leach or even move the carbonates to great depths. The upper boundary of the calcic or petrocalcic horizon is normally within 50 cm of the soil surface. If the soils are irrigated and cultivated, micronutrient deficiencies are normal. These soils are extensive in the western part of the United States and in other arid regions of the world.

Definition

Calcids are the Aridisols that:

1. Have a petrocalcic or calcic horizon that has its upper boundary within 100 cm of the soil surface and do not have an argillic or natric horizon with its upper boundary within 100 cm of the soil surface, unless a petrocalcic horizon is within 100 cm of the soil surface;

2. Have a temperature regime warmer than cryic;

3. Do not have a duripan or a salic, gypsic, or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Great Groups

GFA. Calcids that have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Petrocalcids, p. 355

GFB. Other Calcids.

Haplocalcids, p. 351

Haplocalcids

Haplocalcids are the Calcids that have a calcic horizon with its upper boundary within 100 cm of the soil surface. These soils do not have a duripan or an argillic, natric, or petrocalcic horizon within 100 cm of the soil surface. Some of the soils have a cambic horizon above the calcic horizon. Haplocalcids are extensive.

Definition

Haplocalcids are the Calcids that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

GFBA. Haplocalcids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Lithic Xeric Haplocalcids

GFBB. Other Haplocalcids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Lithic Ustic Haplocalcids

GFBC. Other Haplocalcids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocalcids

GFBD. Other Haplocalcids that have:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocalcids

GFBE. Other Haplocalcids that:

1. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

2. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more,

that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Aquic Durinodic Haplocalcids

GFBF. Other Haplocalcids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplocalcids

GFBG. Other Haplocalcids that have:

1. A duripan that has its upper boundary within 150 cm of the surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Duric Xeric Haplocalcids

GFBH. Other Haplocalcids that have a duripan that has its upper boundary within 150 cm of the surface.

Duric Haplocalcids

GFBI. Other Haplocalcids that have:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Durinodic Xeric Haplocalcids

GFBJ. Other Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplocalcids

GFBK. Other Haplocalcids that have:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Petronodic Xeric Haplocalcids

GFBL. Other Haplocalids that:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Petronodic Ustic Haplocalcids

GFBM. Other Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplocalcids

GFBN. Other Haplocalcids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and a soil moisture regime that borders on xeric.

Sodic Xeric Haplocalcids

GFBO. Other Haplocalcids that meet *both* of the following:

1. Have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Sodic Ustic Haplocalcids

GFBP. Other Haplocalcids that have, in a horizon at least 25 cm thick within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplocalcids

GFBQ. Other Haplocalcids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocalcids

GFBR. Other Haplocalcids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocalcids

GFBS. Other Haplocalcids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Haplocalcids

GFBT. Other Haplocalcids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Haplocalcids

GFBU. Other Haplocalcids.

Typic Haplocalcids

Definition of Typic Haplocalcids

Typic Haplocalcids are the Haplocalcids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

3. Have *both* of the following:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *and*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

5. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

6. Do not have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) for 1 month or more in normal years;

7. Do not have a duripan that has its upper boundary within 150 cm of the surface;

8. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Haplocalcids.—The Typic subgroup is centered on dry soils that lack the features that define the other subgroups. These soils do not have a lithic contact with its upper boundary within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; a significant amount of durinodes or brittleness, nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments; an accumulation of sodium; or a soil moisture regime that borders on xeric or ustic. These soils are common in the desert areas of the world.

Aquic Durinodic Haplocalcids.—These are the Haplocalcids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years and have a significant amount of durinodes or brittleness. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are known to occur in California and Nevada.

Aquic Haplocalcids.—These are the Haplocalcids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or a significant amount of durinodes or brittleness. These soils occur in California, Nevada, Idaho, and Utah.

Duric Haplocalcids.—These are the Haplocalcids that have a duripan with an upper boundary between depths of 100 and 150 cm but do not have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years and do not have a significant amount of durinodes or brittleness. These soils are rare in the world.

Duric Xeric Haplocalcids.—These are the Haplocalcids that have a duripan at a depth of 100 to 150 cm and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. Duric Haplocalcids are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years and do not have a significant amount of durinodes or brittleness. These soils are rare in the world.

Durinodic Haplocalcids.—These are the Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class when moist. These soils do not have a soil moisture regime that borders on xeric, a duripan within 150 cm of the soil surface, a lithic contact within 50 cm of the soil surface, or a high shrink-swell potential. They are not saturated with water for 1 month or more within 100 cm of the soil surface. They occur in Nevada, California, and Arizona.

Durinodic Xeric Haplocalcids.—These are the Haplocalcids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class when moist. These soils have a soil moisture regime that borders on xeric. They do not have a duripan within 150 cm of the soil surface, a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or saturation with water for 1 month or more within 100 cm of the soil surface. They occur in Nevada, California, Idaho, and Utah.

Lithic Haplocalcids.—These are the Haplocalcids that have a lithic contact within 50 cm of the soil surface but do not have a soil moisture regime that borders on either xeric or ustic. These soils occur throughout the deserts of the world.

Lithic Ustic Haplocalcids.—These are the Haplocalcids that have a lithic contact within 50 cm of the soil surface and a soil moisture regime that borders on ustic. These soils are common in the semiarid regions of the world. In the United States, they occur in Texas, Utah, and Arizona.

Lithic Xeric Haplocalcids.—These are the Haplocalcids that have a lithic contact within 50 cm of the soil surface and a soil moisture regime that borders on xeric. In the United States, these soils occur in Nevada, Utah, and Idaho.

Petronodic Haplocalcids.—These are the Haplocalcids that have, in one or more horizons with a combined thickness of 15 cm or more, 20 percent or more nodules and concretions but do not have a soil moisture regime that borders on ustic or xeric. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface, a duripan within 150 cm of the soil surface, or durinodes or brittleness. These soils occur in California, Arizona, Nevada, New Mexico, and Idaho.

Petronodic Ustic Haplocalcids.—These are the Haplocalcids that have, in one or more horizons with a combined thickness of 15 cm or more, 20 percent or more nodules and concretions and that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface, a duripan within 150 cm of the soil surface, or durinodes or brittleness. The soils occur in Arizona, New Mexico, and Texas.

Petronodic Xeric Haplocalcids.—These are the Haplocalcids that have, in one or more horizons with a combined thickness of 15 cm or more, 20 percent or more nodules and concretions and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface, a duripan within 150 cm of the soil surface, or durinodes or brittleness. The soils occur in Nevada, Oregon, and Idaho.

Sodic Haplocalcids.—These are the Haplocalcids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and have a soil moisture regime that does not border on either ustic or xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for

1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of durinodes, nodules, concretions, or brittleness. These soils occur in California, Nevada, and Texas.

Sodic Ustic Haplocalcids.—These are the Haplocalcids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of durinodes, nodules, concretions, or brittleness. These soils occur in Utah.

Sodic Xeric Haplocalcids.—These are the Haplocalcids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of durinodes, nodules, concretions, or brittleness. These soils are known to occur in Idaho, Oregon, and Utah.

Ustic Haplocalcids.—These are the Haplocalcids that have a soil moisture regime that borders on ustic. These soils do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, nodules, concretions, or brittleness. These soils are common in the semiarid deserts of the world.

Vertic Haplocalcids.—These are the Haplocalcids that have a high shrink-swell potential. These soils do not have a lithic contact within 50 cm of the soil surface. They are relatively rare in the world.

Vitrandic Haplocalcids.—These are the Haplocalcids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface and have a soil moisture regime that does not border on xeric. These soils do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of durinodes, nodules, concretions, or brittleness. These soils are not common in the world but occur in areas that have a volcanic influence.

Vitrixerandic Haplocalcids.—These are the Haplocalcids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of durinodes, nodules, concretions, or brittleness. These soils are not common in the world but occur in areas that have a volcanic influence.

Xeric Haplocalcids.—These are the Haplocalcids that have a soil moisture regime that borders on xeric. These soils do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface; a duripan within 150 cm of the soil surface; or a significant amount of volcanic glass, pumice, cinders, pumicelike fragments, durinodes, nodules, concretions, or brittleness. These soils are common in the semiarid deserts of the world where summers are dry and winters are moist.

Petrocalcids

Petrocalcids are the Calcids that have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface. Normally, the upper boundary of the petrocalcic horizon is close to the soil surface. Some of these soils show evidence of former argillic horizons that are now engulfed with carbonates. Generally, Petrocalcids are on gentle slopes that have been stable for long periods. They occur on old landscapes in the southwestern part of the United States and in other deserts of the world.

Definition

Petrocalcids are the Calcids that have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

GFAA. Petrocalcids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Petrocalcids

GFAB. Other Petrocalcids that have a natric horizon.

Natric Petrocalcids

GFAC. Other Petrocalcids that have *both* of the following:

1. An argillic horizon that has its upper boundary within 100 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Xeralfic Petrocalcids

GFAD. Other Petrocalcids that have *both* of the following:

1. An argillic horizon that has its upper boundary within 100 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Ustalfic Petrocalcids

GFAE. Other Petrocalcids that have an argillic horizon that has its upper boundary within 100 cm of the soil surface.

Argic Petrocalcids

GFAF. Other Petrocalcids that have:

1. A calcic horizon overlying the petrocalcic horizon; *and*

2. A lithic contact within 50 cm of the soil surface.

Calcic Lithic Petrocalcids

GFAG. Other Petrocalcids that have a calcic horizon overlying the petrocalcic horizon.

Calcic Petrocalcids

GFAH. Other Petrocalcids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Petrocalcids

GFAI. Other Petrocalcids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Petrocalcids

GFAJ. Other Petrocalcids.

Typic Petrocalcids

Definition of Typic Petrocalcids

Typic Petrocalcids are the Petrocalcids that:

1. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

2. Do not have a natric horizon;

3. Do not have an argillic horizon that has its upper boundary within 100 cm of the soil surface;

4. Do not have a calcic horizon overlying the petrocalcic horizon;

5. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm.

Description of Subgroups

Typic Petrocalcids.—The Typic subgroup is centered on dry soils that do not have any of the features associated with the other subgroups. These soils do not have a natric, argillic, or calcic horizon. They also do not have a soil moisture regime that borders on xeric or ustic. They are saturated with water for 1 month or more in one or more layers within 100 cm of the soil surface. These soils are widespread in the desert areas of the world.

Aquic Petrocalcids.—These are the Petrocalcids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils can have other diagnostic horizons. They are saturated for short periods and dry for most of the year. They are rare but occur in Nevada.

Argic Petrocalcids.—These are the Petrocalcids that have an argillic horizon and have a soil moisture regime that does not border on ustic or xeric. These soils do not have a natric horizon. They occur in the desert areas of several States in the western part of the United States.

Calcic Lithic Petrocalcids.—These are the Petrocalcids that have a calcic horizon, do not have an argillic or natric horizon, and have a lithic contact within 50 cm of the soil surface. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They occur in Arizona, New Mexico, Texas, and other Western States. Most of these soils are used as rangeland.

Calcic Petrocalcids.—These are the Petrocalcids that have a calcic horizon but do not have an argillic or natric horizon. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They occur in Arizona, California, Nevada, New Mexico, Texas, and Utah.

Natric Petrocalcids.—These are the Petrocalcids that have a natric horizon. These soils are not saturated for 1 month or more within 100 cm of the soil surface in normal years. They are rare in the world.

Ustalfic Petrocalcids.—These are the Petrocalcids that have an argillic horizon and have a soil moisture regime that borders on ustic. These soils do not have a natric horizon and are not saturated for 1 month or more within 100 cm of the soil surface during the growing season. They occur in Nevada, New Mexico, Arizona, and Utah.

Ustic Petrocalcids.—These are the Petrocalcids that have a soil moisture regime that borders on ustic. These soils do not have an argillic, calcic, or natric horizon. They are not saturated for 1 month or more in normal years. These soils occur in Arizona, Utah, and New Mexico and in other semiarid areas of the world.

Xeralfic Petrocalcids.—These are the Petrocalcids that have an argillic horizon and have a soil moisture regime that borders on xeric. The soils do not have a natric horizon and are not saturated with water for 1 month or more within 100 cm of the soil surface. They are moist in winter and dry in summer.

Xeric Petrocalcids.—These are the Petrocalcids that have a soil moisture regime that borders on xeric. These soils do not have an argillic, calcic, or natric horizon. They are not saturated for 1 month or more in normal years. These soils occur in California, Utah, and Nevada.

Cambids

These are the Aridisols with the least degree of soil development. These soils have a cambic horizon within 100 cm of the soil surface. They may have other diagnostic horizons, such as a petrocalcic, gypsic, or calcic horizon, but the upper boundary of these horizons must be below 100 cm of the soil surface. These soils are the most common Aridisols in the United States.

Definition

Cambids are the Aridisols that:

1. Have a cambic horizon that has its upper boundary within 100 cm of the soil surface;

2. Have a soil temperature regime warmer than cryic;

3. Do not have a duripan or an argillic, calcic, natric, petrocalcic, gypsic, petrogypsic, or salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Great Groups

GGA. Cambids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquicambids, p. 357

GGB. Other Cambids that have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Petrocambids, p. 364

GGC. Other Cambids that have an anthropic epipedon.

Anthracambids, p. 357

GGD. Other Cambids.

Haplocambids, p. 359

Anthracambids

These are the Cambids that have an anthropic epipedon. These soils generally have been irrigated for many centuries. They are not known to occur in large areas of the United States. The great group is provided for use elsewhere.

Definition

Anthracambids are the Cambids that:

1. Have an anthropic epipedon.

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

3. Do not have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface.

Key to Subgroups

GGCA. All Anthracambids.

Typic Anthracambids

Definition of Typic Anthracambids

All Anthracambids are considered Typic.

Description of Subgroups

Typic Anthracambids.—All Anthracambids are considered Typic. Few data are available for these soils. No soil series have been established for these taxa in the United States. These soils occur in small areas adjacent to Native American ruins.

Aquicambids

These are the Cambids that are saturated with water for short periods in normal years. These soils commonly are adjacent to playas and have accumulations of salts.

Aquicambids commonly have high pH values, which inhibit the formation of redoximorphic features.

Definition

Aquicambids are the Cambids that are either irrigated and have redoximorphic features in one or more layers within 100 cm of the soil surface or are saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Key to Subgroups

GGAA. Aquicambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Aquicambids

GGAB. Other Aquicambids that:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes r are brittle and have at least a firm rupture-resistance class when moist; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Durinodic Xeric Aquicambids

GGAC. Other Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Aquicambids

GGAD. Other Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Aquicambids

GGAE. Other Aquicambids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Aquicambids

GGAF. Other Aquicambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Aquicambids

GGAG. Other Aquicambids that have an irregular decrease in content of organic carbon from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Aquicambids

GGAH. Other Aquicambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Aquicambids

GGAI. Other Aquicambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Aquicambids

GGAJ. Other Aquicambids.

Typic Aquicambids

Definition of Typic Aquicambids

Typic Aquicambids are the Aquicambids that:

1. Do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years;

2. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

3. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more;

5. Have a regular decrease in content of organic carbon from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Description of Subgroups

Typic Aquicambids.—The Typic subgroup is centered on Aquicambids that do not have any of the features defined for the other subgroups. These soils do not have an accumulation of sodium; durinodes or brittleness; a significant amount of nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments; an irregular decrease in content of organic carbon below the cambic horizon; or a soil moisture regime that borders on ustic or xeric.

Durinodic Aquicambids.—These are the Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a cumulative thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils do not have, in a horizon at least 25 cm thick, an exchangeable sodium percentage of 15 or more. The soil moisture regime does not border on xeric.

Durinodic Xeric Aquicambids.—These are the Aquicambids that have a soil moisture regime that borders on xeric and have one or more horizons, within 100 cm of the soil surface and with a cumulative thickness of 15 cm or more, that contain 20 percent or more durinodes or are brittle and have at least a firm rupture-resistance class. These soils do not have, in a horizon at least 25 cm thick, an exchangeable sodium percentage of 15 or more.

Fluventic Aquicambids.—These are the Aquicambids that have an irregular decrease in content of organic carbon below the cambic horizon. These soils do not have a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments and are not brittle.

Petronodic Aquicambids.—These are the Aquicambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more nodules and concretions. These soils do not have a significant amount of sodium, durinodes, or brittleness.

Sodic Aquicambids.—These are the Aquicambids that have, in one or more horizons at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more for at least 1 month in normal years. These soils occur in New Mexico.

Ustic Aquicambids.—These are the Aquicambids that have a soil moisture regime that borders on ustic. These soils do not have a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments and are not brittle. They also do not have an irregular decrease in content of organic carbon below the cambic horizon.

Vitrandic Aquicambids.—These are the Aquicambids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons 18 cm thick within 75 cm of the soil surface but do not have a soil moisture regime that borders on xeric. These soils do not have a significant amount of sodium, durinodes, concretions, or nodules and are not brittle.

Vitrixerandic Aquicambids.—These are the Aquicambids that have a significant amount of volcanic glass, pumice, cinders, or pumicelike fragments in one or more horizons 18 cm thick within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have a significant amount of sodium, durinodes, concretions, or nodules and are not brittle.

Xeric Aquicambids.—These are the Aquicambids that have a soil moisture regime that borders on xeric. These soils do not have a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, pumice, cinders, or pumicelike fragments and are not brittle. They also do not have an irregular decrease in content of organic carbon below the cambic horizon.

Haplocambids

Haplocambids are the most commonly occurring of the Cambids. These soils are characterized by minimal horizon expression. Most Haplocambids have a redistribution of carbonates below the cambic horizon. The amount of carbonates, however, is insufficient to meet the definition of a calcic horizon, or the upper boundary is more than 100 cm below the soil surface. These soils occur on a variety of landscapes, commonly on those that are younger than late-Pleistocene in age.

Definition

Haplocambids are the Cambids that:

1. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

2. Do not have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 150 cm of the soil surface;

3. Do not have an anthropic epipedon.

Key to Subgroups

GGDA. Haplocambids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Lithic Xeric Haplocambids

GGDB. Other Haplocambids that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Lithic Ustic Haplocambids

GGDC. Other Haplocambids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocambids

GGDD. Other Haplocambids that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Xerertic Haplocambids

GGDE. Other Haplocambids that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on ustic.

Ustertic Haplocambids

GGDF. Other Haplocambids that have *at least one* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocambids

GGDG. Other Haplocambids that have *both* of the following:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ºC or higher and a soil moisture regime that borders on xeric.

Durinodic Xeric Haplocambids

GGDH. Other Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes or are brittle and have at least a firm rupture-resistance class when moist.

Durinodic Haplocambids

GGDI. Other Haplocambids that have:

1. One or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and a soil moisture regime that borders on xeric.

Petronodic Xeric Haplocambids

GGDJ. Other Haplocambids that:

1. Have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Petronodic Ustic Haplocambids

GGDK. Other Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) nodules or concretions.

Petronodic Haplocambids

GGDL. Other Haplocambids that have *both*:

1. A horizon at least 25 cm thick within 100 cm of the soil surface that has an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and a soil moisture regime that borders on xeric.

Sodic Xeric Haplocambids

GGDM. Other Haplocambids that meet *both* of the following:

1. Have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Sodic Ustic Haplocambids

GGDN. Other Haplocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplocambids

GGDO. Other Haplocambids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocambids

GGDP. Other Haplocambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocambids

GGDQ. Other Haplocambids that:

1. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric; *and*

2. Have an irregular decrease in content of organic carbon

from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Xerofluventic Haplocambids

GGDR. Other Haplocambids that:

1. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic; *and*

2. Have an irregular decrease in content of organic carbon from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Ustifluventic Haplocambids

GGDS. Other Haplocambids that have an irregular decrease in content of organic carbon from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Haplocambids

GGDT. Other Haplocambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Haplocambids

GGDU. Other Haplocambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Haplocambids

GGDV. Other Haplocambids.

Typic Haplocambids

Definition of Typic Haplocambids

Typic Haplocambids are the Haplocambids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions or are brittle and have at least a firm rupture-resistance class when moist;

3. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

4. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

5. Do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years;

6. Have a regular decrease in content of organic carbon from a depth of 25 cm either to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower;

7. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Haplocambids.—These are the Haplocambids that do not have any of the features defined for the other subgroups. These soils do not have any of the following: a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments; a soil moisture regime that borders on ustic or xeric; or an irregular decrease in content of organic carbon below the cambic horizon.

Durinodic Haplocambids.—These are the Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more, by volume, durinodes or are brittle. These soils do not have a soil moisture regime that borders on xeric. They also do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur in Nevada and California as well as other areas that have a source of silica.

Durinodic Xeric Haplocambids.—These are the Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more, by volume, durinodes or are brittle. These soils have a soil moisture regime that borders on xeric. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur in Nevada, Idaho, Oregon, and Washington as well as other areas that have a source of silica.

Fluventic Haplocambids.—These are the Haplocambids that have an irregular decrease in content of organic carbon below the cambic horizon. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments; or brittleness. These soils occur in Arizona and New Mexico.

Lithic Haplocambids.—These are the Haplocambids that have a lithic contact within 50 cm of the soil surface. These soils do not have a soil moisture regime that borders on ustic or xeric. They are common in the desert areas of the world.

Lithic Ustic Haplocambids.—These are the Haplocambids that have a lithic contact within 50 cm of the soil surface and have a soil moisture regime that borders on ustic.

Lithic Xeric Haplocambids.—These are the Haplocambids that have a lithic contact within 50 cm of the soil surface and have a soil moisture regime that borders on xeric.

Petronodic Haplocambids.—These are the Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more nodules and concretions. These soils do not have a soil moisture regime that borders on ustic or xeric, a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, a significant amount of durinodes, or brittleness.

Petronodic Ustic Haplocambids.—These are the Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more nodules and concretions. These soils have a soil moisture regime that borders on ustic. They do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, a significant amount of durinodes, or brittleness. The soils occur in Arizona and New Mexico.

Petronodic Xeric Haplocambids.—These are the Haplocambids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more nodules and concretions. These soils have a soil moisture regime that borders on xeric. They do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, a significant amount of durinodes, or brittleness.

Sodic Haplocambids.—These are the Haplocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years but do not have a soil moisture regime that borders on xeric or ustic. These soils do not contain a significant amount of durinodes, nodules, or concretions, nor are they brittle. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur in Nevada, New Mexico, and California.

Sodic Ustic Haplocambids.—These are the Haplocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and have a soil moisture regime that borders on ustic. These soils do not contain a significant amount of durinodes, nodules, or concretions and are not brittle. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur in Arizona, New Mexico, and Utah.

Sodic Xeric Haplocambids.—These are the Haplocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years and have a soil moisture regime that borders on xeric. These soils do not contain a significant amount of durinodes, nodules, or concretions, nor are they brittle. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They occur in Oregon, California, and Nevada.

Ustertic Haplocambids.—These are the Haplocambids that have a high shrink-swell potential and have a soil moisture regime that borders on ustic. Most of these soils formed in parent materials rich in smectitic clays. These soils do not have a lithic contact within 50 cm of the soil surface. They are known to occur in Wyoming.

Ustic Haplocambids.—These are the Haplocambids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments; or an irregular decrease in content of organic carbon below the cambic horizon. They occur in the deserts of the western part of the United States and in other deserts of the world.

Ustifluventic Haplocambids.—These are the Haplocambids that have a soil moisture regime that borders on ustic and have an irregular decrease in content of organic carbon below the cambic horizon. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; or a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments. They are known to occur in Arizona, Wyoming, New Mexico, and Texas.

Vertic Haplocambids.—These are the Haplocambids that have a high shrink-swell potential but do not have a soil moisture regime that borders on xeric or ustic. These soils do not have a lithic contact within 50 cm of the soil surface.

Vitrandic Haplocambids.—These are the Haplocambids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential;

brittleness; or a significant amount of sodium, durinodes, nodules, or concretions.

Vitrixerandic Haplocambids.—These are the Haplocambids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; or a significant amount of sodium, durinodes, nodules, or concretions. These soils occur in California, Oregon, Nevada, and Washington.

Xerertic Haplocambids.—These are the Haplocambids that have a high shrink-swell potential and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in Washington and Idaho.

Xeric Haplocambids.—These are the Haplocambids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments; or an irregular decrease in content of organic carbon below the cambic horizon. They occur in many of the deserts in the western part of the United States and in other deserts of the world.

Xerofluventic Haplocambids.—These are the Haplocambids that have a soil moisture regime that borders on xeric and have an irregular decrease in content of organic carbon below the cambic horizon. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; brittleness; or a significant amount of sodium, durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments.

Petrocambids

These soils have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary at a depth between 100 and 150 cm from the soil surface. These soils are not extensive because most Aridisols have these diagnostic horizons at shallower depths. Because of their importance to water movement as well as interpretations, however, classes for these types of soils are provided.

Definition

Petrocambids are the Cambids that:

1. Have a duripan or a petrocalcic or petrogypsic horizon with an upper boundary within 150 cm of the soil surface;

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Key to Subgroups

GGBA. Petrocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Petrocambids

GGBB. Other Petrocambids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Petrocambids

GGBC. Other Petrocambids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Petrocambids

GGBD. Other Petrocambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Petrocambids

GGBE. Other Petrocambids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Petrocambids

GGBF. Other Petrocambids.

Typic Petrocambids

Definition of Typic Petrocambids

Typic Petrocambids are the Petrocambids that:

1. Do not have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years;

2. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ºC or higher;

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Petrocambids.—These are the Petrocambids that do not have a soil moisture regime that borders on ustic or xeric or a significant amount of sodium, volcanic glass, cinders, pumice, or pumicelike fragments.

Sodic Petrocambids.—These are the Petrocambids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more during at least 1 month in normal years.

Ustic Petrocambids.—These are the Petrocambids that have a soil moisture regime that borders on ustic. These soils do not have a significant amount of sodium, volcanic glass, cinders, pumice, or pumicelike fragments.

Vitrandic Petrocambids.—These are the Petrocambids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface and do not have a soil moisture regime that borders on xeric. These soils also do not have a significant amount of sodium.

Vitrixerandic Petrocambids.—These are the Petrocambids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments throughout one or more horizons with a total thickness of 18 or more within 75 cm of the soil surface and have a soil moisture regime that borders on xeric. These soils do not have a significant amount of sodium.

Xeric Petrocambids.—These are the Petrocambids that have a soil moisture regime that borders on xeric. These soils do not have a significant amount of sodium, volcanic glass, cinders, pumice, or pumicelike fragments. They occur in Nevada.

Cryids

Cryids are the Aridisols of cold deserts. Short growing seasons combined with arid conditions limit the use of these soils. The soils are characteristically at high elevations, dominantly in the mountain and basin areas in the United States and Asia and in other parts of the world.

The cold deserts commonly have undergone alternating periods of colder and warmer climates, which have resulted in the expansion and contraction of alpine glaciers in the adjacent mountains. The consequent variations in the sediment load carried by mountain streams have resulted in relict landforms, such as pediments, terraces, and alluvial fans. Cryids commonly show evidence of periglacial features, such as ice-wedged casts, ground wedges, and mounds.

Cryids may have a duripan or an argillic, calcic, cambic, gypsic, natric, petrocalcic, petrogypsic, or salic horizon. These horizons are the basis for great groups. Haplocryids are characterized by minimal development. Some Cryids occur near ustic or xeric soil moisture regimes, which are the basis for subgroups.

Definition

Cryids are the Aridisols that have a cryic temperature regime.

Key to Great Groups

GAA. Cryids that have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Salicryids, p. 372

GAB. Other Cryids that have a duripan or a petrocalcic or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Petrocryids, p. 371

GAC. Other Cryids that have a gypsic horizon that has its upper boundary within 100 cm of the soil surface.

Gypsicryids, p. 368

GAD. Other Cryids that have an argillic or natric horizon.

Argicryids, p. 366

GAE. Other Cryids that have a calcic horizon that has its upper boundary within 100 cm of the soil surface.

Calcicryids, p. 367

GAF. Other Cryids.

Haplocryids, p. 369

Argicryids

These are the Cryids that have an illuvial horizon in which silicate clays have accumulated. In general, the Argicryids without a natric horizon formed in areas of late-Pleistocene or older sediments or surfaces. Many of these soils receive increments of dust, which may be a source of clay-sized particles. Argicryids may be on gentle or steep slopes. These soils are not extensive.

Definition

Argicryids are the Cryids that:

1. Have an argillic or natric horizon;

2. Do not have a duripan or a gypsic, petrocalcic, petrogypsic, or salic horizon with an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GADA. Argicryids that have a lithic contact within 50 cm of the soil surface.

Lithic Argicryids

GADB. Other Argicryids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide throughout a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argicryids

GADC. Other Argicryids that have a natric horizon that has its upper boundary within 100 cm of the soil surface.

Natric Argicryids

GADD. Other Argicryids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argicryids

GADE. Other Argicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Argicryids

GADF. Other Argicryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Argicryids

GADG. Other Argicryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Argicryids

GADH. Other Argicryids.

Typic Argicryids

Definition of Typic Argicryids

Typic Argicryids are the Argicryids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have a natric horizon that has its upper boundary within 100 cm of the soil surface;

4. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C at a depth of 50 cm;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Argicryids.—The Typic subgroup is centered on soils that do not have a soil moisture regime that borders on ustic or xeric. These soils also do not have a high shrink-swell potential; a lithic contact within 50 cm of the soil surface; a natric horizon; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Lithic Argicryids.—These are the Argicryids that have a lithic contact within 50 cm of the soil surface. These soils can have other features, such as a soil moisture regime that borders on ustic or xeric or a natric horizon, but the lithic contact keys first.

Natric Argicryids.—These are the Argicryids that have a natric horizon that has its upper boundary within 100 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential.

Ustic Argicryids.—These are the Argicryids that have a soil moisture regime that borders on ustic. These soils do not have a high shrink-swell potential; a lithic contact within 50 cm of the soil surface; a natric horizon; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Vertic Argicryids.—These are the Argicryids that have a high shrink-swell potential. These soils do not have a lithic contact within 50 cm of the soil surface. They can have a soil moisture regime that borders on ustic or xeric.

Vitrandic Argicryids.—These are the Argicryids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. These soils do not have a soil moisture regime that borders on xeric, a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or a natric horizon. They are associated with areas that have a volcanic influence.

Vitrixerandic Argicryids.—These are the Argicryids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface, a natric horizon, or a high shrink-swell potential.

Xeric Argicryids.—These are the Argicryids that have a soil moisture regime that borders on xeric. These soils do not have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments; a lithic contact within 50 cm of the soil surface; a natric horizon; or a high shrink-swell potential.

Calcicryids

These are the Cryids that are derived from parent materials high in content of lime or that have had lime added as dust. Precipitation is unable to remove the calcium carbonate to substantial depths. These soils typically have an ochric epipedon and a calcic horizon. Some have a cambic horizon overlying the calcic horizon.

Definition

Calcicryids are the Cryids that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a duripan or a gypsic, petrocalcic, petrogypsic, or salic horizon with an upper boundary within 100 cm of the soil surface;

3. Do not have an argillic or natric horizon.

Key to Subgroups

GAEA. Calcicryids that have a lithic contact within 50 cm of the soil surface.

Lithic Calcicryids

GAEB. Other Calcicryids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calcicryids

GAEC. Other Calcicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calcicryids

GAED. Other Calcicryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Calcicryids

GAEE. Other Calcicryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Calcicryids

GAEF. Other Calcicryids.

Typic Calcicryids

Definition of Typic Calcicryids

Typic Calcicryids are the Calcicryids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Calcicryids.—The Typic subgroup is centered on the Calcicryids that do not have the properties associated with the other subgroups. These soils do not have a lithic contact within 50 cm of the soil surface; a soil moisture regime that borders on ustic or xeric, or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Lithic Calcicryids.—These are the Calcicryids that have a lithic contact within 50 cm of the soil surface.

Ustic Calcicryids.—These are the Calcicryids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Vitrandic Calcicryids.—These are the Calcicryids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface.

Vitrixerandic Calcicryids.—These are the Calcicryids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface.

Xeric Calcicryids.—These are the Calcicryids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. They are known to occur in Idaho.

Gypsicryids

Gypsicryids are the Cryids that have a gypsic horizon. An ochric epipedon and a cambic horizon commonly occur above the gypsic horizon. These soils formed in parent materials rich in gypsum. They are rare in the world.

Definition

Gypsicryids are the Cryids that:

1. Have a gypsic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a duripan or a petrocalcic, petrogypsic, or salic horizon with an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GACA. Gypsicryids that have a calcic horizon.

Calcic Gypsicryids

GACB. Other Gypsicryids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 ºC or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Gypsicryids

GACC. Other Gypsicryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Gypsicryids

GACD. Other Gypsicryids.

Typic Gypsicryids

Definition of Typic Gypsicryids

Typic Gypsicryids are the Gypsicryids that:

1. Do not have a calcic horizon;

2. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Gypsicryids.—These are the Gypsicryids that do not have a calcic horizon or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Calcic Gypsicryids.—These are the Gypsicryids that have a calcic horizon. These soils can have other diagnostic horizons or features, but the calcic horizon keys first.

Vitrandic Gypsicryids.—These are the Gypsicryids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric.

Vitrixerandic Gypsicryids.—These are the Gypsicryids that have a significant amount of volcanic glass, cinders, pumice, and pumicelike fragments and have a soil moisture regime that borders on xeric.

Haplocryids

These are the Cryids that have a cambic horizon. An ochric epipedon is common. Other diagnostic horizons may occur below a depth of 100 cm. These soils commonly have accumulations of calcium carbonate below the cambic horizon. They are rare in the world.

Definition

Haplocryids are the Cryids that:

1. Do not have an argillic or natric horizon;

2. Do not have a duripan or a calcic, gypsic, petrocalcic, petrogypsic, or salic horizon that has an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GAFA. Haplocryids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplocryids

GAFB. Other Haplocryids that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide throughout a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryids

GAFC. Other Haplocryids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplocryids

GAFD. Other Haplocryids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplocryids

GAFE. Other Haplocryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Haplocryids

GAFF. Other Haplocryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Haplocryids

GAFG. Other Haplocryids.

Typic Haplocryids

Definition of Typic Haplocryids

Typic Haplocryids are the Haplocryids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C at a depth of 50 cm;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Haplocryids.—The Typic subgroup of Haplocryids is centered on features that are not defined for the other subgroups. These soils do not have a lithic contact within 50 cm of the soil surface; a significant amount of volcanic glass, cinders, pumice, and pumicelike fragments; a high shrink-swell potential; or a soil moisture regime that borders on ustic or xeric.

Lithic Haplocryids.—These are the Haplocryids that have a lithic contact within 50 cm of the soil surface. These soils can have other characteristics, but the lithic contact keys first.

Ustic Haplocryids.—These are the Haplocryids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Vertic Haplocryids.—These are the Haplocryids that have a high shrink-swell potential. These soils do not have a lithic contact within 50 cm of the soil surface.

Vitrandic Haplocryids.—These are the Haplocryids that have a significant amount of volcanic glass, cinders, pumice, and pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils also do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential.

Vitrixerandic Haplocryids.—These are the Haplocryids that have a significant amount of volcanic glass, cinders, pumice, and pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential.

Xeric Haplocryids.—These are the Haplocryids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Petrocryids

These are the Cryids that have a duripan or a petrocalcic or petrogypsic horizon. An argillic, cambic, or natric horizon may occur above the cemented layer. These soils occur in the mountains of Idaho and possibly Wyoming.

Definition

Petrocryids are the Cryids that:

1. Have a duripan or a petrocalcic or petrogypsic horizon with an upper boundary within 100 cm of the soil surface;

2. Do not have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

GABA. Petrocryids that:

1. Have a duripan that is strongly cemented or less cemented in all subhorizons and has its upper boundary within 100 cm of the soil surface; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xereptic Petrocryids

GABB. Other Petrocryids that:

1. Have a duripan that has its upper boundary within 100 cm of the soil surface; *and*

2. Are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Duric Xeric Petrocryids

GABC. Other Petrocryids that have a duripan that has its upper boundary within 100 cm of the soil surface.

Duric Petrocryids

GABD. Other Petrocryids that have a petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Petrogypsic Petrocryids

GABE. Other Petrocryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Petrocryids

GABF. Other Petrocryids that are dry in all parts of the moisture control section for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on ustic.

Ustic Petrocryids

GABG. Other Petrocryids.

Typic Petrocryids

Definition of Typic Petrocryids

Typic Petrocryids are the Petrocryids that:

1. Have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a duripan or a petrogypsic horizon that has an upper boundary within 100 cm of the soil surface;

3. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C at a depth of 50 cm.

Description of Subgroups

Typic Petrocryids.—The central concept of the Typic subgroup is that of dry soils with a petrocalcic horizon. These soils do not have a duripan, a petrogypsic horizon, or a soil moisture regime that borders on ustic or xeric.

Duric Petrocryids.—These are the Petrocryids that have a duripan that is very strongly cemented or indurated in at least some part. These soils do not have a soil moisture regime that borders on xeric.

Duric Xeric Petrocryids.—These are the Petrocryids that have a duripan that is very strongly cemented or indurated and have a soil moisture regime that borders on xeric. These soils occur in Idaho.

Petrogypsic Petrocryids.—These are the Petrocryids that have a petrogypsic horizon. These soils do not have a duripan.

Ustic Petrocryids.—These are the Petrocryids that have a petrocalcic horizon and have a soil moisture regime that borders on ustic. These soils do not have a petrogypsic horizon or a duripan.

Xeric Petrocryids.—These are the Petrocryids that have a petrocalcic horizon and have a soil moisture regime that borders on xeric. These soils do not have a petrogypsic horizon or a duripan.

Xereptic Petrocryids.—These are the Petrocryids that have a duripan that is strongly cemented or less cemented and have a soil moisture regime that borders on xeric. These soils occur in Idaho.

Salicryids

Salicryids are the Cryids that have a salic horizon. These soils can have other diagnostic horizons and characteristics, but the presence of soluble salts is considered important to interpretations. The soils occur in extremely arid, cold regions of the world.

Definition

Salicryids are the Cryids that have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

GAAA. Salicryids that are saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Salicryids

GAAB. Other Salicryids.

Typic Salicryids

Definition of Typic Salicryids

Typic Salicryids are the Salicryids that are not saturated with water in any layer within 100 cm of the soil surface for 1 month or more in normal years.

Description of Subgroups

Typic Salicryids.—These are the Salicryids that are not saturated with water in one or more horizons within 100 cm of the soil surface for at least 1 month in normal years.

Aquic Salicryids.—These are the Salicryids that are saturated with water in one or more horizons for 1 month or more in normal years.

Durids

Durids are the Aridisols that have a duripan that has an upper boundary within 100 cm of the soil surface. In many areas the duripan is within 50 cm of the soil surface. These soils occur dominantly on gentle slopes and formed in sediments that contain pyroclastics. The duripan is cemented partly with opal or chalcedony. The soils commonly have calcium carbonate. The duripan is a barrier to both roots and water.

Some Durids have an argillic or natric horizon above the duripan, and these horizons are the basis for great groups. Where these soils occur in areas adjacent to an ustic or xeric soil moisture regime, intergrades are recognized at the subgroup level. Most of these soils are used for grazing. The amount of forage is low where the duripan is shallow.

These soils occur in the western part of the United States, particularly in Nevada. They are not known to occur outside the United States.

Definition

Durids are the Aridisols that:

1. Have a duripan that has its upper boundary within 100 cm of the surface;

2. Have a soil temperature regime warmer than cryic;

3. Do not have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Great Groups

GCA. Durids that have a natric horizon above the duripan.

Natridurids, p. 377

GCB. Other Durids that have an argillic horizon above the duripan.

Argidurids, p. 372

GCC. Other Durids.

Haplodurids, p. 375

Argidurids

These are the Durids with an argillic horizon above the duripan. Commonly, the duripan is within 50 cm of the soil surface. These soils are close to volcanic areas or formed in eolian or alluvial sediments derived from pyroclastics.

Definition

Argidurids are the Durids that:

1. Have an argillic horizon above the duripan;

2. Do not have a natric horizon above the duripan.

Key to Subgroups

GCBA. Argidurids that have, above the duripan, *one or both* of the following:

1. Cracks between the soil surface and the top of the

duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Argidurids

GCBB. Other Argidurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Argidurids

GCBC. Other Argidurids that have the following combination of characteristics:

1. An argillic horizon that has 35 percent or more clay in the fine-earth fraction of some part; *and either*

a. A clay increase of 15 percent or more (absolute) within a vertical distance of 2.5 cm either within the argillic horizon or at its upper boundary; *or*

b. If there is an Ap horizon directly above the argillic horizon, a clay increase of 10 percent or more (absolute) at the upper boundary of the argillic horizon; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Abruptic Xeric Argidurids

GCBD. Other Argidurids that have an argillic horizon that has 35 percent or more clay in the fine-earth fraction of some part; *and either*

1. A clay increase of 15 percent or more (absolute) within a vertical distance of 2.5 cm within the argillic horizon or at its upper boundary; *or*

2. If there is an Ap horizon directly above the argillic horizon, a clay increase of 10 percent or more (absolute) at the upper boundary of the argillic horizon.

Abruptic Argidurids

GCBE. Other Argidurids that have:

1. A duripan that is strongly cemented or less cemented in all subhorizons; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Haploxeralfic Argidurids

GCBF. Other Argidurids that have a duripan that is strongly cemented or less cemented in all subhorizons.

Argidic Argidurids

GCBG. Other Argidurids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argidurids

GCBH. Other Argidurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Argidurids

GCBI. Other Argidurids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Argidurids

GCBJ. Other Argidurids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Argidurids

GCBK. Other Argidurids.

Typic Argidurids

Definition of Typic Argidurids

Typic Argidurids are the Argidurids that:

1. Do not have *either* of the following:

 a. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, or slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary above the duripan; *or*

 b. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan;

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

3. Have an argillic horizon that has less than 35 percent clay in the fine-earth fraction of some part; *or*

 a. A clay increase of less than 15 percent (absolute) within a vertical distance of 2.5 cm both within the argillic horizon and at its upper boundary; *or*

 b. If there is an Ap horizon directly above the argillic horizon, a clay increase of less than 10 percent (absolute) at the upper boundary of the argillic horizon;

4. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

 a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

 b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more;

6. Have a duripan that is strongly cemented or less cemented in all subhorizons.

Description of Subgroups

Typic Argidurids.—The Typic subgroup of Argidurids is defined in terms of characteristics that are not evident. It does not have the following: a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a significant increase in content of clay either within the argillic horizon or at its upper boundary; a soil moisture regime that borders on ustic or xeric; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. These soils have a duripan that is very strongly cemented or indurated in at least some part.

Abruptic Argidurids.—These are the Argidurids that have a significant increase in content of clay within a short distance either within the argillic horizon or at its upper boundary but do not have a soil moisture regime that borders on xeric. The abrupt increase in content of clay is important to water movement. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They are known to occur in Arizona and Nevada.

Abruptic Xeric Argidurids.—These are the Argidurids that have a significant increase in content of clay within a short distance either within the argillic horizon or at its upper boundary and have a soil moisture regime that borders on xeric. The abrupt increase in content of clay is important to water movement. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They occur in California, Oregon, and Nevada.

Aquic Argidurids.—These are the Argidurids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils are commonly saturated by runoff from melting snow or from heavy rains. They are dry for most of the year. They do not have a high shrink-swell potential.

Argidic Argidurids.—These are the Argidurids that have a duripan that is strongly cemented or less cemented in all subhorizons and do not have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, or a significant increase in content of clay within the argillic horizon or at its upper boundary. These soils are known to occur in Nevada, Oregon, and California.

Haploxeralfic Argidurids.—These are the Argidurids that have a duripan that is strongly cemented or less cemented in all subhorizons and have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential, saturation with water for 1 month or more within 100 cm of the soil surface in normal years, or a significant increase in content of clay within the argillic horizon or at its upper boundary. These soils are known to occur in Nevada, Oregon, Utah, Idaho, and California.

Ustic Argidurids.—These are the Argidurids that have a soil moisture regime that borders on ustic and have a duripan that is very strongly cemented or indurated in at least some part. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a significant increase in content of clay either within the argillic horizon or at its upper boundary; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. These soils occur in Nevada.

Vertic Argidurids.—These are the Argidurids that have a high shrink-swell potential. These soils occur in Nevada.

Vitrandic Argidurids.—These are the Argidurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils have a duripan that is very strongly cemented or indurated in at least some part. They do not have an abrupt change in content of clay within the argillic horizon or at its upper boundary, a high shrink-swell potential, or saturation with water for 1 month or more within 100 cm of the soil surface during the growing season.

Vitrixerandic Argidurids.—These are the Argidurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils have a duripan that is very strongly cemented or indurated in at least some part. They do not have an abrupt change in content of clay within the argillic horizon or at its upper boundary, a high shrink-swell potential, or saturation with water for 1 month or more within 100 cm of the soil surface during the growing season. These soils are known to occur in Oregon.

Xeric Argidurids.—These are the Argidurids that have a soil moisture regime that borders on xeric and have a duripan that is very strongly cemented or indurated in at least some part. These soils do not have a high shrink-swell potential; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; a significant increase in content of clay either within the argillic horizon or at its upper boundary; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. These soils occur in Nevada, Oregon, Idaho, Utah, and California.

Haplodurids

These are the Durids that do not have a natric or argillic horizon. These soils formed in materials that have a pyroclastic influence. Most Haplodurids are used for grazing.

Definition

Haplodurids are the Durids that do not have an argillic or natric horizon above the duripan.

Key to Subgroups

GCCA. Haplodurids that:

1. Have a duripan that is strongly cemented or less cemented in all subhorizons; *and*

2. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquicambidic Haplodurids

GCCB. Other Haplodurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Haplodurids

GCCC. Other Haplodurids that have:

1. A duripan that is strongly cemented or less cemented in all subhorizons; *and*

2. A mean annual soil temperature lower than 22 ^{o}C, a difference of 5 ^{o}C or more between mean summer and mean winter soil temperatures at a depth of 50 cm, and a soil moisture regime that borders on xeric.

Xereptic Haplodurids

GCCD. Other Haplodurids that have a duripan that is strongly cemented or less cemented in all subhorizons.

Cambidic Haplodurids

GCCE. Other Haplodurids that have:

1. A moisture control section that is dry in all parts for three-fourths of the time (cumulative) or less when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplodurids

GCCF. Other Haplodurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplodurids

GCCG. Other Haplodurids that have a mean annual soil temperature lower than 22 °C, a difference of 5 °C or more between mean summer and mean winter soil temperatures at a depth of 50 cm, and a soil moisture regime that borders on xeric.

Xeric Haplodurids

GCCH. Other Haplodurids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Haplodurids

GCCI. Other Haplodurids.

Typic Haplodurids

Definition of Typic Haplodurids

Typic Haplodurids are the Durids that:

1. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

2. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more;

4. Have a duripan that is indurated or very strongly cemented in at least one subhorizon.

Description of Subgroups

Typic Haplodurids.—These are the Haplodurids that have a duripan that is very strongly cemented or indurated in at least some part. These soils do not have a soil moisture regime that borders on ustic or xeric; saturation with water for 1 month or more within 100 cm of the soil surface in normal years; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Aquicambidic Haplodurids.—These are the Haplodurids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years and have a duripan that is strongly cemented or less cemented in all subhorizons. These soils occur in California, Oregon, and Nevada.

Aquic Haplodurids.—These are the Haplodurids that are saturated with water for 1 month or more within 100 cm of the soil surface in normal years and have a duripan that is very strongly cemented or indurated in at least some part. These soils occur in California, Oregon, and Washington.

Cambidic Haplodurids.—These are the Haplodurids that have a duripan that is strongly cemented or less cemented in all subhorizons but do not have a soil moisture regime that borders on xeric. These soils are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada and California.

Ustic Haplodurids.—These are the Haplodurids that have a soil moisture regime that borders on ustic and have a duripan that is very strongly cemented or indurated in at least some part. These soils are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years, nor do they have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Vitrandic Haplodurids.—These are the Haplodurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils have a duripan that is very strongly cemented or indurated in at least some part. They are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils are known to occur in California.

Vitrixerandic Haplodurids.—These are the Haplodurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils also have a duripan that is very strongly cemented or indurated in at least some part. They are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. These soils are known to occur in California and Oregon.

Xeric Haplodurids.—These are the Haplodurids that have a soil moisture regime that borders on xeric and have a duripan that is very strongly cemented or indurated in at least some part. These soils are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years, nor do they have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. They occur in a number of Western States.

Xereptic Haplodurids.—These are the Haplodurids that have a soil moisture regime that borders on xeric and have a duripan that is strongly cemented or less cemented in all subhorizons. These soils are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada, Utah, Oregon, Washington, and Idaho.

Natridurids

These are the Durids that have a natric horizon above the duripan. Commonly, the duripan is within 50 cm of the soil surface. In many areas it is plugged by calcium carbonate. These soils are commonly on gently sloping landscapes and formed in materials derived from pyroclastics. They are not extensive and are used mostly for grazing.

Definition

Natridurids are the Durids that have a natric horizon above the duripan.

Key to Subgroups

GCAA. Natridurids that have, above the duripan, *one or both* of the following:

1. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary above the duripan; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan.

Vertic Natridurids

GCAB. Other Natridurids that meet *both* of the following:

1. Have a duripan that is strongly cemented or less cemented in all subhorizons; *and*

2. Are *either*:

a. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

b. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natrargidic Natridurids

GCAC. Other Natridurids that are *either*:

1. Irrigated and have aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface; *or*

2. Saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years.

Aquic Natridurids

GCAD. Other Natridurids that have the following combination of characteristics:

1. A duripan that is strongly cemented or less cemented in all subhorizons; *and*

2. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric.

Natrixeralfic Natridurids

GCAE. Other Natridurids that have a duripan that is strongly cemented or less cemented in all subhorizons.

Natrargidic Natridurids

GCAF. Other Natridurids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natridurids

GCAG. Other Natridurids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser

than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natridurids

GCAH. Other Natridurids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and have a soil moisture regime that borders on xeric.

Xeric Natridurids

GCAI. Other Natridurids.

Typic Natridurids

Definition of Typic Natridurids

Typic Natridurids are the Durids that:

1. Do not have *either* of the following:

a. Cracks between the soil surface and the top of the duripan that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary above the duripan; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and the top of the duripan;

2. Are not both irrigated and characterized by aquic conditions for some time in normal years in one or more layers within 100 cm of the soil surface and are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

3. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm;

4. Have a duripan that is either indurated or very strongly cemented in at least one subhorizon;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Natridurids.—These are the Natridurids that have a duripan that is very strongly cemented or indurated in at least some part. These soils do not have a soil moisture regime that borders on xeric, a high shrink-swell potential, or saturation with water for 1 month or more within 100 cm of the soil surface in normal years.

Aquic Natrargidic Natridurids.—These are the Natridurids that are saturated with water for at least 1 month within 100 cm of the soil surface in normal years and have a duripan that is strongly cemented or less cemented in all subhorizons. These soils do not have a high shrink-swell potential. They occur in Nevada.

Aquic Natridurids.—These are the Natridurids that have a duripan that is very strongly cemented or indurated in at least some part and are saturated with water for at least 1 month within 100 cm of the soil surface in normal years. These soils do not have a high shrink-swell potential.

Natrargidic Natridurids.—These are the Natridurids that have a duripan that is strongly cemented or less cemented in all subhorizons and have a soil moisture regime that does not border on xeric. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada.

Natrixeralfic Natridurids.—These are the Natridurids that have a duripan that is strongly cemented or less cemented in all subhorizons and have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years. They occur in Nevada and California.

Vertic Natridurids.—These are the Natridurids that have a high shrink-swell potential.

Vitrandic Natridurids.—These are the Natridurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that does not border on xeric. These soils have a duripan that is very strongly cemented or indurated in at least some part. They do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years.

Vitrixerandic Natridurids.—These are the Natridurids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils also have a duripan that is very strongly cemented or indurated in at least some part. They do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years.

Xeric Natridurids.—These are the Natridurids that have a duripan that is very strongly cemented or indurated in at least some part and have a soil moisture regime that borders on xeric. These soils do not have a high shrink-swell potential and are not saturated with water for 1 month or more within 100 cm of the soil surface in normal years.

Gypsids

Gypsids are the Aridisols that have a gypsic or petrogypsic horizon within 100 cm of the soil surface. Accumulation of gypsum takes place initially as crystal aggregates in the voids of the soils. These aggregates grow by accretion, displacing the enclosing soil material. When the gypsic horizon occurs as a cemented impermeable layer, it is recognized as the petrogypsic horizon. Each of these forms of gypsum accumulation implies processes in the soils, and each presents a constraint to soil use. One of the largest constraints is dissolution of the gypsum, which plays havoc with structures, roads, and irrigation delivery systems.

The presence of one or more of these horizons, with or without other diagnostic horizons, defines the great groups of the Gypsids. Gypsids occur in Iraq, Syria, Saudi Arabia, Iran, Somalia, West Asia, and some of the most arid areas of the western part of the United States.

Gypsids are on many segments of the landscape. Some of them have calcic or related horizons that overlie the gypsic horizon.

Definition

Gypsids are the Aridisols that:

1. Have a gypsic or petrogypsic horizon that has an upper boundary within 100 cm of the soil surface;

2. Do not have a petrocalcic horizon overlying the gypsic or petrogypsic horizon;

3. Have a soil temperature regime warmer than cryic;

4. Do not have a duripan or a salic horizon that has an upper boundary within 100 cm of the soil surface.

Key to Great Groups

GDA. Gypsids that have a petrogypsic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Petrogypsids, p. 386

GDB. Other Gypsids that have a natric horizon that has its upper boundary within 100 cm of the soil surface.

Natrigypsids, p. 384

GDC. Other Gypsids that have an argillic horizon that has its upper boundary within 100 cm of the soil surface.

Argigypsids, p. 379

GDD. Other Gypsids that have a calcic horizon that has its upper boundary within 100 cm of the soil surface.

Calcigypsids, p. 381

GDE. Other Gypsids.

Haplogypsids, p. 382

Argigypsids

Argigypsids are the Gypsids that have an argillic horizon. These soils are known to occur in the Four Corners area of the western part of the United States and in Texas. They are used primarily for grazing.

Definition

Argigypsids are the Gypsids that:

1. Have an argillic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a natric, petrocalcic, or petrogypsic horizon with an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GDCA. Argigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Argigypsids

GDCB. Other Argigypsids that have:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argigypsids

GDCC. Other Argigypsids that have a calcic horizon overlying the gypsic horizon.

Calcic Argigypsids

GDCD. Other Argigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Argigypsids

GDCE. Other Argigypsids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Argigypsids

GDCF. Other Argigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 percent or more.

Vitrandic Argigypsids

GDCG. Other Argigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Argigypsids

GDCH. Other Argigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Argigypsids

GDCI. Other Argigypsids.

Typic Argigypsids

Definition of Typic Argigypsids

Typic Argigypsids are the Argigypsids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have a calcic horizon overlying the gypsic horizon;

4. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

5. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions;

6. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Argigypsids.—These are the Argigypsids that do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a calcic horizon above the gypsic horizon; a soil moisture regime that borders on xeric or ustic; a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments; or a significant amount of durinodes, concretions, or nodules.

Calcic Argigypsids.—These are the Argigypsids that have a calcic horizon over the gypsic horizon. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. They are known to occur in Arizona.

Lithic Argigypsids.—These are the Argigypsids that have a lithic contact within 50 cm of the soil surface. They can have a soil moisture regime that borders on ustic or xeric.

Petronodic Argigypsids.—These are the Argigypsids that have a significant amount of durinodes, nodules, or concretions. These soils do not have a calcic horizon above the gypsic horizon, a lithic contact within 50 cm of the soil surface, or a high shrink-swell potential.

Ustic Argigypsids.—These are the Argigypsids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a calcic horizon above the gypsic horizon; a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments; or a significant amount of durinodes, concretions, or nodules.

Vertic Argigypsids.—These are the moderately deep to very deep Argigypsids that have a high shrink-swell potential. They occur in Texas, where they are used as rangeland.

Vitrandic Argigypsids.—These are the Argigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils also do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a calcic horizon above the gypsic horizon; or a significant amount of durinodes, nodules, or concretions.

Vitrixerandic Argigypsids.—These are the Argigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. Vitrixerandic Argigypsids do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a calcic horizon above the gypsic horizon; or a significant amount of durinodes, nodules, or concretions.

Xeric Argigypsids.—These are the Argigypsids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a calcic horizon above the gypsic horizon; or a significant amount of volcanic glass, cinders, pumice, pumicelike fragments, durinodes, concretions, or nodules.

Calcigypsids

Calcigypsids are the Gypsids that have a calcic horizon. Commonly, the calcic horizon is above the gypsic horizon because of differences in the solubility of gypsum and calcium carbonate. These soils are known to occur in New Mexico. Most Calcigypsids are used for grazing.

Definition

Calcigypsids are the Gypsids that:

1. Have both a gypsic and calcic horizon that have their upper boundary within 100 cm of the soil surface;

2. Do not have an argillic, natric, petrogypsic, or petrocalcic horizon that has an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GDDA. Calcigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Calcigypsids

GDDB. Other Calcigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Calcigypsids

GDDC. Other Calcigypsids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Calcigypsids

GDDD. Other Calcigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Calcigypsids

GDDE. Other Calcigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Calcigypsids

GDDF. Other Calcigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Calcigypsids

GDDG. Other Calcigypsids.

Typic Calcigypsids

Definition of Typic Calcigypsids

Typic Calcigypsids are the Calcigypsids that:

1. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

2. Do not have a lithic contact within 100 cm of the soil surface;

3. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

   a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Calcigypsids.—These are the Calcigypsids that do not have a lithic contact within 50 cm of the soil surface; a significant amount of volcanic glass, cinders, pumice, pumicelike fragments, durinodes, nodules, or concretions; or a soil moisture regime that borders on ustic or xeric. These soils are known to occur in Arizona, Texas, and New Mexico.

Lithic Calcigypsids.—These are the Calcigypsids that have a lithic contact within 50 cm of the soil surface. These soils occur in New Mexico and Arizona.

Petronodic Calcigypsids.—These are the Calcigypsids that have a significant amount of durinodes, concretions, or nodules. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in Arizona.

Ustic Calcigypsids.—These are the Calcigypsids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of volcanic glass, cinders, pumice, pumicelike fragments, durinodes, nodules, or concretions. These soils are known to occur in New Mexico and Texas.

Vitrandic Calcigypsids.—These are the Calcigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of durinodes, concretions, or nodules.

Vitrixerandic Calcigypsids.—These are the Calcigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of durinodes, concretions, or nodules.

Xeric Calcigypsids.—These are the Calcigypsids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface or a significant amount of volcanic glass, cinders, pumice, pumicelike fragments, durinodes, nodules, or concretions. These soils are known to occur in Utah.

Haplogypsids

Haplogypsids are the Gypsids that have no petrogypsic, natric, argillic, or calcic horizon that has an upper boundary within 100 cm of the soil surface. Some Haplogypsids have a cambic horizon overlying the gypsic horizon. These soils are commonly very pale in color. They are not extensive in the United States. The largest concentrations in the United States are in New Mexico and Texas. The soils are more common in other parts of the world.

Definition

Haplogypsids are the Gypsids that:

1. Do not have a petrogypsic or calcic horizon that has an upper boundary within 100 cm of the soil surface;

2. Do not have an argillic or natric horizon that has an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GDEA. Haplogypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Haplogypsids

GDEB. Other Haplogypsids that have a gypsic horizon that has its upper boundary within 18 cm of the soil surface.

Leptic Haplogypsids

GDEC. Other Haplogypsids that have, in a horizon at least 25 cm thick within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) during at least 1 month in normal years.

Sodic Haplogypsids

GDED. Other Haplogypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Haplogypsids

GDEE. Other Haplogypsids that have *both*:

   1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the

soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Haplogypsids

GDEF. Other Haplogypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Haplogypsids

GDEG. Other Haplogypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Haplogypsids

GDEH. Other Haplogypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Haplogypsids

GDEI. Other Haplogypsids.

Typic Haplogypsids

Definition of Typic Haplogypsids

Typic Haplogypsids are the Haplogypsids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a gypsic horizon that has its upper boundary within 18 cm of the soil surface;

3. Do not have, in one or more horizons within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or an SAR of 13 or more) for 1 month or more in normal years;

4. Have a moisture control section that is dry in all parts for three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

5. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions;

6. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Haplogypsids.—These are the Haplogypsids that do not have a lithic contact within 50 cm of the soil surface; a gypsic horizon within 18 cm of the soil surface; a significant amount of sodium, durinodes, concretions, nodules, volcanic glass, cinders, pumice, or pumicelike fragments; or a soil moisture regime that borders on xeric or ustic. These soils occur in California, New Mexico, Arizona, Texas, and Nevada.

Leptic Haplogypsids.— These are the Haplogypsids that have a gypsic horizon with its upper boundary within 18 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in Nevada, Arizona, and New Mexico.

Lithic Haplogypsids.—These are the Haplogypsids that have a lithic contact within 50 cm of the soil surface. These soils can have characteristics that are common in the other subgroups.

Petronodic Haplogypsids.—These are the Haplogypsids that have a significant amount of durinodes, concretions, or nodules. These soils do not have a lithic contact within 50 cm of the soil surface, a gypsic horizon with its upper boundary within 18 cm of the soil surface, or a significant amount of sodium.

Sodic Haplogypsids.—These are the Haplogypsids that have, in a horizon at least 25 cm thick within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more. These soils do not have a lithic contact within 50 cm of the soil surface or a gypsic horizon that has its upper boundary within 18 cm of the soil surface.

Ustic Haplogypsids.—These are the Haplogypsids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a gypsic horizon within 18 cm of the soil surface; or a significant amount of sodium, durinodes, concretions, nodules, volcanic glass, cinders, pumice, or pumicelike fragments. Ustic Haplogypsids occur in Utah, Arizona, Colorado, New Mexico, and Wyoming.

Vitrandic Haplogypsids.—These are the Haplogypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a gypsic horizon within 18 cm of the soil surface; or a significant amount of sodium, durinodes, concretions, or nodules.

Vitrixerandic Haplogypsids.—These are the Haplogypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a gypsic horizon within 18 cm of the soil surface; or a significant amount of sodium, durinodes, concretions, or nodules.

Xeric Haplogypsids.—These are the Haplogypsids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a gypsic horizon within 18 cm of the soil surface; or a significant amount of sodium, durinodes, concretions, nodules, volcanic glass, cinders, pumice, or pumicelike fragments. Xeric Haplogypsids occur in Utah and California.

Natrigypsids

Natrigypsids are the Gypsids that have a natric horizon and have no petrogypsic or petrocalcic horizon within 100 cm of the soil surface. The gypsic horizon is commonly below the natric horizon. These soils formed in parent materials high in content of gypsum and sodium, such as sedimentary materials that were deposited in a marine environment. The soils are rare but are known to occur in the Four Corners area of the western part of the United States (northwestern New Mexico, northeastern Arizona, southeastern Utah, and southwestern Colorado). The soils are used primarily for grazing.

Definition

Natrigypsids are the Gypsids that:

1. Have a natric horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a petrogypsic or petrocalcic horizon with an upper boundary within 100 cm of the soil surface.

Key to Subgroups

GDBA. Natrigypsids that have a lithic contact within 50 cm of the soil surface.

Lithic Natrigypsids

GDBB. Other Natrigypsids that have:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrigypsids

GDBC. Other Natrigypsids that have one or more horizons, within 100 cm of the soil surface and with a combined thickness of 15 cm or more, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Petronodic Natrigypsids

GDBD. Other Natrigypsids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Natrigypsids

GDBE. Other Natrigypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Natrigypsids

GDBF. Other Natrigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ºC or higher and have a soil moisture regime that borders on xeric.

Xeric Natrigypsids

GDBG. Other Natrigypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ºC or higher and have a soil moisture regime that borders on ustic.

Ustic Natrigypsids

GDBH. Other Natrigypsids.

Typic Natrigypsids

Definition of Typic Natrigypsids

Typic Natrigypsids are the Natrigypsids that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have *either*:

a. No cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and no slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ºC or higher;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more;

5. Do not have one or more horizons, within 100 cm of the soil surface and with a combined thickness of more than 15 cm, that contain 20 percent or more (by volume) durinodes, nodules, or concretions.

Description of Subgroups

Typic Natrigypsids.—The Typic subgroup of Natrigypsids is defined in terms of characteristics that are not evident. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; a soil moisture regime that borders on xeric or ustic; or a significant amount of durinodes, nodules, concretions, volcanic glass, cinders, pumice, or pumicelike fragments.

Lithic Natrigypsids.—These are the Natrigypsids that have a lithic contact within 50 cm of the soil surface. These soils can have the characteristics defined for the other subgroups. The presence of a lithic contact is considered important to interpretations and keys first.

Petronodic Natrigypsids.—These are the Natrigypsids that have a significant amount of durinodes, nodules, or concretions. These soils do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential.

Ustic Natrigypsids.—These are the Natrigypsids that have a soil moisture regime that borders on ustic. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of durinodes, concretions, nodules, volcanic glass, cinders, pumice, or pumicelike fragments.

Vertic Natrigypsids.—These are the Natrigypsids that have a high shrink-swell potential. These soils do not have a lithic contact within 50 cm of the soil surface.

Vitrandic Natrigypsids.—These are the Natrigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils also do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of durinodes, nodules, and concretions.

Vitrixerandic Natrigypsids.—These are the Natrigypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of durinodes, nodules, and concretions.

Xeric Natrigypsids.—These are the Natrigypsids that have a soil moisture regime that borders on xeric. These soils do not have a lithic contact within 50 cm of the soil surface; a high shrink-swell potential; or a significant amount of durinodes, concretions, nodules, volcanic glass, cinders, pumice, or pumicelike fragments.

Petrogypsids

Petrogypsids are the Gypsids that have a petrogypsic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface. These soils occur in very arid areas of the world where the parent material is high in content of gypsum. When the petrogypsic horizon is close to the surface, crusting forms pseudohexagonal patterns on the soil surface. Petrogypsids occupy old surfaces. In Syria and Iraq, they are on the highest terraces along the Tigris and Euphrates Rivers. These soils are not extensive in the United States but are extensive in other countries.

Definition

Petrogypsids are the Gypsids that have a petrogypsic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

GDAA. Petrogypsids that have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.

Petrocalcic Petrogypsids

GDAB. Other Petrogypsids that have a calcic horizon overlying the petrogypsic horizon.

Calcic Petrogypsids

GDAC. Other Petrogypsids that have *both*:

1. A moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature is 5 °C or higher at a depth of 50 cm and a soil moisture regime that borders on xeric; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrixerandic Petrogypsids

GDAD. Other Petrogypsids that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Petrogypsids

GDAE. Other Petrogypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on xeric.

Xeric Petrogypsids

GDAF. Other Petrogypsids that have a moisture control section that is dry in all parts for less than three-fourths of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher and have a soil moisture regime that borders on ustic.

Ustic Petrogypsids

GDAG. Other Petrogypsids.

Typic Petrogypsids

Definition of Typic Petrogypsids

Typic Petrogypsids are the Petrogypsids that:

1. Do not have a petrocalcic horizon within 100 cm of the soil surface;

2. Do not have a calcic horizon overlying the petrogypsic horizon;

3. Have a moisture control section that is dry in all parts for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Description of Subgroups

Typic Petrogypsids.—These are the Petrogypsids that have a petrogypsic horizon. These soils do not have a calcic or petrocalcic horizon above the petrogypsic horizon or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments. The moisture regime does not border on ustic or xeric.

Calcic Petrogypsids.—These are the Petrogypsids that have a calcic horizon above the petrogypsic horizon. These soils do not have a petrocalcic horizon.

Petrocalcic Petrogypsids.—These are the Petrogypsids that have a petrocalcic horizon. These soils are known to occur in Nevada.

Ustic Petrogypsids.—These are the Petrogypsids that have a petrogypsic horizon and have a soil moisture regime that borders on ustic. These soils do not have a calcic or petrocalcic horizon above the petrogypsic horizon or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Vitrandic Petrogypsids.—These are the Petrogypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments but do not have a soil moisture regime that borders on xeric. These soils do not have a calcic horizon overlying the petrogypsic horizon and do not have a petrocalcic horizon.

Vitrixerandic Petrogypsids.—These are the Petrogypsids that have a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments and have a soil moisture regime that borders on xeric. These soils do not have a calcic horizon overlying the petrogypsic horizon and do not have a petrocalcic horizon.

Xeric Petrogypsids.—These are the Petrogypsids that have a petrogypsic horizon and have a soil moisture regime that borders on xeric. These soils do not have a calcic horizon above the petrogypsic horizon; a petrocalcic horizon; or a significant amount of volcanic glass, cinders, pumice, or pumicelike fragments.

Salids

Salids are most common in depressions (playas) in the deserts or in closed basins in the wetter areas bordering the deserts. In North Africa and in the Near East, such depressions are referred to as Sebkhas or Chotts, depending on the presence or absence of surface water for prolonged periods.

Under the arid environment and hot temperatures, accumulation of salts commonly occurs when there is a supply of salts and a net upward movement of water in the soils. In some areas a salic horizon has formed in salty parent materials without the presence of ground water. The most common form of salt is sodium chloride (halite), but sulfates (thenardite, mirabilite, and hexahydrite) and other salts may also occur.

The concept of Salids is one of accumulation of an excessive amount of salts that are more soluble than gypsum. This is implicit in the definition, which requires a minimum absolute EC of 30 dS/m in 1:1 extract (about 2 percent salt) and a product of EC and thickness of at least 900.

As a rule, Salids are unsuitable for agricultural use, unless the salts are leached out. Leaching the salts is an expensive undertaking, particularly if there is no natural outlet for the drainage water.

Two great groups are recognized—Aquisalids, which are saturated with water for 1 month or more during the year, and Haplosalids, which are drier.

Definition

Salids are the Aridisols that have:

1. A salic horizon that has its upper boundary within 100 cm of the soil surface;

2. A soil temperature regime warmer than cryic.

Key to Great Groups

GBA. Salids that are saturated with water in one or more layers within 100 cm of the mineral soil surface for 1 month or more in normal years.

Aquisalids, p. 387

GBB. Other Salids.

Haplosalids, p. 388

Aquisalids

These are the salty soils in wet areas in the deserts where capillary rise and evaporation of water concentrate the salts near the surface. Some of these soils have redoximorphic depletions and concentrations. In other soils redoximorphic features may not be evident because of a high pH and the associated low redox potential, which inhibit iron and manganese reduction. These soils occur dominantly in depressional areas where ground water saturates the soils at least part of the year. The vegetation on these soils generally is sparse, consisting of salt-tolerant shrubs, grasses, and forbs. Although these soils may hold water at a tension less than 1500 kPa, the dissolved salt content makes the soils physiologically dry.

Definition

Aquisalids are the Salids that are saturated with water in one or more layers within 100 cm of the mineral soil surface for 1 month or more in normal years.

Key to Subgroups

GBAA. Aquisalids that have a gypsic or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Gypsic Aquisalids

GBAB. Other Aquisalids that have a calcic or petrocalcic horizon that has an upper boundary within 100 cm of the soil surface.

Calcic Aquisalids

GBAC. Other Aquisalids.

Typic Aquisalids

Definition of Typic Aquisalids

Typic Aquisalids are the Aquisalids that do not have a calcic, gypsic, petrocalcic, or petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Aquisalids.—These are the Aquisalids that do not have a calcic, petrocalcic, gypsic, or petrogypsic horizon. These soils occur in most States in the West.

Calcic Aquisalids.—These are the Aquisalids that have a calcic or petrocalcic horizon within 100 cm of the soil surface. These soils do not have a gypsic or petrogypsic horizon with an upper boundary within 100 cm of the soil surface. They occur in Nevada and Texas.

Gypsic Aquisalids.—These are the Aquisalids that have a gypsic or petrogypsic horizon with an upper boundary within 100 cm of the soil surface. These soils occur in Texas and Colorado.

Haplosalids

These are the Salids that have a high concentration of salts but do not have the saturation that is associated with the Aquisalids. Haplosalids may be saturated for shorter periods than Aquisalids or may have had a water table associated with a past climate. In the Four Corners area of the United States, salic horizons have formed without the influence of a water table in saline parent materials.

Definition

Haplosalids are the Salids that are not saturated with water in one or more layers within 100 cm of the mineral soil surface for 1 month or more in normal years.

Key to Subgroups

GBBA. Haplosalids that have a duripan that has its upper boundary within 100 cm of the soil surface.

Duric Haplosalids

GBBB. Other Haplosalids that have a petrogypsic horizon that has its upper boundary within 100 cm of the soil surface.

Petrogypsic Haplosalids

GBBC. Other Haplosalids that have a gypsic horizon that has its upper boundary within 100 cm of the soil surface.

Gypsic Haplosalids

GBBD. Other Haplosalids that have a calcic horizon that has its upper boundary within 100 cm of the soil surface.

Calcic Haplosalids

GBBE. Other Haplosalids.

Typic Haplosalids

Definition of Typic Haplosalids

Typic Haplosalids are the Haplosalids that do not have a calcic, gypsic, or petrogypsic horizon or a duripan that has an upper boundary within 100 cm of the soil surface.

Description of Subgroups

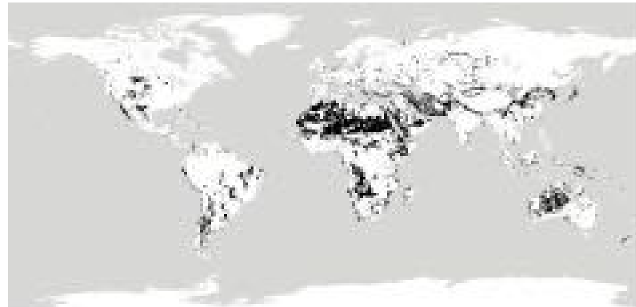
Typic Haplosalids.—These are the Haplosalids that do not have a calcic, gypsic, or petrogypsic horizon or a duripan with an upper boundary within 100 cm of the soil surface. Before 1994, these soils were identified as Torriorthents if a salic horizon was the only diagnostic horizon. These soils occur in California.

Calcic Haplosalids.—These are the Haplosalids that have a calcic horizon that has its upper boundary within 100 cm of the soil surface. These soils do not have a gypsic or petrogypsic horizon or a duripan with an upper boundary within 100 cm of the soil surface. They occur in Arizona.

Duric Haplosalids.—These are the Haplosalids that have a duripan with its upper boundary within 100 cm of the soil surface.

Gypsic Haplosalids.—These are the Haplosalids that have a gypsic horizon with its upper boundary within 100 cm of the soil surface. These soils do not have a duripan. They occur in California.

Petrogypsic Haplosalids.—These are the Haplosalids that have a petrogypsic horizon that has its upper boundary within 100 cm of the soil surface. These soils do not have a duripan.



CHAPTER 12

Entisols

The central concept of Entisols is that of soils that have little or no evidence of the development of pedogenic horizons. Most Entisols have no diagnostic horizons other than an ochric epipedon. Very few have an anthropic epipedon. A few that have a sandy or sandy-skeletal particle-size class have a horizon that would be a cambic horizon were it not for the particle-size class exclusion. Very few Entisols have an albic horizon. In coastal marshes some Entisols that have sulfidic materials within 50 cm of the mineral soil surface have a histic epipedon.

On many landscapes the soil material is not in place long enough for pedogenic processes to form distinctive horizons. Some of these soils are on steep, actively eroding slopes, and others are on flood plains or glacial outwash plains that receive new deposits of alluvium at frequent intervals. Some Entisols are old enough to have formed diagnostic horizons, but they consist mostly of quartz or other minerals that are resistant to the weathering needed to form diagnostic horizons. Buried diagnostic horizons are permitted in Entisols if they meet the requirements for buried soil defined in chapter 1.

Entisols may have any mineral parent material, vegetation, age, or moisture regime and any temperature regime, but they do not have permafrost. The only features common to all soils of the order are the virtual absence of diagnostic horizons and the mineral nature of the soils.

Definition of Entisols and Limits Between Entisols and Soils of Other Orders

Entisols are mineral soils that:

1. Do not have an Ap horizon containing 85 percent or more spodic materials;

2. Do not have a fragipan or an argillic, kandic, natric, oxic, or spodic horizon;

3. Do not have andic soil properties in 60 percent or more of the thickness, whether buried or not, between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact if shallower than 60 cm;

4. Do not have permafrost within 100 cm of the soil surface or both gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

5. Do not have *all* of the following:

 a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

 b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, *and* 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

 c. Cracks that open and close periodically;

6. Do not have both a salic horizon and an aridic moisture regime;

7. Do not have *all* of the following:

 a. A salic horizon; *and*

 b. A moisture control section that is dry at some time in normal years; *and*

 c. Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years;

8. Do not have both a mollic epipedon and a base saturation (by NH_4OAc) of 50 percent or more in all horizons *either* between the mineral soil surface and a depth of 180 cm *or* between the mineral soil surface and a densic, lithic, or paralithic contact, whichever is shallower;

9. Do not have a cambic horizon with its upper boundary within 100 cm of the mineral soil surface or its lower boundary at a depth of 25 cm or more below the mineral soil surface;

10. Do not have both a cambic horizon and a cryic temperature regime;

11. Do not have a duripan or a calcic, petrocalcic, gypsic, petrogypsic, or placic horizon unless its upper boundary is more than 100 cm below the mineral soil surface;

12. Do not have a sulfuric horizon unless its upper boundary is more than 150 cm below the mineral soil surface; *and*

13. Unless the soil has either sulfidic materials within 50 cm of the mineral soil surface or has, in one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction, do not have:

a. In 50 percent or more of the layers between the mineral soil surface and a depth of 50 cm, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more), which decreases with increasing depth below 50 cm, and also ground water within 100 cm of the mineral soil surface at some time during the year when the soil is not frozen in any part; *or*

b. A histic, mollic, plaggen, or umbric epipedon.

Limits Between Entisols and Soils of Other Orders

The definition of Entisols must provide criteria that separate Entisols from all other orders. These criteria define the limits of Entisols in relation to all other known kinds of soil.

1. Unlike Alfisols, Entisols must not have an argillic, natric, or kandic horizon.

2. Unlike Andisols, Entisols must not have andic soil properties in 60 percent or more of the thickness, whether buried or not, between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact if shallower than 60 cm.

3. Unlike Aridisols, Entisols must not have:

a. *All* of the following:

(1) A salic horizon; *and*

(2) A moisture control section that is dry at some time in normal years; *and*

(3) Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *or*

b. Both an anthropic or ochric epipedon and an aridic moisture regime; *and*

(1) An argillic or natric horizon; *or*

(2) A cambic horizon with its lower boundary below 25 cm or its upper boundary within 100 cm of the soil surface; *or*

(3) A calcic, petrocalcic, gypsic, petrogypsic, or salic horizon or a duripan with its upper boundary within 100 cm of the soil surface.

4. Unlike Gelisols, Entisols do not have permafrost within 100 cm of the soil surface, nor do they have both gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

5. Unlike Inceptisols, Entisols:

a. Must not have *any* of the following:

(1) A cambic horizon with its upper boundary within 100 cm of the mineral soil surface or its lower boundary at a depth of 25 cm or more below the mineral soil surface;

(2) A duripan or a calcic, petrocalcic, gypsic, petrogypsic, or placic horizon unless its upper boundary is more than 100 cm below the mineral soil surface;

(3) A fragipan or an oxic or spodic horizon;

(4) A sulfuric horizon unless its upper boundary is more than 150 cm below the mineral soil surface;

(5) Both a cambic horizon and a cryic temperature regime; *and*

b. Have either sulfidic materials within 50 cm of the mineral soil surface or have, in one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction, if they have:

(1) In 50 percent or more of the layers between the mineral soil surface and a depth of 50 cm, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more), which decreases with increasing depth below 50 cm, and also ground water within 100 cm of the mineral soil surface at some time during the year when the soil is not frozen in any part; *or*

(2) A histic, mollic, plaggen, or umbric epipedon.

6. Unlike Histosols, Entisols must meet the definition of mineral soils.

7. Unlike Mollisols, Entisols must not have a mollic epipedon unless they also either have sulfidic materials within 50 cm of the mineral soil surface or have, in one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction.

8. Unlike Oxisols, Entisols must not have an oxic or kandic horizon.

9. Unlike Spodosols, Entisols must not have a spodic horizon or an Ap horizon consisting of 85 percent or more spodic materials.

10. Unlike Ultisols, Entisols must not have an argillic or kandic horizon.

11. Unlike Vertisols, Entisols must not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, *and* 30 percent or more clay in all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically.

Representative Pedon and Data

Following is a description of a representative Entisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Entisol."

Classification: Mixed, mesic Typic Ustipsamment
Site identification number: 87P0168
Location: Blaine County, Nebraska; 520 m north and 90 m west of the southeast corner of sec. 9, T. 22 N., R. 22 E.
Landscape: Sandhills
Landform: Dune
Slope: 19 percent, north facing
Elevation: 778 m above m.s.l.
Soil moisture regime: Ustic
Soil temperature regime: Mesic
Permeability class: Rapid
Drainage class: Excessively drained
Depth to water table: More than 150 cm
Land use: Rangeland (grazed)
Hazard of erosion or deposition: Slight
Parent material: Sandy eolian material
Described by: Shurtliff

In the following pedon description, colors are for dry soil unless otherwise indicated.

A—0 to 13 cm; grayish brown (10YR 5/2) fine sand, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable; many fine and medium roots; slightly acid (pH 6.3); clear smooth boundary.
AC—13 to 28 cm; light brownish gray (10YR 6/2) fine sand, dark grayish brown (10YR 4/2) moist; single grain; loose; common fine and medium roots; neutral (pH 7.0); clear smooth boundary.
C1—28 to 64 cm; pale brown (10YR 6/3) fine sand, brown (10YR 5/3) moist; single grain; loose; few or common fine roots; neutral (pH 7.0); clear smooth boundary.
C2—64 to 152 cm; very pale brown (10YR 7/3) fine sand, pale brown (10YR 6/3) moist; single grain; loose; few fine roots; neutral (pH 7.0).

Key to Suborders

LA. Entisols that have *one or more* of the following:

1. Aquic conditions and sulfidic materials within 50 cm of the mineral soil surface; *or*

2. Permanent saturation with water and a reduced matrix in all horizons below 25 cm from the mineral soil surface; *or*

3. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm below the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. A texture finer than loamy fine sand and, in 50 percent or more of the matrix, *one or more* of the following:

(1) Chroma of 0; *or*

(2) Chroma of 1 or less and a color value, moist, of 4 or more; *or*

(3) Chroma of 2 or less and redox concentrations; *or*

b. A texture of loamy fine sand or coarser and, in 50 percent or more of the matrix, *one or more* of the following:

(1) Chroma of 0; *or*

(2) Hue of 10YR or redder, a color value, moist, of 4 or more, and chroma of 1; *or*

(3) Hue of 10YR or redder, chroma of 2 or less, and redox concentrations; *or*

(4) Hue of 2.5Y or yellower, chroma of 3 or less, and distinct or prominent redox concentrations; *or*

(5) Hue of 2.5Y or yellower and chroma of 1; *or*

(6) Hue of 5GY, 5G, 5BG, or 5B; *or*

(7) Any color if it results from uncoated sand grains; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquents, p. 393

LB. Other Entisols that have, in one or more layers at a depth between 25 and 100 cm below the mineral soil surface, 3

Characterization Data for an Entisol

SITE IDENTIFICATION NO.: 87P0168
CLASSIFICATION: MIXED, MESIC TYPIC USTIPSAMMENT
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	-4- TOTAL CLAY LT .002	-5- TOTAL SILT .002 -.05	-6- TOTAL SAND .05 -2	-7- CLAY FINE LT .0002	-8- CLAY CO_3 LT .002	-9- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS (mm) WEIGHT 2 -5	-17- WEIGHT 5 -20	-18- WEIGHT 20 -75	-19- WEIGHT .1- 75	-20- (>2mm) WT PCT OF WHOLE SOIL
			<- Pct of <2mm (3A1)											->	<- Pct of <75mm(3B1)			->	
87P 904	0- 13	A	3.5	3.2	93.3			0.7	2.5	19.9	66.0	7.1	0.3	--	--	--	--	73	--
87P 905	13- 28	AC	2.8	2.1	95.1			0.5	1.6	18.8	67.6	8.5	0.2	--	--	--	--	76	--
87P 906	28- 64	C1	2.5	1.2	96.3			0.2	1.0	16.4	72.4	7.3	0.2	--	--	--	--	80	--
87P 907	64-152	C2	2.5	1.0	96.5			--	1.0	13.0	73.0	10.2	0.3	--	--	--	--	83	--

DEPTH (cm)	ORGN C 6A1c	TOTAL N 6B3a	EXTR P 6S3	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG - LIMITS -) LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
	Pct	<2mm	ppm	<- Percent	of	<2mm	-->			Pct <0.4mm		<- - g/cc		- - ->	cm/cm	<- - -Pct of <2mm			- ->	cm/cm
0- 13	0.58	0.049						1.20	0.86										3.0	
13- 28	0.35	0.033						1.29	0.79										2.2	
28- 64	0.09							1.20	0.64										1.6	
64-152	0.06							1.00	0.56										1.4	

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9b	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8b	BASES + Al 5A3b	Al SAT 5G1	(BASE SAT) SUM 5C3	NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	(PH) $CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- - - - - - - - - - - - -meq / 100 g									- ->	<- - - - -Pct		- - - ->					
0- 13	3.0	0.6	TR	0.3	3.9	1.5		5.4	4.2			72	93				5.2	5.8
13- 28	2.7	0.5	TR	0.2	3.4	0.8		4.2	3.6			81	94				5.4	6.1
28- 64	2.2	0.5	TR	0.1	2.8	0.7		3.5	3.0			80	93				5.6	6.3
64-152	1.8	0.4	TR	0.1	2.3	0.3		2.6	2.5			88	92				5.6	6.4

SAND - SILT MINERALOGY (2.0-0.002mm)

SAMPLE NUMBER	FRAC-TION	X-RAY 7A2i (Peak Size)	THERMAL DTA 7A3c (Percent)	THERMAL TGA 7A4c (Percent)	OPTICAL TOT RE	OPTICAL GRAIN COUNT 7B1a (Percent)	INTER-PRETA-TION
87P 905	FS				66	QZ61 FK20 FP 9 AR 6 CD 5 PRtr	
87P 905	FS					TMtr FEtr HNtr GStr GNtr	
87P 906	FS				76	QZ68 FK12 CD 8 FP 7 AR 5 GStr	
87P 906	FS					PRtr OPtr HNtr	
87P 907	FS				68	QZ63 FK18 FP10 CD 5 AR 4 PRtr	
87P 907	FS					HNtr GNtr POtr	

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: FS, fine sand, 0.1-0.25 mm.
Mineral interpretation: QZ, quartz; FK, potassium feldspar; FP, plagioclase feldspar; AR, weathered aggregate; CD, chalcedony; PR, pyroxene; TM, tourmaline; FE, iron oxides; HN, hornblende; GS, glass; GN, garnet; OP, opaques; PO, plant opal.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.

percent or more (by volume) fragments of diagnostic horizons that are not arranged in any discernible order.

Arents, p. 403

LC. Other Entisols that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers (sandy loam lamellae are permitted) within the particle-size control section.

Psamments, p. 432

LD. Other Entisols that do not have a densic, lithic, or paralithic contact within 25 cm of the mineral soil surface and have:

1. A slope of less than 25 percent; *and*

2. *Either* 0.2 percent or more organic carbon of Holocene age at a depth of 125 cm below the mineral soil surface *or* an irregular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A soil temperature regime:

a. That is warmer than cryic; *or*

b. That is cryic and the soil has:

(1) No gelic material; *and*

(2) Either a slope of less than 5 percent or less than 15 percent volcanic glass in the 0.02 to 2.0 mm fraction in some part of the particle-size control section.

Fluvents, p. 406

LE. Other Entisols.

Orthents, p. 420

Aquents

These are the wet Entisols. They may be in tidal marshes, on deltas, on the margins of lakes where the soils are continuously saturated with water, on flood plains along streams where the soils are saturated at some time of the year, or in areas of wet, sandy deposits. Many Aquents have bluish or grayish colors and redoximorphic features. They may have any temperature regime. Most of them formed in recent sediments, and they support vegetation that tolerates permanent or periodic wetness.

Definition

Aquents are the Entisols that have *one or more* of the following:

1. Aquic conditions and sulfidic materials within 50 cm of the mineral soil surface; *or*

2. Permanent saturation with water and a reduced matrix in all horizons below 25 cm from the mineral soil surface; *or*

3. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm below the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *either*:

a. A texture finer than loamy fine sand and, in 50 percent or more of the matrix, *either*:

(1) Chroma of 0; *or*

(2) Chroma of 2 or less if there are redox concentrations; *or*

(3) Chroma of 1 or less and a color value, moist, of 4 or more if there are no redox concentrations; *or*

b. A texture of loamy fine sand or coarser and, in 50 percent or more of the matrix, *either*:

(1) Chroma of 0; *or*

(2) Hue of 10YR or redder, a color value, moist, of 4 or more, and chroma of 1; *or*

(3) Hue of 10YR or redder and chroma of 2 or less if there are redox concentrations; *or*

(4) Hue of 2.5Y or yellower and chroma of 3 or less if there are distinct or prominent redox concentrations; *or*

(5) Hue of 2.5Y or yellower and chroma of 1; *or*

(6) Hue of 5GY, 5G, 5BG, or 5B; *or*

(7) Any color if it results from uncoated sand grains; *or*

c. Enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

LAA. Aquents that have sulfidic materials within 50 cm of the mineral soil surface.

Sulfaquents, p. 403

LAB. Other Aquents that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction.

Hydraquents, p. 400

LAC. Other Aquents that have a cryic soil temperature regime.

Cryaquents, p. 394

LAD. Other Aquents that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers (sandy loam lamellae are permitted) within the particle-size control section.

Psammaquents, p. 401

LAE. Other Aquents that have *either* 0.2 percent or more organic carbon of Holocene age at a depth of 125 cm below the mineral soil surface *or* an irregular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquents, p. 397

LAF. Other Aquents that have episaturation.

Epiaquents, p. 396

LAG. Other Aquents.

Endoaquents, p. 395

Cryaquents

These are the cold, wet soils in high mountains or of high latitudes. Cryaquents are on flood plains, in depressional areas, and in coastal marshes. Many are grayish and stratified. Those in coastal marshes commonly have greenish to bluish hues. Because they are both cold and wet, Cryaquents have low potential for farming. The major areas of these soils in the United States are in Alaska, where they are in coastal marshes, on outwash plains, and on flood plains. The soils formed in recent sediments and are extensive in Alaska south of the permafrost zone. Most Cryaquents support mixed forest, shrub, or grassy vegetation. Many are nearly level, and their parent materials are typically Holocene or late-Pleistocene sediments.

Definition

Cryaquents are the Aquents that:

1. Have a cryic soil temperature regime;

2. Do not have sulfidic materials within 50 cm of the mineral soil surface;

3. Do not have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction.

Key to Subgroups

LACA. Cryaquents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquents

LACB. Other Cryaquents.

Typic Cryaquents

Definition of Typic Cryaquents

Typic Cryaquents are the Cryaquents that do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

1. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

2. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Cryaquents.—More variability in properties is permitted in this subgroup than in most Typic subgroups because the soils are both cold and wet. There are no restrictions on particle size, organic carbon, and other properties that are used to distinguish taxa in many places in this taxonomy. These soils are of moderate extent in the United States, occurring mostly on wet flood plains in Alaska and in the high mountains of the Western States. Most of the Typic Cryaquents are under their native vegetation and have a thin O horizon.

Aquandic Cryaquents.—These soils have a layer in the upper 75 cm that is 18 cm or more thick and is rich in pyroclastics. The clays in this layer normally do not disperse well and have a high pH-dependent charge. These soils are rare in the United States and are known to occur only on wet flood plains in Alaska.

Endoaquents

Endoaquents are the Aquents that have an isofrigid, frigid, or warmer temperature regime and endoaquic saturation. The ground water fluctuates from a level near or above the soil surface to about 100 cm below the soil surface and is sometimes below 200 cm.

Many Endoaquents support either a deciduous or coniferous forest. Some have been cleared and are used as cropland or pasture. Generally, Endoaquents are nearly level, and their parent materials are typically late-Pleistocene or Holocene sediments.

Definition

Endoaquents are the Aquents that:

1. Do not have sulfidic materials within 50 cm of the mineral soil surface;

2. Do not have a cryic soil temperature regime;

3. Have either an *n* value of 0.7 or less or less than 8 percent clay in some or all horizons at a depth between 20 and 50 cm below the mineral soil surface;

4. In some part of the particle-size control section, have *either*:

   a. A texture finer than loamy fine sand; *or*

   b. 35 percent or more (by volume) rock fragments;

5. Have less than 0.2 percent organic carbon of Holocene age at a depth of 125 cm below the mineral soil surface and a regular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

6. Have endosaturation.

Key to Subgroups

LAGA. Endoaquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0.

Sulfic Endoaquents

LAGB. Other Endoaquents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquents

LAGC. Other Endoaquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Endoaquents

LAGD. Other Endoaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Hue of 5Y or redder and chroma of 2 or more if there are no redox concentrations.

Aeric Endoaquents

LAGE. Other Endoaquents that have *both*:

1. An Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Endoaquents

LAGF. Other Endoaquents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Endoaquents

LAGG. Other Endoaquents.

Typic Endoaquents

Definition of Typic Endoaquents

Typic Endoaquents are the Endoaquents that:

1. Have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

   a. If there are redox concentrations, *either*:

      (1) Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 2 or less; *or*

      (2) Hue less yellow and less red than 5Y; *or*

      (3) Hue of 5Y and chroma of 2 or less; *or*

   b. Chroma of 1 or less;

2. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) and materials in the upper 15 cm that have one or more of these colors after mixing;

3. Do not have a lithic contact within 50 cm of the mineral soil surface;

4. Do not have, within 100 cm of the mineral soil surface, *either*:

a. Sulfidic materials; *or*

b. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0; *and*

5. Do not have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Description of Subgroups

Typic Endoaquents.—The central concept or Typic subgroup of Endoaquents is centered on moderately deep or deeper soils with low chroma throughout the layer at a depth between 25 and 75 cm below the mineral soil surface. These soils have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. The soils do not have, within 100 cm of the mineral soil surface, a horizon with an exchangeable sodium percentage of 15 or more, sulfidic materials, or any horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0.

Soils that have a shallow lithic contact are excluded from the Typic subgroup. Typic Endoaquents are of small extent in the United States. They are widely distributed, mostly in the humid parts of the country.

Aeric Endoaquents.—These soils are like Typic Endoaquents, but they have some subhorizon at a depth between 25 and 75 cm in which hue is redder or chroma is higher than is typical for Endoaquents or there are no redox concentrations. These colors are thought to reflect a level of ground water that is not so shallow as the level in the Typic subgroup or is shallow for a shorter period. These soils are of small extent in the United States. They are widely distributed, mostly in the humid parts of the country.

Humaqueptic Endoaquents.—These soils are like Typic Endoaquents, but they have an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. These soils are considered intergrades to Humaquepts. They are mainly in the north-central part of the United States. They are of small extent in the United States.

Lithic Endoaquents.—These soils are like Typic Endoaquents, but they have a lithic contact within 50 cm of the soil surface. They are of small extent in the United States.

Mollic Endoaquents.—These soils are like Typic Endoaquents, but they have an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. These soils are considered intergrades to Aquolls. They are mainly in the north-central part of the United States.

Sodic Endoaquents.—These soils are like Typic Endoaquents, but they have, within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more for 6 or more months in normal years. These soils are of small extent and are known to occur only in tidal-influenced areas on the gulf coast in the United States. They support mostly grassy vegetation.

Sulfic Endoaquents.—These soils are like Typic Endoaquents, but they have sulfidic materials at a depth between 50 and 100 cm below the mineral soil surface. These soils are not known to occur in the United States. The subgroup has been established for use in other countries.

Epiaquents

Epiaquents are the Aquents that have an isofrigid, frigid, isomesic, mesic, or warmer temperature regime and epiaquic saturation. The ground water is perched during some periods in these soils and fluctuates from a level near or above the soil surface in wet seasons. The water table does not occur in the upper 200 cm during some periods in some of these soils.

Many Epiaquents support either a deciduous or a coniferous forest. Some have been cleared and are used as cropland or pasture. Generally, Epiaquents are nearly level, and their parent materials are typically late-Pleistocene or Holocene sediments.

Definition

Epiaquents are the Aquents that:

1. Do not have sulfidic materials within 50 cm of the mineral soil surface;

2. Do not have a cryic soil temperature regime;

3. Have either an *n* value of 0.7 or less or less than 8 percent clay in some or all horizons at a depth between 20 and 50 cm below the mineral soil surface;

4. In some part of the particle-size control section, have *either*:

a. A texture finer than loamy fine sand; *or*

b. 35 percent or more (by volume) rock fragments;

5. Have less than 0.2 percent organic carbon of Holocene age at a depth of 125 cm below the mineral soil surface and a

regular decrease in content of organic carbon from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

6. Have episaturation.

Key to Subgroups

LAFA. Epiaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Chroma of 2 or more if there are no redox concentrations.

Aeric Epiaquents

LAFB. Other Epiaquents that have *both*:

1. An Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Epiaquents

LAFC. Other Epiaquents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Epiaquents

LAFD. Other Epiaquents.

Typic Epiaquents

Definition of Typic Epiaquents

Typic Epiaquents are the Epiaquents that have:

1. In one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

a. If there are redox concentrations, *either*:

(1) Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 2 or less; *or*

(2) Hue less yellow or less red than 5Y; *or*

(3) Hue of 5Y and chroma of 2 or less; *or*

b. Chroma of 1 or less; *and*

2. An Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Description of Subgroups

Typic Epiaquents.—The Typic subgroup of Epiaquents is centered on soils with low chroma throughout the layer at a depth between 25 and 75 cm below the mineral soil surface. These soils have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. The soils are of small extent in the United States. They are widely distributed, mostly in the humid parts of the country.

Aeric Epiaquents.—These soils are like Typic Epiaquents, but they have some subhorizon at a depth between 25 and 75 cm in which hue is redder or chroma is higher than is typical for Epiaquents or there are no redox concentrations. These colors are thought to reflect a level of ground water that is not so shallow as the level in the Typic subgroup or is shallow for a shorter period. These soils are of small extent in the United States. They are widely distributed, mostly in the humid parts of the country.

Humaqueptic Epiaquents.—These soils are like Typic Epiaquents, but they have an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. These soils are considered intergrades to Humaquepts. They are of small extent in the United States. They occur mainly in the north-central part of the country.

Mollic Epiaquents.—These soils are like Typic Epiaquents, but they have an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or have materials in the upper 15 cm that have these colors after mixing. These soils are considered intergrades to Aquolls. They are mainly in the north-central part of the United States.

Fluvaquents

Fluvaquents are primarily the stratified, wet soils on flood plains and deltas of middle and low latitudes. The stratification reflects deposition of sediments under changing currents and in shifting channels. The sediments are of Holocene age and have a relatively high content of organic carbon at a considerable depth when compared with many other wet, mineral soils. The materials have dried or have partially dried from time to time as they accumulated, and the *n* values are low. These soils are extensive along large rivers, particularly in humid areas. The ground water fluctuates from a level near or above the soil surface to about 100 cm below the soil surface and is sometimes below 200 cm. Generally, Fluvaquents are nearly level.

Many Fluvaquents support either a deciduous or a coniferous forest. Some have been cleared and protected from flooding and are used as cropland or pasture.

Definition

Fluvaquents are the Aquents that:

1. Have a soil temperature regime warmer than cryic;

2. Have an *n* value of 0.7 or less or have less than 8 percent clay in some or all subhorizons between depths of 20 and 50 cm;

3. Have either a texture finer than loamy fine sand or 35 percent or more (by volume) rock fragments in some or in all parts of the particle-size control section;

4. Have a content of Holocene-age organic carbon that decreases irregularly with increasing depth below 25 cm or that remains more than 0.2 percent to a depth of 125 cm (thin strata of sand may have less organic carbon if the finer sediments at a depth of 125 cm or below have 0.2 percent organic carbon or more); *and*

5. Do not have sulfidic materials within 50 cm of the mineral soil surface.

Key to Subgroups

LAEA. Fluvaquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0.

Sulfic Fluvaquents

LAEB. Other Fluvaquents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Fluvaquents

LAEC. Other Fluvaquents that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Fluvaquents

LAED. Other Fluvaquents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Fluvaquents

LAEE. Other Fluvaquents that have, in one or more horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

1. Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 3 or more; *or*

2. Hue of 2.5Y or redder, a color value, moist, of 5 or less, and chroma of 2 or more; *or*

3. Hue of 5Y and chroma of 3 or more; *or*

4. Chroma of 2 or more if there are no redox concentrations.

Aeric Fluvaquents

LAEF. Other Fluvaquents that have *both*:

1. An Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Fluvaquents

LAEG. Other Fluvaquents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Fluvaquents

LAEH. Other Fluvaquents.

Typic Fluvaquents

Definition of Typic Fluvaquents

Typic Fluvaquents are the Fluvaquents that:

1. Have, in all horizons between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, colors in 50 percent or more of the matrix as follows:

   a. If there are redox concentrations, *either*:

      (1) Hue of 2.5Y or redder, a color value, moist, of 6 or more, and chroma of 2 or less; *or*

      (2) Hue less yellow and less red than 5Y; *or*

      (3) Hue of 5Y and chroma of 2 or less; *or*

   b. Chroma of 1 or less;

2. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

   a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

   b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

   c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Do not have *either*:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing;

5. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the soil surface; *and*

6. Do not have, within 100 cm of the mineral soil surface, *either*:

   a. Sulfidic materials; *or*

   b. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0.

Description of Subgroups

Typic Fluvaquents.—The concept of Typic Fluvaquents is centered almost exclusively on very young water-laid deposits that are mostly in wet areas on flood plains. These soils have fine strata at a shallow depth, or they show too little evidence of alteration to have a cambic horizon. Redoximorphic features in the soils extend downward from a point very close to the surface, and the water table is at or close to the surface most of the year unless artificial drainage has been provided. The soils do not have a layer of fine pyroclastic materials that is as thick as or thicker than 18 cm and that is within 75 cm of the surface. They do not have a buried Histosol or a buried histic epipedon within a depth of 100 cm. They do not have a dark surface horizon or, if one occurs, it is thin. These characteristics were selected for the Typic subgroup not because they are most common but because they represent the wettest and most recent Fluvaquents. As horizons begin to develop, the soils are classified in intergrade subgroups that indicate their nature.

Most Typic Fluvaquents are nearly level, and their parent materials are Holocene sediments. Many support forest vegetation, but some support shrub or grassy vegetation. Some areas have been cleared, drained, and protected from flooding and are used as cropland or pasture.

Aeric Fluvaquents.—These soils are like Typic Fluvaquents, but they have some subhorizon at a depth between 25 and 75 cm in which chroma is higher than that of soils in the Typic subgroup, reflecting a level of ground water that is not so shallow as in the Typic subgroup or is shallow a shorter period.

Most Aeric Fluvaquents are nearly level. Most support forest vegetation, but some support shrub or grassy vegetation. Many areas have been cleared, drained, and protected from flooding and are used as cropland or pasture.

Aquandic Fluvaquents.—These soils are similar to Typic Fluvaquents, but they have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. In the United States, these soils occur in western Washington but are not extensive. Most Aquandic Fluvaquents are nearly level and support forest vegetation. Many areas have been cleared, drained, and protected from flooding and are used as hayland or pasture.

Humaqueptic Fluvaquents.—These soils have a surface horizon that has the color and other properties of an umbric epipedon, except for thickness. In the United States, these soils occur on nearly level flood plains in areas where Ultisols or other soils that have low base saturation are the dominant upland soils. Most Humaqueptic Fluvaquents are forested. Some are pastured, and a few have been drained and are cultivated. Humaqueptic Fluvaquents are not extensive soils.

Mollic Fluvaquents.—These soils have a surface horizon that has the color and other properties of a mollic epipedon, except for thickness. The epipedon is less than 25 cm thick. These soils are otherwise like Typic Fluvaquents in defined properties. They have high base saturation, and some of them are calcareous. Many of them are on flood plains along streams in areas where Mollisols are extensive soils on uplands. Mollic Fluvaquents are moderately extensive soils in the United States. Nearly all have been cleared, drained, and protected from flooding and are used as cropland or pasture.

Sulfic Fluvaquents.—These soils have sulfidic materials at a depth between 50 and 100 cm below the mineral soil surface. They are of small extent in the States of Washington and California in the United States.

Thapto-Histic Fluvaquents.—These soils are similar to Typic Fluvaquents, but they have a buried Histosol or a buried histic epipedon that has its upper boundary within 100 cm of the soil surface. Many Thapto-Histic Fluvaquents in the United States formed within the last 100 to 150 years as a result of erosion on hillsides and the deposition of sediment on a Histosol. In the United States, Thapto-Histic Fluvaquents are of moderately small extent and in many areas are farmed or pastured. In other parts of the world, these soils occur near streams in coastal marshes.

Vertic Fluvaquents.—These soils are like Typic Fluvaquents, but they either have cracks and slickensides or wedge-shaped aggregates or have a linear extensibility of 6.0 or more within 100 cm of the mineral soil surface. These soils are mainly in backswamps on flood plains where water stands for long periods unless the soils have been artificially drained. Because there are no restrictions on the color value of Vertisols, Vertic Fluvaquents are permitted, but not required, to have a lower color value than the soils of the Typic subgroup. Vertic Fluvaquents have fine strata near the surface. They are of moderate extent in the United States. They are nearly level and support forest, shrub, or grassy vegetation. Many areas have been cleared, drained, and protected from flooding and are used as cropland or pasture.

Hydraquents

These are loamy and clayey soils in tidal marshes that are permanently saturated with water. Hydraquents formed in sediments that were deposited under water and have a low bulk density, commonly about 0.6 g/cc, and a high water content, commonly more than 100 percent of the dry weight. If the soils are drained, the loss of water is irreversible and the bulk density increases as water is withdrawn. The soils deposited in tidal marshes retain their high water content. Hydraquents never have been dry, and consequently the bulk density is low and the water content is very high. The soils typically have reduced matrices, and their colors mostly are bluish gray to greenish gray and change to shades of brown when the soils are exposed to air. A color change normally can be seen within a matter of seconds or a few minutes but may not be complete until some weeks have passed.

Because the water content is high, the soil strength is low, commonly too low for the soils to support grazing animals. Nevertheless, some Hydraquents may be grazed if the water content in the surface layer is relatively low or if vegetation adds strength to the surface layer.

Hydraquents are extensive in tidal marshes. In the United States, they are largely confined to the Atlantic and gulf coasts, although a few are on the northern Pacific coast and near San Francisco Bay.

Definition

Hydraquents are the Aquents that:

1. Do not have sulfidic materials within 50 cm of the mineral soil surface; *and*

2. Have, in all subhorizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay.

Key to Subgroups

LABA. Hydraquents that have, within 100 cm of the mineral soil surface, *one or both* of the following:

1. Sulfidic materials; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0.

Sulfic Hydraquents

LABB. Other Hydraquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Hydraquents

LABC. Other Hydraquents that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Hydraquents

LABD. Other Hydraquents.

Typic Hydraquents

Definition of Typic Hydraquents

Typic Hydraquents are the Hydraquents that:

1. Do not have, within 100 cm of the mineral soil surface, *one or both* of the following:

 a. Sulfidic materials; *or*

 b. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0;

2. Do not have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years; *and*

3. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Hydraquents.—These are the Hydraquents that, within 100 cm of the soil surface, do not have any horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0, and do not have sulfidic materials or an exchangeable sodium percentage of 15 or more. These soils have neither a buried Histosol nor a buried histic epipedon that has its upper boundary within 100 cm of the mineral soil surface.

Typic Hydraquents are of moderate extent in the United States. They are nearly level and support swamp forest, shrub, or grassy vegetation. Most of these soils are used as wildlife habitat.

Sodic Hydraquents.—These are the Hydraquents that, within 100 cm of the soil surface, have an exchangeable sodium percentage of 15 or more. They do not have, within 100 cm of the soil surface, any sulfidic materials or any horizon 15 cm or more thick that has a pH value of 3.5 to 4.0 and any other characteristics of a sulfuric horizon.

Sodic Hydraquents are of small extent in the United States, occurring mostly in the Mississippi delta and westward along the gulf coast. They are nearly level and support mostly grassy and forb vegetation. Most of these soils are used as wildlife habitat.

Sulfic Hydraquents.—These are the Hydraquents that, within 100 cm of the soil surface, have sulfidic materials or a horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH value between 3.5 and 4.0. The soils are of small extent in the United States. They are nearly level and support mostly grassy and forb vegetation. Most of these soils are used as wildlife habitat.

Thapto-Histic Hydraquents.—These soils are like Typic Hydraquents, but they have a buried Histosol or a buried histic epipedon that has its upper boundary within 100 cm of the mineral soil surface. Within 100 cm of the soil surface, they do not have any sulfidic materials or any horizon 15 cm or more thick that has a pH value of 3.5 to 4.0 and any other characteristics of a sulfuric horizon and do not have an exchangeable sodium percentage of 15 or more.

Thapto-Histic Hydraquents are of small extent in the United States. They are nearly level and support swamp forest, shrub, or grassy vegetation. Most of these soils are used as wildlife habitat.

Psammaquents

These Aquents have a sandy texture and commonly are gray, with or without redox concentrations. The water table is at or near the surface for long periods unless artificial drainage has been provided. Most of these soils formed in late-Pleistocene to recent sediments. Most do not have distinctive features, but a few have a B horizon that is similar to the one in Spodosols but is too weakly developed to be a spodic horizon. Others show some darkening and accumulation of organic matter in an A horizon but too little for a mollic or umbric epipedon.

Definition

Psammaquents are the Aquents that:

1. Do not have sulfidic materials within 50 cm of the mineral soil surface;

2. Do not have, in any horizon at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction;

3. Do not have a cryic soil temperature regime;

4. Have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the control section for the family particle-size class.

Key to Subgroups

LADA. Psammaquents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammaquents

LADB. Other Psammaquents that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Psammaquents

LADC. Other Psammaquents that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

 1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus 1/2 Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammaquents

LADD. Other Psammaquents that have *both*:

1. An Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humaqueptic Psammaquents

LADE. Other Psammaquents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Psammaquents

LADF. Other Psammaquents.

Typic Psammaquents

Definition of Typic Psammaquents

Typic Psammaquents are the Psammaquents that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) and materials in the upper 15 cm that have these colors after mixing;

3. Do not have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus 1/2 Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon; *and*

4. Do not have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Description of Subgroups

Typic Psammaquents.—The central concept or Typic subgroup of Psammaquents is fixed on moderately deep or deeper soils that have an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more or that have materials in the upper 15 cm that have these colors after mixing. These soils do not have an exchangeable sodium percentage of 15 or more within 100 cm of the mineral soil surface. They do not have a horizon that approaches the criteria for a spodic horizon. They are saturated with water part of the time. A range in the length of the periods of saturation is permitted.

Typic Psammaquents are locally extensive in the United States, particularly on the coastal plains and in areas covered by Wisconsinan outwash. Few of them are farmed. Most are used for grazing or forest, depending on their natural vegetation.

Humaqueptic Psammaquents.—These soils are like Typic Psammaquents, but the A or Ap horizon resembles an umbric epipedon but is less than 25 cm thick. The base saturation (by NH_4OAc) is less than 50 percent in some part of the soils within the upper 100 cm. In the United States, these soils are of small extent. Most support mixed forest vegetation. Some have been cleared and drained and are used as cropland, hayland, or pasture.

Lithic Psammaquents.—These soils are like Typic Psammaquents, but they have a lithic contact within 50 cm of the soil surface. They are of small extent in the United States.

Mollic Psammaquents.—These soils are like Typic Psammaquents, but the A or Ap horizon resembles a mollic epipedon but is less than 25 cm thick. They have a base saturation of 50 percent or more in all horizons within 100 cm of the soil surface. These soils are moderately extensive in the United States, mostly in areas of Wisconsinan outwash. The A horizon generally is black or very dark gray but is too thin to meet the requirements for a mollic epipedon, which in sands must be at least 25 cm thick. Many of these soils support hardwood forest, and some support grass or grass and widely scattered trees. Mollic Psammaquents are used for grazing or forest, depending on their natural vegetation. Some of the soils have been cleared and drained and are used as cropland or pasture.

Sodic Psammaquents.—These soils have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more. They are not extensive in the United States. They are mostly on the low coastal plains in Texas. Most of them support their native vegetation of grasses and forbs and are used as rangeland.

Spodic Psammaquents.—These soils have a weak accumulation of amorphous materials, mostly humus. They are not extensive in the United States. They are in Florida, on the low coastal plains along the Atlantic Ocean and the Gulf of Mexico. Most of them still have their native vegetation of forest or shrubs and grasses. Some have been cleared and drained and are used as cropland or pasture.

Sulfaquents

These are the Aquents that have an appreciable amount of sulfides close to the mineral soil surface and have few or no carbonates. The sulfides are close enough to the surface for the soils to become extremely acid and virtually sterile if drained. These soils are largely restricted to coastal marshes where the water is brackish. Tidal marshes at the mouth of rivers normally have areas of these soils unless the river sediments are rich in carbonates. Coastal marshes that are not near rivers also may have areas of these soils if storms periodically flood them with salt water.

Sulfaquents are permanently saturated at or near the surface, and many are nearly neutral in reaction. The *n* value typically is high, commonly more than 1 in most horizons. A histic epipedon composed of organic soil materials is common. These soils can have any mineral particle-size class, but those with less than 8 percent clay are not considered typical. If the soils are drained, the sulfides oxidize and the soils change rapidly to Sulfaquepts.

Sulfaquents commonly are not used as cropland, but some are used for the production of rice. The areas used for rice are kept flooded at all times, except for a very brief period while the crop is harvested.

Sulfaquents are extensive along coasts and bays from the Equator to high latitudes. They are moderately extensive on the east coast of the United States, where they border the Atlantic Ocean in areas not protected by barrier islands.

Definition

Sulfaquents are the Aquents that have sulfidic materials within 50 cm of the mineral soil surface.

Key to Subgroups

LAAA. Sulfaquents that have, in some horizons at a depth between 20 and 50 cm below the mineral soil surface, *either or both*:

1. An *n* value of 0.7 or less; *or*

2. Less than 8 percent clay in the fine-earth fraction.

Haplic Sulfaquents

LAAB. Other Sulfaquents that have a histic epipedon.

Histic Sulfaquents

LAAC. Other Sulfaquents that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Sulfaquents

LAAD. Other Sulfaquents.

Typic Sulfaquents

Definition of Typic Sulfaquents

Typic Sulfaquents are the Sulfaquents that:

1. Do not have, in one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, *either or both*:

   a. Less than 8 percent clay in the fine-earth fraction; *or*

   b. An *n* value of 0.7 or less;

2. Do not have a histic epipedon;

3. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Sulfaquents.—The central concept or Typic subgroup of Sulfaquents is fixed on soils that have, in all horizons at a depth between 20 and 50 cm below the mineral soil surface, both an *n* value of more than 0.7 and 8 percent or more clay in the fine-earth fraction. These soils do not have a histic epipedon or a buried histic epipedon. They are extensive in the coastal marshes along the Atlantic seaboard but are not extensive elsewhere in the United States. They are nearly level and support mostly grassy and forb vegetation. Most of the soils are used as wildlife habitat.

Haplic Sulfaquents.—These are the Sulfaquents that have, in one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, either or both less than 8 percent clay in the fine-earth fraction or an *n* value of 0.7 or less. These soils are of small extent in the United States. They are nearly level and support mostly grassy and forb vegetation. Most of these soils are used as wildlife habitat.

Histic Sulfaquents.—These soils are like Typic Sulfaquents, but they have a histic epipedon. They are of small extent in the United States. They are nearly level and support mostly grassy and forb vegetation. Most of these soils are used as wildlife habitat.

Thapto-Histic Sulfaquents.—These are the Sulfaquents that have a buried Histosol or a buried histic epipedon with its upper boundary within 100 cm of the soil surface. These soils have both *n* values of more than 0.7 and 8 or more percent clay in the fine-earth fraction. They are in New Jersey, Maryland, and Delaware.

Arents

These are the Entisols that do not have horizons because they have been deeply mixed by plowing, spading, or other methods of moving by humans. The soils retain fragments that can be identified as parts of a former spodic or argillic horizon, a duripan, and so on, but the fragments do not themselves form horizons. Rather, they are scattered through the soils and are mixed with the materials of other horizons. Some of these soils are the result of deliberate soil modification intended to break or remove a pan. Some are the result of replacing the soil profile after strip-mining. Others have resulted from cuts and fills made to shape the surface or even from the accident of location in an area of intensive bombardment during a war.

Arents are not extensive in the United States. Their area is increasing, however, because of increased use of modern power machinery to modify soils for high-intensity crop production.

Arents form a unique suborder in that there are no Typic subgroups. Subgroups of Arents are intergrades to other orders, suborders, or great groups, according to the nature of the fragments that can be identified. The Arents that do not meet other subgroup criteria are assigned to the Haplic subgroup.

Definition

Arents are the Entisols that:

1. Have 3 percent or more, by volume, fragments of diagnostic horizons in one or more subhorizons at a depth between 25 and 100 cm below the soil surface, and the fragments are not arranged in a discernible order; *and*

2. Do not have, within 50 cm of the mineral soil surface, aquic conditions; *and*

a. The colors defined for Aquents; *or*

b. Sulfidic materials; *or*

c. A positive reaction to alpha,alpha-dipyridyl when the soil is not being irrigated.

Key to Great Groups

LBA. Arents that have an ustic moisture regime.

Ustarents, p. 405

LBB. Other Arents that have a xeric moisture regime.

Xerarents, p. 406

LBC. Other Arents that have an aridic (or torric) moisture regime.

Torriarents, p. 404

LBD. Other Arents.

Udarents, p. 404

Torriarents

These are the Arents of arid regions. They have an aridic (or torric) moisture regime. Generally, they are neutral or more alkaline, and many are calcareous. Many have gentle slopes. Most have been modified for irrigated agriculture. Torriarents are extensive in California but occur throughout the Western United States.

Definition

Torriarents are the Arents that have an aridic soil moisture regime.

Key to Subgroups

LBCA. Torriarents that have, in one or more horizons within 100 cm of the mineral soil surface, 3 percent or more fragments of a natric horizon.

Sodic Torriarents

LBCB. Other Torriarents that have, within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or a petrocalcic horizon;

Duric Torriarents

LBCC. Other Torriarents.

Haplic Torriarents

Description of Subgroups

Haplic Torriarents.—The Haplic subgroup of Torriarents is centered on soils that have 3 percent or more fragments of an argillic or cambic horizon. These soils are permitted to have fragments of any diagnostic horizon, but they cannot have, in any horizon within 100 cm of the mineral soil surface, fragments of a duripan or a petrocalcic or natric horizon. Many of the soils have gentle slopes. Most have been modified for irrigated agriculture. Haplic Torriarents are used as irrigated cropland. They are of moderately small extent. They are mostly in California but occur throughout the Western United States.

Duric Torriarents.—The Duric subgroup of Torriarents is centered on soils that have, in some horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or a petrocalcic horizon. Many of these soils have gentle slopes. Most have been modified for irrigated agriculture. Duric Torriarents are used as irrigated cropland. They are of moderate extent. They are mostly in California but occur throughout the Western United States.

Sodic Torriarents.—The Sodic subgroup of Torriarents is centered on soils that have, in some horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a natric horizon. Many of these soils have gentle slopes. Most have been modified for irrigated agriculture. Sodic Torriarents are used as irrigated cropland. They are of small extent. They are known to occur only in California in the United States.

Udarents

These are the Arents of moist regions. They have a udic moisture regime. Many have gentle slopes. Many have been modified in the process of strip-mining. The top part of the soil profile was removed and then replaced after the mining was completed. Some of these soils have a densic contact with compacted layers of soil materials. Some formed in fill material. Udarents are moderately extensive in the United States. They are used mostly as pasture, but some are used as woodland, cropland, or homesites.

Definition

Udarents are the Arents that have a udic soil moisture regime.

Key to Subgroups

LBDA. Udarents that have 3 percent or more fragments of an argillic horizon in some horizon within 100 cm of the mineral soil surface and have a base saturation (by sum of cations) of 35 percent or more in all parts within 100 cm of the mineral soil surface.

Alfic Udarents

LBDB. Other Udarents that have 3 percent or more fragments of an argillic horizon in some horizon within 100 cm of the mineral soil surface.

Ultic Udarents

LBDC. Other Udarents that have 3 percent or more fragments of a mollic epipedon in some horizon within 100 cm of the mineral soil surface and have a base saturation (by sum of cations) of 35 percent or more in all parts within 100 cm of the mineral soil surface.

Mollic Udarents

LBDD. Other Udarents.

Haplic Udarents

Description of Subgroups

Haplic Udarents.—The Haplic subgroup of Udarents is centered on soils that have 3 percent or more fragments of a cambic horizon in some horizon within 100 cm of the mineral soil surface. These soils are permitted to have fragments of other diagnostic horizons, but they cannot have, in any horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of an argillic horizon. They cannot have 3 percent or more fragments of a mollic epipedon unless some horizon within 100 cm of the mineral soil surface has a base saturation of less than 35 percent. Commonly, these soils have gentle slopes. They formed in a number of ways. Some have been modified in the process of strip-mining. The top part of the soil profile was removed and then replaced after the mining was completed. Some of the soils have a densic contact with compacted layers of soil materials. Haplic Udarents are of small extent in the United States.

Alfic Udarents.—The Alfic subgroup of Udarents is fixed on soils that have 3 percent or more fragments of an argillic horizon in some horizon and have a base saturation (by sum of cations) of 35 percent or more in all parts within 100 cm of the mineral soil surface. These soils are permitted to have fragments of other diagnostic horizons. Many of the soils have gentle slopes. Alfic Udarents formed in a number of ways. Many have been modified in the process of strip-mining. The top part of the soil profile was removed and then replaced after the mining was completed. Some of these soils have a densic contact with compacted layers of soil materials. Alfic Udarents are moderately extensive in the United States. They are used mostly as pasture or cropland. Some are used as woodland and some as homesites.

Mollic Udarents.—The Mollic subgroup of Udarents is fixed on soils that have 3 percent or more fragments of a mollic epipedon in some horizon within 100 cm of the mineral soil surface and have a base saturation (by sum of cations) of 35 percent or more in all parts within 100 cm of the mineral soil surface. These soils are permitted to have fragments of other diagnostic horizons, but they cannot have, in any horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of an argillic horizon. Many of the soils have gentle slopes. Mollic Udarents formed in a number of ways. Some have been modified in the process of strip-mining. The top part of the soil profile was removed and then replaced after the mining was completed. Some of the soils have a densic contact with compacted layers of soil materials. Mollic Udarents are of small extent in the United States. They are used mostly as pasture or cropland, but some are used as homesites.

Ultic Udarents.—The Ultic subgroup of Udarents is fixed on soils that have 3 percent or more fragments of an argillic horizon and have a base saturation (by sum of cations) of less than 35 percent in some part within 100 cm of the mineral soil surface. These soils are permitted to have fragments of other diagnostic horizons. Many have gentle slopes. Ultic Udarents formed in a number of ways. A few have been modified in the process of strip-mining. The top part of the soil profile was removed and then replaced after the mining was completed. Some of these soils have a densic contact with compacted layers of soil materials. Ultic Udarents are of small extent in the United States. They are used mostly as pasture, woodland, or cropland.

Ustarents

These are the Arents that have an ustic moisture regime. Many of these soils have gentle slopes. Most formed in fill material. Some have a densic contact with compacted layers of soil materials. Ustarents are of small extent in the United States. They are used mostly as pasture or are idle.

Definition

Ustarents are the Arents that have an ustic soil moisture regime.

Key to Subgroups

LBAA. All Ustarents.

Haplic Ustarents

Description of Subgroups

Haplic Ustarents.—The Haplic subgroup of Ustarents is the only subgroup recognized. These soils have, in some horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a diagnostic horizon. They are permitted to have fragments of any diagnostic horizon. Commonly, they have gentle slopes. Most formed in fill material. Some have a densic contact with compacted layers of soil materials. Haplic Ustarents are of small extent in the United States. They are used mostly as pasture or are idle.

Xerarents

These are the Arents that have a xeric moisture regime. Most of these soils have been modified for irrigated agriculture. Many have gentle slopes. Xerarents occur mostly in California in the United States.

Definition

Xerarents are the Arents that have a xeric soil moisture regime.

Key to Subgroups

LBBA. Xerarents that have, in one or more horizons within 100 cm of the mineral soil surface, 3 percent or more fragments of a natric horizon.

Sodic Xerarents

LBBB. Other Xerarents that have, within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or a petrocalcic horizon.

Duric Xerarents

LBBC. Other Xerarents that have fragments of an argillic horizon with a base saturation (by sum of cations) of 35 percent or more within 100 cm of the mineral soil surface.

Alfic Xerarents

LBBD. Other Xerarents.

Haplic Xerarents

Description of Subgroups

Haplic Xerarents.—The Haplic subgroup of Xerarents is centered on soils that have 3 percent or more fragments of a cambic horizon or another diagnostic horizon. These soils are not permitted to have, in any horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or an argillic or natric horizon. Many of the soils have gentle slopes. Most have been modified for irrigated agriculture. Haplic Xerarents are used as irrigated cropland. They are of small extent, mostly in California.

Alfic Xerarents.—The Alfic subgroup of Xerarents is centered on soils that have 3 percent or more fragments of an argillic horizon in some horizon and have a base saturation (by sum of cations) of 35 percent or more in all parts within 100 cm of the mineral soil surface. These soils are not permitted to have, in any horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or a petrocalcic or natric horizon. They are permitted to have fragments of other diagnostic horizons. Many of the soils have gentle slopes. Most have been modified for irrigated agriculture. Alfic Xerarents are used as irrigated cropland. They are of moderate extent, mostly in California.

Duric Xerarents.—The Duric subgroup of Xerarents is centered on soils that have, in some horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a duripan or a natric or petrocalcic horizon. Many of these soils have gentle slopes. Most have been modified for irrigated agriculture. Duric Xerarents are used as irrigated cropland. They are of moderate extent, mostly in California.

Sodic Xerarents.—The Sodic subgroup of Xerarents is centered on soils that have, in some horizon within 100 cm of the mineral soil surface, 3 percent or more fragments of a natric horizon. Many of these soils have gentle slopes. Most have been modified for irrigated agriculture. Sodic Xerarents are used as irrigated cropland. They are of small extent and are known to occur only in California in the United States.

Fluvents

These are mostly brownish to reddish soils that formed in recent water-deposited sediments, mainly on flood plains, fans, and deltas of rivers and small streams but not in backswamps where drainage is poor. The age of the sediments in humid regions commonly is a few years or decades or a very few hundred years. In arid regions it may be somewhat more. Many Fluvents are frequently flooded unless they are protected by dams or levees. Stratification of the materials is normal. Most of the alluvial sediments are derived from eroding soils or streambanks and contain an appreciable amount of organic carbon, which is mainly in the clay fraction. Strata of clayey or loamy materials commonly have more organic carbon than the overlying more sandy strata. Thus, the percentage of organic carbon of Holocene age decreases irregularly with increasing depth if the materials are stratified. If the texture is homogeneous, the content of organic carbon decreases regularly with increasing depth. Because the deposits generally are loamy and recent, however, the percentage of carbon in the deep layers is higher than in soils that formed in parent materials other than alluvium. This difference in content of organic carbon is the basis for the definition of Fluvents that follows. Fluvents can have any vegetation and any temperature regime. They can have any moisture regime that does not meet the criteria for Aquents. Soils that formed in recent alluvium and have a permanently frozen substratum are grouped with Gelisols. Some soils that formed in volcanic tephra and some that have gelic materials are excluded from Fluvents because they have a different mode of formation and different interpretations.

Definition

Fluvents are the Entisols that:

1. Have 35 percent or more (by volume) rock fragments or a texture of loamy very fine sand or finer in some part of the particle-size control section;

2. Do not have, in one or more layers at a depth between 25 and 100 cm below the mineral soil surface, 3 percent or more (by volume) fragments of diagnostic horizons that can be identified and that occur more or less without a discernible order;

3. Have a slope of less than 25 percent;

4. Have a content of Holocene-age organic carbon that decreases irregularly with increasing depth or that is 0.2 percent or more at a depth of 125 cm or at a densic, lithic, or paralithic contact if shallower;

5. Do not have, within 50 cm of the mineral soil surface, aquic conditions; *and*

a. The colors defined for Aquents; *or*

b. Sulfidic materials; *or*

c. A positive reaction to alpha,alpha-dipyridyl when the soil is not being irrigated;

6. Do not have both permanent saturation with water and a reduced matrix in all horizons below 25 cm from the mineral soil surface;

7. Have a soil temperature regime:

a. That is warmer than cryic; *or*

b. That is cryic and the soil has:

(1) No gelic material; *and*

(2) Either a slope of less than 5 percent or less than 15 percent volcanic glass in the 0.02 to 2.0 mm fraction in some part of the particle-size control section; *and*

8. Do not have a densic, lithic, or paralithic contact within 25 cm of the soil surface.

Key to Great Groups

LDA. Fluvents that have a cryic soil temperature regime.
Cryofluvents, p. 407

LDB. Other Fluvents that have a xeric moisture regime.
Xerofluvents, p. 417

LDC. Other Fluvents that have an ustic moisture regime.
Ustifluvents, p. 414

LDD. Other Fluvents that have an aridic (or torric) moisture regime.
Torrifluvents, p. 408

LDE. Other Fluvents.
Udifluvents, p. 411

Cryofluvents

These are the cold Fluvents. They do not have permafrost or gelic materials, but the growing season is short and cool. The vegetation typically is a coniferous or mixed forest. In the United States, these soils are mostly in Alaska, but some are in mountain valleys in the West. Cryofluvents are moderately extensive.

Definition

Cryofluvents are the Fluvents that have a cryic temperature regime.

Key to Subgroups

LDAA. Cryofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and percent aluminum plus $^1/_2$ the iron percentage (by ammonium oxalate) totaling more than 1.0.
Andic Cryofluvents

LDAB. Other Cryofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.
Vitrandic Cryofluvents

LDAC. Other Cryofluvents that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryofluvents

LDAD. Other Cryofluvents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Cryofluvents

LDAE. Other Cryofluvents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Cryofluvents

LDAF. Other Cryofluvents.

Typic Cryofluvents

Definition of Typic Cryofluvents

Typic Cryofluvents are the Cryofluvents that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 1 month or more in normal years; *and*

4. Have an A or Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed or that is less than 15 cm thick.

Description of Subgroups

Typic Cryofluvents.—The Typic subgroup of Cryofluvents is centered on soils without ground water within the upper 100 cm, except for short periods following floods. When these soils thaw in spring, the soil above the layer that remains frozen may be saturated and very soft, but the water drains out rapidly when the frozen layer thaws. Redox depletions with chroma of 2 or less do not occur within 50 cm of the mineral soil surface. The soils do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. An O horizon at the surface is normal, but the A horizon is thin or faint. Both fine and coarse strata are common below a depth of a few centimeters.

Andic and Vitrandic Cryofluvents.—These soils are like Typic Cryofluvents, but they have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. Andic and Vitrandic Cryofluvents have slopes of less than 5 percent. They are of very minor extent, but they have been observed in the State of Washington.

Aquic Cryofluvents.—These soils are like Typic Cryofluvents, but they have some redox depletions with low chroma (2 or less) within the upper 50 cm of the mineral soil surface in horizons that also have aquic conditions for some time in normal years (or artificial drainage). These soils are intergrades to Aquents. They are not extensive even in Alaska.

Mollic Cryofluvents.—These soils have a surface horizon that meets the criteria for a mollic epipedon, except that it is too thin or finely stratified. The soils are not extensive. They are along streams in areas where Cryolls occur, mainly at intermediate elevations in the mountains of the Western United States.

Oxyaquic Cryofluvents.—These soils are like Typic Cryofluvents, but they are saturated with water in one or more layers within 100 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of the soils have redox depletions with low chroma (2 or less) below 50 cm from the mineral soil surface. Oxyaquic Cryofluvents are considered intergrades to Aquents. They are not extensive.

Torrifluvents

These are the Fluvents of arid climates. They have an aridic (or torric) moisture regime and a temperature regime warmer than cryic. Most of them have a high pH value and are calcareous, and a few are somewhat salty. The soils are subject to flooding, but most are not flooded frequently or for long periods. The larger areas that have a favorable topography and are close to a source of water commonly are irrigated. The natural vegetation on the Torrifluvents in the United States consisted mostly of grasses, xerophytic shrubs, and cacti, but in some parts of the world the only vegetation on the soils has been irrigated crops because the sediments accumulated while the soils were being cultivated.

Definition

Torrifluvents are the Fluvents that have an aridic (or torric) moisture regime and a soil temperature regime warmer than cryic.

Key to Subgroups

LDDA. Torrifluvents that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^{o}C or higher; *and*

3. An aridic (or torric) moisture regime that borders on ustic.

Ustertic Torrifluvents

LDDB. Other Torrifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Torrifluvents

LDDC. Other Torrifluvents that have:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^{o}C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric; *and*

3. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrixerandic Torrifluvents

LDDD. Other Torrifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Torrifluvents

LDDE. Other Torrifluvents that have, in one or more horizons within 100 cm of the soil surface, both redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage).

Aquic Torrifluvents

LDDF. Other Torrifluvents that are saturated with water in one or more layers within 150 cm of the soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Torrifluvents

LDDG. Other Torrifluvents that have:

1. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^{o}C or higher; *and*

3. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Duric Xeric Torrifluvents

LDDH. Other Torrifluvents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Torrifluvents

LDDI. Other Torrifluvents that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

2. An aridic (or torric) moisture regime that borders on ustic.

Ustic Torrifluvents

LDDJ. Other Torrifluvents that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Xeric Torrifluvents

LDDK. Other Torrifluvents that have an anthropic epipedon.

Anthropic Torrifluvents

LDDL. Other Torrifluvents.

Typic Torrifluvents

Definition of Typic Torrifluvents

Typic Torrifluvents are the Torrifluvents that:

1. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has as much as 20 percent durinodes in a nonbrittle matrix or is brittle and has a firm rupture-resistance class when moist;

2. Have *neither*:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *nor*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have an anthropic epipedon;

4. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or more;

5. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Do not have, in any horizon within 100 cm of the soil surface, both redox depletions with chroma of 2 or less and aquic conditions; *and*

7. Are not saturated with water in any layer within 150 cm of the soil surface for either or both 30 or more cumulative days or 20 or more consecutive days in normal years.

Description of Subgroups

Typic Torrifluvents.—These are the driest Fluvents. They are subject to flooding, but flooding is rare in some areas of the soils.

Weak cementation by silica is excluded from the Typic subgroup because it is considered to indicate the initial development of a duripan. Cracks and slickensides or wedge-shaped aggregates are properties shared with Vertisols and are the basis for defining the Vertic subgroup. Typic Torrifluvents do not have an anthropic epipedon or a water table within a depth of 150 cm. They do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm.

The concept of the Typic subgroup is that of the drier part of the range of Torrifluvents. Extra moisture coming as summer rain or during summer floods is the basis for defining the Ustic subgroup. Extra moisture coming as cool-season rain or during winter floods is the basis for defining the Xeric subgroups.

Typic Torrifluvents are extensive soils in the intermountain States of the United States. Many of them are irrigated. The others furnish only a small amount of forage for grazing.

Anthropic Torrifluvents.—These soils are like Typic Torrifluvents, but they have an anthropic epipedon. They have been irrigated for many years or even many centuries. They are not known to occur in the United States. They are mainly along rivers flowing through deserts in parts of the world with a long irrigation history.

Aquic Torrifluvents.—These soils have a water table within a depth of 100 cm. They have some redox depletions with chroma of 2 or less within 100 cm of the mineral soil surface, although chroma of 3 or more is commonly dominant to this depth or deeper. These soils are intergrades between Ustifluvents and Aquents. They are not extensive in the United States as a whole but are locally important on the flood plains along the larger rivers. Many Aquic Torrifluvents in the United States are irrigated and cultivated. Some have a water table that is partly or fully a result of excess irrigation water.

Duric Torrifluvents.—These soils have, within the upper meter, a horizon that is partially cemented by silica. This horizon is at least 15 cm thick. It has at least 20 percent durinodes, by volume, or it is both brittle and firm when moist. Either of these characteristics causes some interference with water movement and root penetration. These soils are intergrades between Fluvents and Durids. They are not extensive in the United States, but they occur in Nevada. They are used only as rangeland.

Duric Xeric Torrifluvents.—These soils have a moisture regime that is marginal to xeric. The moisture control section is regularly moist in winter and early in spring but is very dry in summer. These soils have, within the upper meter, a horizon that is partially cemented by silica. This horizon is 15 cm or more thick. It has at least 20 percent durinodes, by volume, or it is both brittle and firm when moist. Either of these characteristics causes some interference with water movement and root penetration. These soils are intergrades between Fluvents and Durixerolls.

The moisture that is stored in winter results in better plant growth on these soils than on the related Duric Torrifluvents, which have a lower and less reliable supply of moisture. Duric Xeric Torrifluvents are rare in the United States. They are used mainly for winter and spring grazing.

Oxyaquic Torrifluvents.—These soils are like Typic Torrifluvents, but they are saturated with water in one or more layers within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of the soils have redox depletions with low chroma (2 or less) at a depth below 100 cm from the mineral soil surface. Oxyaquic Torrifluvents are considered intergrades to Aquents. They are not extensive. Some of the soils have a water table that is partly or fully a result of excess irrigation water. Oxyaquic Torrifluvents are used mainly as cropland.

Ustertic Torrifluvents.—These soils have a high linear extensibility and deep cracks. The moisture that closes the cracks comes during a growing season when the soils are warm. These soils are not extensive in the United States, but they are widely scattered along the rivers in the drier parts of the northern Great Plains. Some of the soils are irrigated and used as cropland, and others are used for summer grazing.

Ustic Torrifluvents.—These soils are like Typic Torrifluvents, but they have more available moisture during summer or, in tropical regions, during rainy seasons. They either receive more rainfall or are flooded more frequently than the soils in the Typic subgroup. Ustic Torrifluvents are moist in some or all parts of the moisture control section for more than one-fourth of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher. These soils are extensive along the rivers in the drier parts of the Great Plains in the United States. Many of the soils are irrigated and used as cropland, and the others are used for summer grazing.

Vertic Torrifluvents.—These soils are like Typic Torrifluvents, but they have cracks and slickensides or wedge-shaped aggregates and have many of the properties of Vertisols. Vertic Torrifluvents are not extensive in the United States. Some that have a low content of salts are irrigated. Others, particularly those that are salty, furnish only a small amount of forage for grazing.

Vitrandic Torrifluvents.—These soils are like Typic Torrifluvents, but they have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. These soils are of minor extent, mostly in California.

Vitrixerandic Torrifluvents.—These soils are like Typic Torrifluvents, but they have a moisture regime that is marginal to xeric. The moisture control section is regularly moist in winter and early in spring but is very dry in summer. These soils have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. The moisture stored in winter results in better plant growth on these soils than on the soils in the Typic subgroup. Vitrixerandic Torrifluvents are of minor extent in the United States. They are used as rangeland or cropland.

Xeric Torrifluvents.—These soils are like Typic Torrifluvents, but they have a moisture regime that is marginal to xeric. The moisture control section is regularly moist in winter and early in spring but is very dry in summer. The moisture stored in winter results in better plant growth on these soils than on the soils in the Typic subgroup.

Xeric Torrifluvents are moderately extensive in the northern intermountain States of the United States. Many of the soils are irrigated and used as cropland, and the others are used for winter and spring grazing.

Udifluvents

These are the Fluvents that have a udic moisture regime and a temperature regime warmer than cryic. They are on flood plains along streams and rivers, and they may be flooded during almost any season. There is little or no evidence of alteration of the fine stratification in the alluvium, although in some Udifluvents that have a fine-silty or fine particle-size class, identifying the stratification may be difficult. Some Udifluvents formed under forest vegetation, but many have had no vegetation other than pasture or cultivated crops because the sediments in which the soils formed were deposited while the soils were being used. Udifluvents are extensive in the United States.

Definition

Udifluvents are the Fluvents that:

1. Have a udic moisture regime; *and*

2. Have a temperature regime warmer than cryic.

Key to Subgroups

LDEA. Udifluvents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. *Either or both* of the following:

a. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

b. In one or more horizons within 100 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Udifluvents

LDEB. Other Udifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Udifluvents

LDEC. Other Udifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Udifluvents

LDED. Other Udifluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Udifluvents

LDEE. Other Udifluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 100 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udifluvents

LDEF. Other Udifluvents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udifluvents

LDEG. Other Udifluvents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Udifluvents

LDEH. Other Udifluvents.

Typic Udifluvents

Definition of Typic Udifluvents

Typic Udifluvents are the Udifluvents that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have *either*:

a. In any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less or aquic conditions; *or*

b. In any horizon within 100 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B or aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days;

4. Have either an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed or materials in the upper 15 cm thick that have these colors after mixing; *and*

5. Do not have *either* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Udifluvents.—These are the Udifluvents that have moderately good or good drainage. They occur in relatively high areas on flood plains, and the water table is deeper than 50 cm all of the time or enough of the time for there to be no redox depletions with chroma of 2 or less or aquic conditions within 50 cm of the mineral soil surface and no chroma of 0 or hue bluer than 10Y or aquic conditions within a depth of 100 cm. The Typic subgroup excludes soils that have either cracks and slickensides or wedge-shaped aggregates or a linear extensibility of 6.0 or more within 100 cm of the mineral soil surface. Typic Udifluvents are considered intergrades to Vertisols. They do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. They are extensive along the rivers in the humid parts of the United States and in many other countries. If redox depletions are shallow, the soils are excluded from the Typic subgroup and are considered intergrades to Aquents. Most of the Typic Udifluvents in the United States are used as cropland if the areas of the soils are large enough.

Andic and Vitrandic Udifluvents.—These soils are like Typic Udifluvents, but they have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. They are of minor extent, mostly in the States of Washington and Oregon.

Aquertic Udifluvents.—These soils have either cracks and slickensides or wedge-shaped aggregates or a linear extensibility of 6.0 or more within 100 cm of the mineral soil surface. They also have a water table that is shallower than the one in Typic Udifluvents or that persists for longer periods within a depth of 50 cm. They have some redox depletions with chroma of 2 or less within 50 cm of the mineral soil surface, although chroma of 3 or more is dominant to this depth or deeper, or they have chroma of 0 or hue bluer than 10Y in one or more horizons at a depth between 50 and 100 cm below the mineral soil surface. In either situation, they have aquic conditions for some time in normal years within these depths (or artificial drainage). These soils are intergrades between Udifluvents and Aquerts. They are not extensive in the United States as a whole but are locally important on the flood plains along some of the larger rivers. Most of the Aquertic Udifluvents in the United States have been cleared and are used as cropland.

Aquic Udifluvents.—These soils have a water table that is shallower than the one in Typic Udifluvents or that persists for longer periods within a depth of 50 cm. They have some redox depletions with chroma of 2 or less within 50 cm of the mineral soil surface, although chroma of 3 or more is dominant to this depth or deeper, or they have chroma of 0 or hue bluer than 10Y in one or more horizons at a depth between 50 and 100 cm below the mineral soil surface. In either situation, they have aquic conditions for some time in normal years within these depths (or artificial drainage). These soils are intergrades between Udifluvents and Aquents. They are not extensive in the United States as a whole but are locally extensive on the flood plains along the larger rivers. Nearly all of the Aquic Udifluvents in the United States are used as cropland.

Mollic Udifluvents.—These soils differ from Typic

Udifluvents in that the Ap horizon or the upper 15 cm, after mixing, has colors as dark as those of a mollic epipedon. The sediments below this depth are finely stratified and may have dark colors. The soils have not been in place long enough for mixing by roots and by burrowing animals and insects, volume changes on wetting and drying, and frost action to have obliterated the fine strata below the Ap horizon or a depth of 15 cm. Mollic Udifluvents are associated with Udolls in the central part of the Northern United States. They are adjacent to streams and are not extensive. Most of them are used as cropland.

Oxyaquic Udifluvents.—These soils are like Typic Udifluvents, but they are saturated with water in one or more layers within 100 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of these soils have redox depletions with low chroma (2 or less) at a depth below 100 cm from the mineral soil surface. Oxyaquic Udifluvents are considered intergrades to Aquents. They are not extensive.

Vertic Udifluvents.—These soils have either cracks and slickensides or wedge-shaped aggregates or a linear extensibility of 6.0 or more within 100 cm of the mineral soil surface. The soils are intergrades between Udifluvents and Uderts. They are not extensive in the United States as a whole but are locally important on the flood plains along some of the larger rivers. Most of the Vertic Udifluvents in the United States have been cleared and are used as cropland.

Ustifluvents

These are the Fluvents that have an ustic moisture regime and a temperature regime warmer than cryic. These soils are on flood plains along rivers and streams in areas of middle or low latitudes. Flooding can occur in any season but is most common in summer in the middle latitudes and during the rainy season in the Tropics. A few of the soils are flooded regularly in summer because of melting snow in high mountains, even though the summer is rainless.

Definition

Ustifluvents are the Fluvents that:

1. Have an ustic moisture regime; *and*

2. Have a temperature regime warmer than cryic.

Key to Subgroups

LDCA. Ustifluvents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. *Either or both* of the following:

a. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

b. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Ustifluvents

LDCB. Other Ustifluvents that have *both* of the following:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, remains moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Ustifluvents

LDCC. Other Ustifluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Ustifluvents

LDCD. Other Ustifluvents that have anthraquic conditions.

Anthraquic Ustifluvents

LDCE. Other Ustifluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustifluvents

LDCF. Other Ustifluvents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustifluvents

LDCG. Other Ustifluvents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 180 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Aridic Ustifluvents

LDCH. Other Ustifluvents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Ustifluvents

LDCI. Other Ustifluvents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Ustifluvents

LDCJ. Other Ustifluvents.

Typic Ustifluvents

Definition of Typic Ustifluvents

Typic Ustifluvents are the Ustifluvents that:

1. Do not have *either*:

a. In any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less or aquic conditions; *or*

b. In any horizon within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B or aquic conditions;

2. Are not saturated with water in any layer within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days;

3. Do not have anthraquic conditions;

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

5. Have either an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed or materials in the upper 15 cm that have these colors after mixing; *and*

6. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for 105 or more cumulative days per year but is not dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for four- to six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for 120 or more cumulative days and moist for 180 or more cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ºC.

Description of Subgroups

Typic Ustifluvents.—These are the Ustifluvents that have good or moderately good drainage and that do not have a fine particle-size class and clay of a swelling type in a major part of the upper 125 cm. These soils occur in relatively high areas on flood plains, and the water table is deeper than 100 cm, except for very brief periods. There are no redox depletions with chroma of 2 or less or aquic conditions within 50 cm of the mineral soil surface and no chroma of 0 or hue bluer than 10Y or aquic conditions within a depth of 100 cm.

There normally is little or no evidence of alteration of the fine stratification in the alluvium. In some Typic Ustifluvents that have a fine-silty or fine particle-size class, however, stratification cannot be easily identified. Typic Ustifluvents are extensive along streams in the subhumid or semiarid parts of the Great Plains in the United States and also are extensive in many other countries. Many of these soils are used as cropland, with or without irrigation. Others are used for summer grazing.

Anthraquic Ustifluvents.—These soils are like Typic Ustifluvents, but they have a human-made perched water table near the soil surface. They commonly have some redox depletions with chroma of 2 or less in the Ap horizon. They are intergrades between Ustifluvents and Aquents. Anthraquic Ustifluvents may or may not have an Ap horizon or material in the upper 15 cm that would be a mollic epipedon, except that the layer rests on finely stratified sediment. These soils are not known to occur in the United States. They are irrigated and are used for paddy rice.

Aquertic Ustifluvents.—These soils have aquic conditions within 50 cm of the mineral soil surface for some time in normal years and have a high shrink-swell potential. They are of limited extent in the West and on the Great Plains in the United States. They commonly are used as grazing land.

Aquic Ustifluvents.—These soils have a shallower water table than that in Typic Ustifluvents or one that persists for long periods within a depth of 150 cm. They commonly have some redox depletions with chroma of 2 or less within 50 cm of the mineral soil surface, or they have chroma of 0 or hue bluer than 10Y at some depth between 50 and 150 cm. They are intergrades between Ustifluvents and Aquents. Aquic Ustifluvents may or may not have an Ap horizon or material in the upper 15 cm that would be a mollic epipedon, except that the layer rests on finely stratified sediment. These soils are not extensive in the United States. Most of them are used as cropland, some of which is irrigated.

Aridic Ustifluvents.—These soils are drier than Typic Ustifluvents. They are intergrades between Ustifluvents and Torrifluvents. They are moderately extensive in the southern part of the Great Plains of the United States. Slopes in general are gentle or moderate. Many of these soils are used for grazing, and others are used as cropland. Some of the cropland is irrigated, and some is used for drought-tolerant crops.

Mollic Ustifluvents.—These soils differ from Typic Ustifluvents in that the Ap horizon or the upper 15 cm, after mixing, has colors as dark as those of a mollic epipedon. The sediments below this depth are finely stratified and may have dark colors. The soils have not been in place long enough for mixing by roots and by burrowing animals and insects, volume changes on wetting and drying, and frost action to have obliterated the fine strata below the Ap horizon or a depth of 15 cm. Mollic Ustifluvents are associated with Ustolls on the Great Plains and in areas to the west in the United States. They are adjacent to streams and are not extensive. They are used as cropland or grazing land.

Oxyaquic Ustifluvents.—These soils have a shallower water table than that in Typic Ustifluvents. The water table persists for either or both 20 or more consecutive days or 30 or more cumulative days within a depth of 150 cm. The soils commonly have some redox depletions with chroma of 2 or less at a depth between 50 and 150 cm below the mineral soil surface. They are intergrades between Ustifluvents and Aquents. They may or may not have an Ap horizon or material in the upper 15 cm that would be a mollic epipedon, except that the layer rests on finely stratified sediment. These soils are not extensive in the United States. Most of them are used as cropland, with or without irrigation.

Torrertic Ustifluvents.—These soils are drier than Typic Ustifluvents. They have cracks and high COLE values, which are properties shared with Vertisols. They do not yet have the properties that are diagnostic for Vertisols. Because there are no restrictions on the color value of Vertisols, Torrertic Ustifluvents are permitted, but not required, to have a lower color value than the soils in the Typic subgroup. Torrertic Ustifluvents are rare in the United States. Some of them are used as cropland, with or without irrigation, and the others are used as grazing land.

Udic Ustifluvents.—These soils are like Typic Ustifluvents, but they are less dry. They are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic. They are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Ustifluvents and Udifluvents. They are moderately extensive on the Great Plains in the United States. Their slopes are gentle. Where areas are large, most of these soils are used as cropland.

Vertic Ustifluvents.—These soils are like Typic Ustifluvents, but they have cracks and high COLE values, which are properties shared with Vertisols. They do not yet have the properties that are diagnostic for Vertisols. Because there are no restrictions on the color value of Vertisols, Vertic Ustifluvents are permitted, but not required, to have a lower color value than the soils in the Typic subgroup. Vertic Ustifluvents are rare in the United States. Some of them are used as cropland, with or without irrigation, and the others are used as grazing land.

Xerofluvents

These are the Fluvents that have a xeric moisture regime and a frigid, mesic, or thermic temperature regime. These soils are on flood plains along rivers or streams or on alluvial fans, mostly in areas with Mediterranean climates. Flooding is most common in winter, but some of the soils are flooded in spring because of melting snow in the nearby mountains. Not all Fluvents in Mediterranean climates are Xerofluvents. Some are flooded during summer because of melting snow in high mountains. This flooding can supply moisture during the summer. The vegetation on Xerofluvents is commonly mixed forest or grass and shrubs. The Xerofluvents in the United States are mostly in California and the Northwestern States. The soils are moderately extensive.

Definition

Xerofluvents are the Fluvents that have a xeric moisture regime and a frigid, mesic, or thermic soil temperature regime.

Key to Subgroups

LDBA. Xerofluvents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Xerofluvents

LDBB. Other Xerofluvents that have:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue bluer than 10Y and also aquic conditions for some time in normal years (or artificial drainage); *and*

3. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Xerofluvents

LDBC. Other Xerofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Xerofluvents

LDBD. Other Xerofluvents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Xerofluvents

LDBE. Other Xerofluvents that have *either*:

1. In one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *or*

2. In one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B or aquic conditions for some time in normal years.

Aquic Xerofluvents

LDBF. Other Xerofluvents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xerofluvents

LDBG. Other Xerofluvents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Durinodic Xerofluvents

LDBH. Other Xerofluvents that have either an Ap horizon that has a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) or materials in the upper 15 cm that have these colors after mixing.

Mollic Xerofluvents

LDBI. Other Xerofluvents.

Typic Xerofluvents

Definition of Typic Xerofluvents

Typic Xerofluvents are the Xerofluvents that:

1. Do not have *either*:

a. In any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less or aquic conditions; *or*

b. In any horizon within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue of 5GY, 5G, 5BG, or 5B or aquic conditions;

2. Are not saturated with water in any layer within 150 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

5. Have either an Ap horizon that has a color value, moist, of 4 or more or a color value, dry, of 6 or more when crushed and smoothed or materials in the upper 15 cm that have these colors after mixing; *and*

6. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Xerofluvents.—The central concept or Typic subgroup of Xerofluvents is fixed on soils that have good or moderately good drainage, that show little or no evidence of cementation by silica, and that do not have a fine particle-size class and clay of a swelling type in the upper 100 cm. These soils do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. They are in relatively high areas on flood plains, and the water table is deeper than 150 cm in normal years.

Partial cementation by silica causes soils to be excluded from the Typic subgroup because this feature is considered to indicate an intergrade to Durids or Durixerepts. Soils that have cracks and slickensides or wedge-shaped aggregates are excluded from the Typic subgroup because they have most of the properties of Xererts. Presumably, the deposits are too recent to have the evidence of movement that is necessary in Vertisols.

Typic Xerofluvents are moderately extensive in the Western United States. They are nearly level and are used mostly as pasture or irrigated cropland.

Andic and Vitrandic Xerofluvents.—These soils are like Typic Xerofluvents, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur on flood plains in the Western United States. They are permitted, but not required, to have color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. These soils are of small extent. Most have gentle slopes, have been cleared and protected from flooding, and are used as cropland. Some are used as forest or pasture.

Aquandic Xerofluvents.—These soils have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage), or they have, in one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue bluer than 10Y and also aquic conditions for some time in normal years (or artificial drainage). The soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils occur on flood plains in the Western United States. They are permitted, but not required, to have a color value of 3 or less, moist, and 5 or less, dry, in surface horizons, after mixing to a depth of 15 cm. The soils are not extensive. Most have gentle slopes, have been cleared and protected from flooding, and are used as cropland. Some are used as pasture or forest.

Aquic Xerofluvents.—These soils have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage), or they have, in one or more horizons within 150 cm of the mineral soil surface, a color value, moist, of 4 or more and either chroma of 0 or hue bluer than 10Y and also aquic conditions for some time in normal years (or artificial drainage). The soils are otherwise like Typic Xerofluvents in defined properties, but they tend to have more salts bacause of capillary rise and evapotranspiration. Aquic Xerofluvents are on nearly level flood plains. They are used mostly as irrigated cropland or pasture. Some are used for native pasture, hay, or grazing. These soils are moderately extensive in the Western United States.

Durinodic Xerofluvents.—These soils differ from Typic Xerofluvents in that they are partially cemented by silica. They are in relatively high areas on flood plains, and the water table is deeper than 150 cm in normal years. Durinodic Xerofluvents are intergrades to Durids or Durixerepts. They are nearly level and are used for native pasture or irrigated crops. They are not extensive in the United States.

Mollic Xerofluvents.—These soils differ from Typic Xerofluvents in that the Ap horizon or the upper 15 cm, after mixing, has colors as dark as those of a mollic epipedon. The sediments below this depth are finely stratified and may have dark colors. The soils have not been in place long enough for mixing by roots and by burrowing animals and insects, wetting and drying, and frost action to have obliterated the fine strata below the Ap horizon or a depth of 15 cm. Mollic Xerofluvents are associated with Xerolls in the Western United States. They are adjacent to streams and are not extensive.

Oxyaquic Xerofluvents.—These soils are like Typic Xerofluvents, but they are saturated with water in one or more layers within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of the soils have redox depletions with low chroma (2 or less) at a depth below 100 cm from the mineral soil surface. Oxyaquic Xerofluvents are considered intergrades to Aquents. They are not extensive. Some have a water table that is partly or fully a result of excess irrigation water.

Vertic Xerofluvents.—These soils have a fine texture and deep, wide cracks, but they do not yet have all of the properties that are diagnostic for Vertisols. There is no restriction on the presence of ground water above a depth of 150 cm. Vertic

Xerofluvents generally are in low areas on flood plains. They are rare in the United States.

Orthents

These are primarily Entisols on recent erosional surfaces. The erosion may be geologic or may have been induced by cultivation, mining, or other factors. Any former soil that was on the landscape has been completely removed or so truncated that the diagnostic horizons for all other orders do not occur. A few Orthents are in areas of recent loamy or fine eolian deposits, in areas of solifluction or glacial deposits, or in areas of debris from recent landslides and mudflows.

Orthents occur in any climate and under any vegetation. They are do not occur in areas that have aquic conditions, a high water table, and the colors defined for Aquents or on shifting or stabilized sand dunes.

Definition

Orthents are the Entisols that:

1. Have a texture of loamy very fine sand or finer or 35 percent (by volume) or more rock fragments in some layer within the particle-size control section;

2. Do not have fragments of diagnostic horizons that can be identified and that occur more or less without a discernible order below any Ap horizon but above a depth of 100 cm or above a densic, lithic, or paralithic contact that is shallower than 100 cm;

3. Have a slope of more than 25 percent or have a content of Holocene-age organic carbon that decreases regularly with increasing depth and reaches a level of 0.2 percent or less within a depth of 125 cm; *and*

4. Do not have, within 50 cm of the mineral soil surface, aquic conditions; *and*

a. The colors defined for Aquents; *or*

b. Sulfidic materials; *or*

c. A positive reaction to alpha,alpha-dipyridyl when the soil is not being irrigated.

Key to Great Groups

LEA. Orthents that have a cryic soil temperature regime.
Cryorthents, p. 420

LEB. Other Orthents that have an aridic (or torric) moisture regime.
Torriorthents, p. 421

LEC. Other Orthents that have a xeric moisture regime.
Xerorthents, p. 430

LED. Other Orthents that have an ustic moisture regime.
Ustorthents, p. 426

LEE. Other Orthents.
Udorthents, p. 425

Cryorthents

These are the Orthents of high mountains or high latitudes. Most of them are sandy-skeletal, are on slopes where rock is very shallow, or are in areas of recent solifluction or volcanic deposits. The vegetation may be coniferous forest, tundra, or even the sparse vegetation of very cold, dry areas. Few areas are cultivated. These soils are of small extent in high mountains and in areas of tundra vegetation in the United States. Some of the soils are cold and dry, have a thin efflorescence of salt on the surface during summer, and may be dry in all horizons during some periods. Most of the Cryorthents in the United States still support their native vegetation.

Definition

Cryorthents are the Orthents that have a cryic soil temperature regime.

Key to Subgroups

LEAA. Cryorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryorthents

LEAB. Other Cryorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Cryorthents

LEAC. Other Cryorthents that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryorthents

LEAD. Other Cryorthents that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Cryorthents

LEAE. Other Cryorthents that have lamellae within 200 cm of the mineral soil surface.

Lamellic Cryorthents

LEAF. Other Cryorthents.

Typic Cryorthents

Definition of Typic Cryorthents

Typic Cryorthents are the Cryorthents that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

   a. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days;

4. Do not have a lithic contact within 50 cm of the soil surface; *and*

5. Do not have lamellae within 200 cm of the mineral soil surface.

Description of Subgroups

Typic Cryorthents.—These are the Cryorthents that are not saturated with water within a depth of 100 cm and that, in the upper 75 cm, do not have a deposit of pyroclastic materials that is as thick as 18 cm. Most of the soils are sandy-skeletal or very shallow to a paralithic or densic contact. Most are in forests, and they have an O horizon, a thin or sandy A horizon, and a B horizon too sandy or too thin to be a cambic horizon. Typic Cryorthents do not have diagnostic horizons other than an ochric epipedon. Because cultivation is not likely in the foreseeable future, the soils cannot have a cambic horizon even if the base is at a depth of less than 25 cm below the mineral soil surface. Typic Cryorthents are of small extent.

Aquic Cryorthents.—These soils are saturated with water within 50 cm of the surface at some time during normal years and have redox depletions with chroma of 2 or less within that depth. The dominant chroma, however, is more than 2. These soils are considered intergrades to Cryaquents. They are rare in the United States.

Lamellic Cryorthents.—These soils have lamellae within 200 cm of the soil surface. The uppermost lamellae commonly are within 75 cm of the soil surface, but other lamellae may be as deep as 200 cm. These soils are of very small extent, mostly in the mountains of the Western United States. They formed under coniferous forest vegetation.

Lithic Cryorthents.—These soils have a lithic contact within 50 cm of the soil surface and commonly at a depth appreciably less than 50 cm. The soils may be saturated with water above the lithic contact when snow melts. They are of small extent, mostly in the mountains of the Western United States. Some are in Alaska, and some are in the mountains of the Northeastern United States. Lithic Cryorthents formed under forest vegetation or under grasses and shrubs.

Oxyaquic Cryorthents.—These soils are saturated with water within 100 cm of the surface at some time during normal years. They can have redox depletions that have chroma of 2 or less below a depth of 50 cm. These soils are considered intergrades to Cryaquents. They are rare in the United States.

Vitrandic Cryorthents.—These soils formed in volcanic deposits or have a deposit of fine pyroclastic materials near the surface. Most of these deposits are of Holocene or historic age. These soils are considered intergrades to Vitricryands. They are of small extent, mostly in the mountains of the Western United States.

Torriorthents

These are the dry Orthents of cool to hot, arid regions. They have an aridic (or torric) moisture regime and a temperature regime warmer than cryic. Generally, they are neutral or calcareous and are on moderate to very steep slopes. A few are on gentle slopes. Many of the gently sloping soils are on rock pediments, are very shallow, have a sandy-skeletal particle-size class, or are salty. Others are on fans where sediments are recent but have little organic carbon. The vegetation on Torriorthents commonly is sparse and consists mostly of xerophytic shrubs and ephemeral grasses and forbs. The vegetation on a few of the soils is saltgrass. Torriorthents are used mainly for grazing. They are extensive in the Western United States.

Definition

Torriorthents are the Orthents that have an aridic (or torric) moisture regime and have a soil temperature regime warmer than cryic.

Key to Subgroups

LEBA. Torriorthents that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

3. A hyperthermic, thermic, mesic, frigid, or *iso* soil temperature regime and an aridic (or torric) moisture regime that borders on ustic.

Lithic Ustic Torriorthents

LEBB. Other Torriorthents that have:

1. A lithic contact within 50 cm of the soil surface; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

3. A thermic, mesic, or rigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Lithic Xeric Torriorthents

LEBC. Other Torriorthents that have a lithic contact within 50 cm of the soil surface.

Lithic Torriorthents

LEBD. Other Torriorthents that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

3. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Xerertic Torriorthents

LEBE. Other Torriorthents that have:

1. *One or both* of the following:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

3. An aridic (or torric) moisture regime that borders on ustic.

Ustertic Torriorthents

LEBF. Other Torriorthents that have *one or both* of the following:

1. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Torriorthents

LEBG. Other Torriorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Torriorthents

LEBH. Other Torriorthents that have, in one or more horizons within 100 cm of the soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Torriorthents

LEBI. Other Torriorthents that are saturated with water in one or more layers within 150 cm of the soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Torriorthents

LEBJ. Other Torriorthents that have a horizon within 100 cm of the soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Torriorthents

LEBK. Other Torriorthents that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^{o}C or higher; *and*

2. A hyperthermic, thermic, mesic, frigid, or *iso* soil temperature regime and an aridic (or torric) moisture regime that borders on ustic.

Ustic Torriorthents

LEBL. Other Torriorthents that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^{o}C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Xeric Torriorthents

LEBM. Other Torriorthents.

Typic Torriorthents

Definition of Typic Torriorthents

Typic Torriorthents are the Torriorthents that:

1. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

2. Do not have a lithic contact within 50 cm of the surface;

3. Do not have *either*:

a. Cracks within 125 cm of the soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher;

5. Do not have, in any horizon within 100 cm of the soil surface, redox depletionswith chroma of 2 or less and also aquic conditions;

6. Are not saturated with water in any layer within 150 cm of the soil surface for either or both 30 or more cumulative days or 20 or more consecutive days in normal years; *and*

7. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Torriorthents.—The Typic subgroup is fixed on the driest Torriorthents. Many of these soils are shallow to weakly cemented rock. Some are moderately deep or deep to hard rock.

Soils that are partially cemented by silica are excluded from the Typic subgroup because this feature is considered to indicate the initial development of a duripan. The Torriorthents that have a high linear extensibility or cracks and slickensides or wedge-shaped aggregates also are excluded because they share so many properties with Torrerts. Typic Torriorthents do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm.

Typic Torriorthents are extensive soils in the intermountain States of the United States. Most of them have moderate or strong slopes and are used only for grazing. Others that have gentle slopes are irrigated. The gently sloping soils are mostly on fans or piedmont slopes where the sediments are recent and have little organic carbon.

Aquic Torriorthents.—These soils have, in one or more horizons within 100 cm of the soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils formed mostly in recent alluvium, but they have too little organic matter to meet the requirements for Fluvents. Ground water is evident mostly during the high-water stages of streams. Most Aquic Torriorthents have conductivity well in excess of 2 dS/m as a result of salts that accumulate through capillary rise and evapotranspiration. Soil moisture depends greatly on subirrigation and is unpredictable, and there are no restrictions on it in the definition. These soils are rare in the United States. They have gentle slopes, and many of them are irrigated.

Duric Torriorthents.—These soils are partially cemented by silica. In the soils in the United States, the cementation is in the form of durinodes. Duric Torriorthents formed mostly in rather recent alluvium, but they have too little organic matter to meet the requirements for Fluvents. Most of the soils have conductivity well in excess of 2 dS/m. The parent materials were derived from rocks rich in pyroclastic materials. Duric Torriorthents are rare in the United States.

Lithic Torriorthents.—These soils have a lithic contact that is within 50 cm of the surface and commonly is at a depth of less than 25 cm. They have a low moisture-storage capacity, and they occur mostly in association with soils of other orders or subgroups that have more moisture available to plants. Lithic Torriorthents are of moderate extent in the United States. They are used mostly for winter or spring grazing.

Lithic Ustic Torriorthents.—These soils have more available moisture than Lithic Torriorthents during summer or, if located in the Tropics, during the rainy seasons. They are moist in some or all parts of the moisture control section for more than one-fourth of the time (cumulative) when the soil temperature at a depth of 50 cm exceeds 5 ^{o}C. They have a shallow or very shallow lithic contact, which limits the moisture-storage capacity. Consequently, the soils commonly are associated with the Ustalfs and Ustolls on more stable surfaces. Lithic Ustic Torriorthents are of moderate extent in the United States. They are used mostly for winter or spring grazing.

Lithic Xeric Torriorthents.—These soils have a lithic contact within 50 cm of the surface and have more available moisture than the soils of the Lithic subgroup. They are in regions that have enough winter precipitation for the moisture control section to be moist in all parts during late winter or early spring, but they are continuously dry in all parts of the moisture control section for most of the summer in normal years. The lithic contact commonly limits the moisture-storage capacity of the moisture control section. Lithic Xeric Torriorthents are of moderate extent in the United States. They are used mostly for winter or spring grazing.

Oxyaquic Torriorthents.—These soils are like Typic Torriorthents, but they are saturated with water in one or more layers within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of the soils have redox depletions with low chroma (2 or less) at a depth below 100 cm from the mineral soil surface. Oxyaquic Torriorthents are considered intergrades to Aquents. They are not extensive. Some have a water table that is partly or fully a result of excess irrigation water.

Ustertic Torriorthents.—These soils have a high linear extensibility or cracks and slickensides or wedge-shaped aggregates. In the soils in the United States, the cracks are closed in spring and periodically in summer. Most of the soils have cracks and a high linear extensibility. Some have all of the properties of Vertisols but have a densic or paralithic contact at a shallow depth. Most are on flood plains on the Great Plains. Ustertic Torriorthents are not extensive. Many of them are used for summer grazing, and some are used as cropland.

Ustic Torriorthents.—These soils have more available moisture than Typic Torriorthents during summer or during rainy seasons in the Tropics. They are moist in some or all parts of the moisture control section for more than one-fourth of the time (cumulative) when the soil temperature at a depth of 50 cm exceeds 5 ^{o}C. These soils can support somewhat more vegetation than the soils in the Typic subgroup. They commonly are associated with the Ustolls or Ustalfs on the gentler slopes of the more stable surfaces. In many areas Ustic Torriorthents lose an appreciable part of their precipitation as runoff. These soils are extensive in the United States. They are used mostly for grazing, but some are used as cropland.

Vertic Torriorthents.—These soils have a high linear extensibility or cracks and slickensides or wedge-shaped aggregates. They commonly have two short, undependable rainy seasons. Slopes of the soils in the United States range from nearly level to strong. Where slopes are suitable and water is available, most of the soils are irrigated. Others are used for grazing. Vertic Torriorthents are of small extent in the Southwestern United States.

Vitrandic Torriorthents.—These soils are like Typic Torriorthents, but they formed in volcanic deposits or have a layer of pyroclastic materials that is 18 cm or more thick and that is in the upper 75 cm. These soils are of small extent, mostly in California, Oregon, and Nevada.

Xerertic Torriorthents.—These soils have a high linear extensibility and cracks that regularly close during a cool or cold season. They are in areas of winter precipitation and have a moisture regime that approaches xeric. These soils can produce more vegetation than the soils of the Typic or Ustic subgroup because of the reliable supply of moisture stored in winter. Xerertic Torriorthents are of small extent, mostly in Utah. Most of these soils are used for grazing, but some are used as irrigated cropland.

Xeric Torriorthents.—These soils are moist in some part of the moisture control section for more than one-fourth of the time when the soil temperature at a depth of 50 cm is 5 ^{o}C or higher. They are in areas of winter precipitation and have a moisture regime that approaches xeric. These soils can produce more vegetation than the soils of the Typic or Ustic subgroup because of the reliable supply of moisture stored in winter.

Xeric Torriorthents are extensive in the intermountain and Pacific States of the United States. Some have moderate to very steep slopes and formed mostly in weakly cemented country rock. Others have gentle slopes and formed in alluvium that had little organic matter. The gently sloping soils are mostly on fans and piedmont slopes. Where slopes are suitable and water is available, most of the Xeric Torriorthents are irrigated and used as cropland. Those that are not irrigated are used mainly for winter and spring grazing.

Udorthents

These are the Orthents of cool to hot, moist regions. They have a udic moisture regime and a temperature regime warmer than cryic. Generally, they are acid to neutral, but some are calcareous. Slopes generally are moderate to steep but are gentle in a few areas. Udorthents commonly occur in areas of very recently exposed regolith, such as loess or till; in areas of weakly cemented rocks, such as shale; or in areas of thin regolith over hard rocks. Many of the gently sloping soils are the result of mining or other earth-moving activities. Some have a sandy-skeletal particle-size class. The vegetation is commonly a deciduous forest, or the soils are used as pasture. Udorthents are extensive soils on steep slopes in the humid parts of the United States.

Definition

Udorthents are the Orthents that:

1. Have a udic moisture regime; *and*

2. Have a soil temperature regime warmer than cryic.

Key to Subgroups

LEEA. Udorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Udorthents

LEEB. Other Udorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Udorthents

LEEC. Other Udorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udorthents

LEED. Other Udorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udorthents

LEEE. Other Udorthents that have 50 percent or more (by volume) wormholes, wormcasts, and filled animal burrows between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 100 cm or a densic, lithic, paralithic, or petroferric contact, whichever is shallower.

Vermic Udorthents

LEEF. Other Udorthents.

Typic Udorthents

Definition of Typic Udorthents

Typic Udorthents are the Udorthents that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 150 cm of the mineral soil surface for either or both 30 or more

cumulative days or 20 or more consecutive days in normal years;

4. Do not have a lithic contact within 50 cm of the mineral soil surface; *and*

5. Have less than 50 percent (by volume) wormholes, wormcasts, and filled animal burrows between the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, and either a depth of 100 cm or a densic, lithic, paralithic, or petroferric contact if one occurs above a depth of 100 cm.

Description of Subgroups

Typic Udorthents.—The central concept or Typic subgroup of Udorthents is fixed on soils that are shallow to weakly cemented rock or deep or moderately deep to rock and that have deep ground water and low animal activity. Many of these soils formed in mine spoil or fill material. Some have a densic contact with compacted layers of soil materials. Typic Udorthents do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. These soils are used mostly as pasture or forest. A few are used as cropland, and a few are idle.

Aquic Udorthents.—These soils have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not extensive in the United States. They have slopes that range from nearly level to steep. They are used mostly for grazing or forest, but some that are gently sloping are used for cultivated crops.

Lithic Udorthents.—These soils have a lithic contact within 50 cm of the surface. The lithic contact is at a depth of less than 25 cm in most of the soils. Lithic Udorthents are otherwise like Typic Udorthents, except that possibly some of them have very high biological activity above the lithic contact. Lithic Udorthents are of small extent in the United States. They are used mostly as pasture or forest. A few of these soils are used as wildlife habitat.

Oxyaquic Udorthents.—These soils are saturated with water for 20 consecutive days and/or 30 cumulative days within 150 cm of the mineral soil surface during normal years. They may or may not have redoximorphic features, but they do not have redox depletions with chroma of 2 or less within 100 cm of the mineral soil surface. These soils occur in the Midwestern and Northeastern United States. The soils in the Northeast commonly are forested, but some are used for hay and pasture. The soils in the Midwest are used mostly for crop production.

Vermic Udorthents.—These soils have been so completely reworked by animals, generally by earthworms, that distinct horizons cannot be identified. The soils have not been identified in the United States but have been observed in other countries.

Vitrandic Udorthents.—These soils formed in volcanic deposits or have a deposit of fine pyroclastic material 18 cm thick or thicker within the upper 75 cm and generally at the surface. Most of these deposits are of Holocene or historic age. These soils are considered intergrades to Vitrands. They are of small extent, mostly in the mountains of the Western United States.

Ustorthents

These are the Orthents of cool to hot regions. They have an ustic moisture regime and a temperature regime warmer than cryic. Generally, they are neutral to calcareous, but some are acid. Slopes generally are moderate to steep but are gentle in a few areas. Ustorthents commonly occur in areas of very recently exposed regolith, mostly weakly cemented sedimentary deposits, or in areas of thin regolith over hard rocks. The vegetation in warm regions commonly is a deciduous forest or savanna. The soils that have a mesic or frigid temperature regime commonly support scattered grasses mixed with xerophytic shrubs. Some of the soils that have been cultivated for a long time probably now consist of what was the C horizon of other soils, particularly Ustalfs. The cultivated soils probably never had any vegetation, except for cultivated crops. A few of the soils that are in areas of loamy-skeletal or sandy-skeletal sediments, mostly alluvium, have gentle slopes. Ustorthents are extensive in the United States, particularly on the Great Plains.

Definition

Ustorthents are the Orthents that:

1. Have a soil temperature regime warmer than cryic; *and*

2. Have an ustic soil moisture regime.

Key to Subgroups

LEDA. Ustorthents that have:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, remains moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Aridic Lithic Ustorthents

LEDB. Other Ustorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Ustorthents

LEDC. Other Ustorthents that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, remains moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Torrertic Ustorthents

LEDD. Other Ustorthents that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Ustorthents

LEDE. Other Ustorthents that have anthraquic conditions.

Anthraquic Ustorthents

LEDF. Other Ustorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustorthents

LEDG. Other Ustorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustorthents

LEDH. Other Ustorthents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Durinodic Ustorthents

LEDI. Other Ustorthents that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, remains moist in some or all parts for less than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. Throughout one or more horizons with a total thickness

of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Ustorthents

LEDJ. Other Ustorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Ustorthents

LEDK. Other Ustorthents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 180 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^oC.

Aridic Ustorthents

LEDL. Other Ustorthents that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 105 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^oC; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for less than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^oC.

Udic Ustorthents

LEDM. Other Ustorthents that have 50 percent or more (by volume) wormholes, wormcasts, and filled animal burrows between either the Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 100 cm or a densic, lithic, paralithic, or petroferric contact, whichever is shallower.

Vermic Ustorthents

LEDN. Other Ustorthents.

Typic Ustorthents

Definition of Typic Ustorthents

Typic Ustorthents are the Ustorthents that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 150 cm of the mineral soil surface for either or both 30 or more cumulative days or 20 or more consecutive days in normal years;

3. Do not have anthraquic conditions;

4. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

5. Do not have a lithic contact within 50 cm of the surface;

6. Have less than 50 percent (by volume) wormholes, wormcasts, and filled animal burrows between the bottom of the Ap horizon or a depth of 25 cm, whichever is deeper, and a

depth of 100 cm or a densic, lithic, or paralithic or petroferric contact, whichever is shallower;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

8. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for 105 or more cumulative days per year but is not dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for four- to six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is dry in some or all parts for 120 or more cumulative days and moist for 180 or more cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

9. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Ustorthents.—The central concept or Typic subgroup of Ustorthents is fixed on soils that are deep or moderately deep to hard rock and that do not have ground water within a depth of 150 cm, do not have appreciable cementation by silica, do not have high biologic activity, do not have a clayey texture and a swelling type of clay, and do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. The most common of these soils have a thin or very thin ochric epipedon resting on weakly cemented rock or on sediments. Some Typic Ustorthents formed in mine spoil or fill material. Soils that have a shallow lithic contact are excluded from the Typic subgroup, a convention used throughout this taxonomy.

Slopes of Typic Ustorthents range from nearly level to very steep. These soils are used mostly for grazing, forest, or catchments, but some are used for nonirrigated grain and a few that have gentle slopes are used as irrigated cropland. Typic Ustorthents are of moderate extent on the Great Plains in the United States.

Anthraquic Ustorthents.—These soils are like Typic Ustorthents, but they have a human-made perched water table near the soil surface. They commonly have some redox depletions with chroma of 2 or less in the Ap horizon. They are intergrades between Ustorthents and Aquents. Anthraquic Ustorthents are not known to occur in the United States. They are irrigated and are used for paddy rice.

Aquic Ustorthents.—These soils have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are on low terraces or fans, in areas of sediments that are partly sandy and partly loamy. Ground water is shallow during wet periods or during periods when snow melts on the adjacent mountains. The water has a very low salt content. These soils either are nearly level or are in depressions. They commonly have been drained and are used for irrigated crops. They are not extensive in the United States.

Aridic Lithic Ustorthents.—These are the Ustorthents that are drier than the soils in the Typic subgroup and have a lithic contact within 50 cm of the mineral soil surface. Aridic Lithic Ustorthents occur in the more arid regions of the Great Plains in the United States. They range from gently sloping to steep. Most are used as rangeland and wildlife habitat.

Aridic Ustorthents.—These soils are drier than Typic Ustorthents and do not have a lithic contact within 50 cm of the mineral soil surface. They are intergrades between Ustorthents and Torriorthents. They are moderately extensive in the southern part of the Great Plains in the United States. Slopes are gentle to steep. Many Aridic Ustorthents are used for grazing. Some of the less sloping soils are used as cropland. Some of the cropland is irrigated, and some is used for drought-tolerant crops.

Durinodic Ustorthents.—These soils differ from Typic Ustorthents in that they are partially cemented by silica. They are intergrades to Durids or Durustepts. They are not known to occur in the United States.

Lithic Ustorthents.—These soils have a lithic contact within 50 cm of the soil surface. Generally, the lithic contact is appreciably shallower than 50 cm and is most commonly at a depth of less than 25 cm. These soils are otherwise like those of the Typic subgroup in defined characteristics. Slopes range from gentle to very steep. Lithic Ustorthents are used mostly as grazing land and watersheds, but some areas are used as forest. These soils are moderately extensive in parts of the Western United States.

Oxyaquic Ustorthents.—These soils are like Typic Ustorthents, but they are saturated with water in one or more layers within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of these soils have redox depletions with low chroma (2 or less) at a depth of more than 100 cm below the mineral soil surface. Oxyaquic Ustorthents are considered intergrades to Aquents. They are not extensive. Some of the soils have a water table that is partly or fully a result of excess irrigation water.

Torrertic Ustorthents.—These soils have a high shrink-swell potential and a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the mineral soil surface. They occur in the western Dakotas as well as Montana, Wyoming, Colorado, Arizona, and New Mexico. They are used mostly as rangeland.

Udic Ustorthents.—These soils are like Typic Ustorthents, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for less than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Ustorthents and Udorthents. They are of very small extent in the United States.

Vermic Ustorthents.—These soils have been so completely reworked by animals, such as rodents, earthworms, and insects, that diagnostic horizons cannot be identified. The soils have not been identified in the United States but have been observed in other countries.

Vertic Ustorthents.—These soils have high linear extensibility or cracks and slickensides or wedge-shaped aggregates. Slopes of the soils in the United States range from nearly level to strong. Vertic Ustorthents are of small extent in the United States. They are used mostly for grazing.

Vitrandic Ustorthents.—These soils are like Typic Ustorthents, but they are composed of volcanic deposits or have a layer of pyroclastic materials that is 18 cm or more thick and is in the upper 75 cm. These soils are of minor extent, mostly in the States of Arizona and New Mexico.

Vitritorrandic Ustorthents.—These soils are like Typic Ustorthents, but they are composed of volcanic deposits or have a layer of pyroclastic materials that is 18 cm or more thick and is in the upper 75 cm. The soils have a moisture regime that is marginal to aridic. They are of minor extent, mostly in the States of Arizona and New Mexico.

Xerorthents

These are the Orthents of Mediterranean climates. They have a xeric moisture regime and a frigid, mesic, or thermic soil temperature regime. Generally, they are neutral to moderately alkaline, but some are acid. Slopes are mostly moderate to steep but are gentle in a few areas. Because many of the soils are strongly sloping and lose water through runoff, not all Orthents in a Mediterranean climate have a xeric moisture regime, particularly if the regolith is thin. Winter rains usually are gentle, summer drought is certain, and most of the Orthents in a Mediterranean climate are Xerorthents. The Xerorthents commonly are in sandy-skeletal families or occur in areas of very recently exposed regolith, such as loess or till; in areas of weakly cemented rocks, such as shale; or in areas of very thin regolith over hard rocks. Some of these soils, particularly those that have been cultivated for a long time or reshaped for irrigation, consist of what was the C horizon of other Xeric great groups, chiefly Xeralfs and Xerolls. The vegetation is commonly trees or shrubs, or the soils are used as pasture.

Definition

Xerorthents are the Orthents that have a xeric moisture regime and a frigid, mesic, or thermic soil temperature regime.

Key to Subgroups

LECA. Xerorthents that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Xerorthents

LECB. Other Xerorthents that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Xerorthents

LECC. Other Xerorthents that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Xerorthents

LECD. Other Xerorthents that are saturated with water in one or more layers within 150 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xerorthents

LECE. Other Xerorthents that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Durinodic Xerorthents

LECF. Other Xerorthents that have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm below the mineral soil surface.

Dystric Xerorthents

LECG. Other Xerorthents.

Typic Xerorthents

Definition of Typic Xerorthents

Typic Xerorthents are the Xerorthents that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 150 cm of the mineral soil surface for either or both 30 or more cumulative days or 20 or more consecutive days in normal years;

3. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

4. Do not have a lithic contact within 50 cm of the soil surface;

5. Have a base saturation (by NH_4OAc) of 60 percent or more in some part at a depth between 25 and 75 cm below the soil surface; *and*

6. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Xerorthents.—The central concept or Typic subgroup of Xerorthents is fixed on soils that are moderately deep or deep to hard rock, do not have ground water within a depth of 150 cm, and are not partially cemented by silica. These soils have a base saturation (by NH_4OAc) of 60 percent or more in some part at a depth of between 25 and 75 cm below the soil surface. Soils that have a shallow lithic contact are excluded from the Typic subgroup, a convention used throughout this taxonomy. Soils that are partially cemented by silica are excluded because such soils are thought to represent intergrades to Durixerepts.

Commonly, Typic Xerorthents are in a sandy-skeletal family or have a thin ochric epipedon that rests on a densic or paralithic contact with weakly cemented rock or dense sediments. Some of these soils have been cultivated for a long time or have been reshaped for irrigation and consist of what was the C horizon of other soils, chiefly Xeralfs and Xerolls.

Typic Xerorthents are used mostly as forest or grazing land. A few of these soils are used as cropland, and a few are idle.

Aquic Xerorthents.—These soils have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are on low terraces in the western part of the United States and are not extensive.

Durinodic Xerorthents.—These soils differ from the soils in the Typic subgroup because they have, within 100 cm of the mineral soil surface, a horizon that is more than 15 cm thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. The Durinodic Xerorthents in the United States occur mainly in eastern Washington, where there is appreciable volcanic ash in the loess. The soils are used for small grain or as grazing land.

Dystric Xerorthents.—These are the Xerorthents that occur in areas of relatively high rainfall. The soils have a base saturation (by NH_4OAc) of less than 60 percent in some part at a depth between 25 and 75 cm below the surface. They have coarse textures, but they are excluded from Psamments because they have a high content of rock fragments and from Xerepts because the textures are coarser than is permitted in cambic horizons. Dystric Xerorthents are of moderate extent in the Western United States, mostly in California, Washington, and Oregon. They are used mostly as forest, but some are used as cropland.

Lithic Xerorthents.—These soils have a lithic contact within 50 cm of the soil surface, normally within 25 cm of the surface. Slopes range from gentle to very steep. Lithic Xerorthents are used mostly as grazing land and watersheds, but some areas are used as forest. These soils are moderately extensive in parts of the Western United States.

Oxyaquic Xerorthents.—These soils are saturated with water for 20 or more consecutive days and/or 30 or more cumulative days within 100 cm of the mineral soil surface during normal years. They do not have redox depletions with chroma of 2 or less within 100 cm of the mineral soil surface. These soils are of limited extent in California, Idaho, and eastern Oregon. They are used as grazing land.

Vitrandic Xerorthents.—These soils are like Typic Xerorthents, but they are composed of volcanic deposits or have a layer of pyroclastic materials that is 18 cm or more thick and is in the upper 75 cm. The soils are of minor extent, mostly in the States of California, Oregon, and Washington.

Psamments

These are the sandy Entisols. They are sandy in all layers within the particle-size control section. Some formed in poorly graded (well sorted) sands on shifting or stabilized sand dunes, in cover sands, or in sandy parent materials that were sorted in an earlier geologic cycle. Some formed in sands that were sorted by water and are on outwash plains, lake plains, natural levees, or beaches. A few Psamments formed in material weathered from sandstone or granitic bedrock. Psamments occur under any climate, but they cannot have permafrost within 100 cm of the soil surface. They can have any vegetation and are on surfaces of virtually any age from recent historic to Pliocene or older. The Psamments on old stable surfaces commonly consist of quartz sand. Ground water typically is deeper than 50 cm and commonly is much deeper.

Psamments have a relatively low water-holding capacity. Those that are bare and become dry are subject to soil blowing and drifting and cannot easily support wheeled vehicles. Because very gravelly sands do not have the two qualities just described, they are excluded from Psamments and are grouped with Orthents. Thus, not all Entisols that have a sandy texture are Psamments.

Definition

Psamments are the Entisols that:

1. Have have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section;

2. Do not have, within 50 cm of the mineral soil surface, aquic conditions; *and*

   a. The colors defined for Aquents; *or*

   b. Sulfidic materials; *or*

   c. A positive reaction to alpha,alpha-dipyridyl when the soil is not being irrigated;

3. Do not have fragments of diagnostic horizons that can be identified and that occur more or less without a discernible order below any Ap horizon but within the particle-size control section; *and*

4. Do not have sulfidic materials within 50 cm of the mineral soil surface or both the aquic conditions and colors defined for Aquents.

Key to Great Groups

LCA. Psamments that have a cryic soil temperature regime.

Cryopsamments, p. 432

LCB. Other Psamments that have an aridic (or torric) moisture regime.

Torripsamments, p. 436

LCC. Other Psamments that have, in the 0.02 to 2.0 mm fraction within the particle-size control section, a total of more than 90 percent (by weighted average) resistant minerals.

Quartzipsamments, p. 434

LCD. Other Psamments that have an ustic moisture regime.

Ustipsamments, p. 439

LCE. Other Psamments that have a xeric moisture regime.

Xeropsamments, p. 441

LCF. Other Psamments.

Udipsamments, p. 438

Cryopsamments

These are the Psamments of cold areas. In the United States, they are primarily in high mountains of the West and in Alaska. Generally, they have, or had before they were disturbed, a coniferous forest vegetation. They are of small extent. Most of them formed in material weathered from granitic rocks or in deposits of late-Pleistocene or recent age. Some formed in recent volcanic deposits.

Definition

Cryopsamments are the Psamments that have a cryic soil temperature regime.

Key to Subgroups

LCAA. Cryopsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryopsamments

LCAB. Other Cryopsamments that have, in one or more horizons within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cryopsamments

LCAC. Other Cryopsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*
2. 30 or more cumulative days.

Oxyaquic Cryopsamments

LCAD. Other Cryopsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Cryopsamments

LCAE. Other Cryopsamments that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*
2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*
3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Cryopsamments

LCAF. Other Cryopsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Cryopsamments

LCAG. Other Cryopsamments.

Typic Cryopsamments

Definition of Typic Cryopsamments

Typic Cryopsamments are the Cryopsamments that:

1. Do not have lamellae within 200 cm of the soil surface;
2. Do not have, in any horizon within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;
3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years;
4. Do not have a lithic contact within 50 cm of the soil surface;
5. Do not have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:
    a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*
    b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*
    c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon; *and*
6. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is less than 30.

Description of Subgroups

Typic Cryopsamments.—The central concept or Typic subgroup of Cryopsamments is fixed on deep sands that have ground water deeper than 100 cm, that do not have a weak accumulation of amorphous materials, and do not have lamellae within 200 cm of the soil surface.

These soils do not have, in the upper 75 cm, a deposit of pyroclastic materials that is as thick as 18 cm. Lamellae with illuvial clay are considered to represent a transition to Cryalfs. Shallow mottles with low chroma and short periods of saturation in the mottled horizon are considered features of the intergrades to Psammaquents. Soils that have a weak accumulation of amorphous materials are considered intergrades to Spodosols.

Typic Cryopsamments are of small extent. Most are in Alaska, but some are in the mountains of other Western States.

Aquic Cryopsamments.—These soils have aquic conditions for some time in normal years (or artificial drainage) and redox depletions with chroma of 2 or less within 50 cm of the mineral soil surface. The soils have not been identified as series in the United States, but the subgroup is provided for use if needed.

Lamellic Cryopsamments.—These soils have lamellae within 200 cm of the soil surface. An albic horizon normally is below an O horizon or a thin A or Ap horizon in these soils. The soils are rare in the United States and are at elevations above 1,200 m. They are used as forest.

Lithic Cryopsamments.—These soils have a lithic contact within a depth of 50 cm. They are permitted to have redox depletions with low chroma (2 or less) above the lithic contact. These soils are not known to occur in the United States.

Oxyaquic Cryopsamments.—These soils are like Typic Cryopsamments, but they are saturated with water in one or more layers within 100 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of these soils have redox depletions with low chroma (2 or less) at a depth below 50 cm from the mineral soil surface. Oxyaquic Cryopsamments are considered intergrades to Aquents. They are not known to occur in the United States.

Spodic Cryopsamments.—These soils have a weak accumulation of amorphous materials. They are presumed to be developing toward Spodosols, mainly Cryods, but are too weakly developed to be classified as Spodosols. No series has been established, but the subgroup is provided for use if needed.

Vitrandic Cryopsamments.—These soils formed in volcanic deposits or have a deposit of fine pyroclastic materials near the surface. The soils are considered intergrades to Vitricryands. They are of small extent, mostly in the mountains of the Western United States.

Quartzipsamments

These are the freely drained Psamments that have more than 90 percent resistant minerals. They are in humid to semiarid, cool to hot regions. They can have any temperature regime, except for cryic, and any moisture regime, except for aridic (or torric). These soils are high in content of quartz sand and are white or stained with shades of brown, yellow, or red. Because they commonly have virtually no minerals that can weather, they can occur on some extremely old land surfaces. They also occur on late-Pleistocene and younger surfaces. A spodic horizon is known to lie beneath white sand, particularly in tropical areas, at a depth of several meters, so deep that determination of its presence or absence is not practical. The most important properties in such areas are those of the upper 2 m or so that consists of uncoated quartz sand.

The vegetation on Quartzipsamments varies widely with climate. Few of these soils are cultivated, except in Florida. Quartzipsamments are extensive on the coastal plains in the United States.

Definition

Quartzipsamments are the Psamments that:

1. Have a temperature regime warmer than cryic;

2. Have a moisture regime other than aridic (or torric); *and*

3. Average more than 90 percent resistant minerals in the 0.02 to 2.0 mm fraction within the particle-size control section.

Key to Subgroups

LCCA. Quartzipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Quartzipsamments

LCCB. Other Quartzipsamments that have *both*:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Aquodic Quartzipsamments

LCCC. Other Quartzipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Quartzipsamments

LCCD. Other Quartzipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Quartzipsamments

LCCE. Other Quartzipsamments that meet *all* of the following:

1. Have an ustic moisture regime; *and*

2. Have a clay fraction with a CEC of 16 cmol(+) or less per kg clay (by NH_4OAc pH 7); *and*

3. The sum of the weighted average silt plus 2 times the weighted average clay (both by weight) is more than 5.

Ustoxic Quartzipsamments

LCCF. Other Quartzipsamments that meet *all* of the following:

1. Have a udic moisture regime; *and*

2. Have a clay fraction with a CEC of 16 cmol(+) or less per kg clay (by NH_4OAc pH 7); *and*

3. The sum of the weighted average silt plus 2 times the weighted average clay (both by weight) is more than 5.

Udoxic Quartzipsamments

LCCG. Other Quartzipsamments that have 5 percent or more (by volume) plinthite in one or more horizons within 100 cm of the mineral soil surface.

Plinthic Quartzipsamments

LCCH. Other Quartzipsamments that have *both*:

1. Lamellae within 200 cm of the mineral soil surface; *and*

2. An ustic moisture regime.

Lamellic Ustic Quartzipsamments

LCCI. Other Quartzipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Quartzipsamments

LCCJ. Other Quartzipsamments that have an ustic moisture regime.

Ustic Quartzipsamments

LCCK. Other Quartzipsamments that have a xeric moisture regime.

Xeric Quartzipsamments

LCCL. Other Quartzipsamments that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Quartzipsamments

LCCM. Other Quartzipsamments.

Typic Quartzipsamments

Definition of Typic Quartzipsamments

Typic Quartzipsamments are the Quartzipsamments that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 30 or more cumulative days or 20 or more consecutive days in normal years;

3. Do not have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

   a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

   b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

   c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon;

4. Do not have a lithic contact within 50 cm of the soil surface;

5. Have a clay fraction with a CEC of more than 16 than cmol(+) per kg clay (by NH_4OAc pH 7) if the sum of the weighted average silt plus 2 times the weighted clay (both by weight) is more than 5;

6. Have less than 5 percent plinthite in all horizons above a depth of 100 cm;

7. Have a udic or perudic moisture regime; *and*

8. Do not have lamellae within 200 cm of the soil surface.

Description of Subgroups

Typic Quartzipsamments.—The Typic subgroup of Quartzipsamments is centered on soils that have a udic or perudic moisture regime, have deep ground water in all seasons, do not have distinct color horizons, have a moderately thick or thicker regolith, and have at least moderately active clays or very little clay. These soils are extensive in the United States. They are mostly in the Southeastern States. Most are used as forest, but some are used as cropland or pasture.

Aquic Quartzipsamments.—These soils have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are considered intergrades to Psammaquents. They are of small extent in the United States.

Aquodic Quartzipsamments.—These soils have weak accumulations of amorphous materials. They also have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and aquic conditions for some time in normal years (or artificial drainage). These soils are considered intergrades to Aquods. They are of small extent in the United States.

Lamellic Quartzipsamments.—These soils have lamellae within 200 cm of the soil surface. The Lamellic Quartzipsamments in the United States have a udic moisture regime, although the subgroup also allows soils with a xeric regime. Because of the lamellae, Lamellic Quartzipsamments have more moisture available for deep-rooted plants, such as trees and perennial grasses, than Typic Quartzipsamments. Lamellic Quartzipsamments are of small extent in the United States.

Lamellic Ustic Quartzipsamments.—These soils have an ustic moisture regime and have lamellae within 200 cm of the soil surface. Because of the lamellae, these soils have more moisture available for deep-rooted plants, such as trees and perennial grasses, than other Quartzipsamments with an ustic moisture regime. Lamellic Ustic Quartzipsamments are of small extent in the United States.

Lithic Quartzipsamments.—These soils are shallow to a lithic contact. They are of small extent in the United States.

Oxyaquic Quartzipsamments.—These soils are saturated with water in one or more layers within 150 cm of the mineral soil surface for either or both 20 or more consecutive days or 30 or more cumulative days in normal years. Some of the soils have redox depletions with low chroma (2 or less) at a depth below 100 cm from the mineral soil surface. Oxyaquic Quartzipsamments are considered intergrades to Aquents. They are of small extent in the United States.

Plinthic Quartzipsamments.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Spodic Quartzipsamments.—These soils are like Typic Quartzipsamments, but they have a weak accumulation of amorphous materials. The ground water is deeper than 100 cm most of the year in the soils of this subgroup. These soils are of small extent in the United States.

Udoxic Quartzipsamments.—These soils are like Typic Quartzipsamments, but they have a clay fraction that meets the CEC requirements for an oxic horizon, but the amount of clay is too small for an oxic horizon. Udoxic Quartzipsamments are not known to occur in the United States, but they are extensive in the equatorial regions of Africa and South America.

Ustic Quartzipsamments.—These soils are like Typic Quartzipsamments, but they have an ustic moisture regime. They are of small extent in the United States.

Ustoxic Quartzipsamments.—These soils are like Typic Quartzipsamments, but they have an ustic moisture regime and have a clay fraction that meets the CEC requirements of clay in an oxic horizon. The amount of clay is too small to meet the requirements for an oxic horizon. These soils are not known to occur in the United States, but they are extensive in Africa and South America.

Xeric Quartzipsamments.—These soils are like Typic Quartzipsamments, but they have a xeric moisture regime. They are not known to occur in the United States.

Torripsamments

These are the cool to hot Psamments of arid climates. They have an aridic (or torric) moisture regime and a temperature regime warmer than cryic. Many of these soils are on stable surfaces, some are on dunes, some are stabilized, and some are moving. Torripsamments consist of quartz, mixed sands, volcanic glass, or even gypsum and may have any color. Generally, they are neutral or calcareous and are nearly level to steep. The vegetation consists mostly of xerophytic shrubs, grasses, and forbs. Many of these soils support more vegetation than other soils with an aridic moisture regime, presumably because they lose less water as runoff. Some of the soils on dunes support a few ephemeral plants or have a partial cover of xerophytic and ephemeral plants. The shifting dunes may be devoid of plants in normal years. Most of the deposits are of late-Pleistocene or younger age. These soils are used mainly for grazing. They are extensive in the Western United States.

Definition

Torripsamments are the Psamments that have an aridic (or torric) moisture regime and a soil temperature regime warmer than cryic.

Key to Subgroups

LCBA. Torripsamments that have a lithic contact within 50 cm of the soil surface.

Lithic Torripsamments

LCBB. Other Torripsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Torripsamments

LCBC. Other Torripsamments that have a horizon within 100 cm of the soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Haploduridic Torripsamments

LCBD. Other Torripsamments that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 ^oC or higher; *and*

2. An aridic (or torric) moisture regime that borders on ustic.

Ustic Torripsamments

LCBE. Other Torripsamments that have *both*:

1. A moisture control section that, in normal years, is dry in all its parts for less than three-fourths of the cumulative days per year when the soil temperature at a depth of 50 cm from the soil surface is 5 °C or higher; *and*

2. A thermic, mesic, or frigid soil temperature regime and an aridic (or torric) moisture regime that borders on xeric.

Xeric Torripsamments

LCBF. Other Torripsamments that have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Torripsamments

LCBG. Other Torripsamments.

Typic Torripsamments

Definition of Typic Torripsamments

Typic Torripsamments are the Torripsamments that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

3. Are dry in all parts of the moisture control section for three-fourths or more of the time (cumulative) when the soil temperature at a depth of 50 cm is 5 °C or higher;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more; *and*

5. Do not have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Description of Subgroups

Typic Torripsamments.—The Typic subgroup consists of the Torripsamments that are dry for more than three-fourths of the time when the soil temperature is 5 °C or higher. These soils do not have evident cementation by silica and are moderately deep or deep to a lithic contact. The limitation on moisture restricts the subgroup to the drier part of the range of the great group. The restriction against a lithic contact is the same one that is applied in Typic subgroups throughout most of this taxonomy. Many of these soils support more vegetation than other soils with an aridic moisture regime, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an aridic moisture regime. Some water is stored below the soil moisture control section. Typic Torripsamments are moderately extensive in the Western United States. They are used mainly for grazing.

Haploduridic Torripsamments.—These soils have, within 100 cm of the surface, a horizon that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist. The soils are permitted to have a moisture regime that is not so dry as that of the Typic subgroup. Some volcanic ash and other pyroclastic materials are in some of these soils. Haploduridic Torripsamments are not known to occur in the United States.

Lithic Torripsamments.—These soils are less than 50 cm deep to a lithic contact. Because the soils are shallow, a wider range in the moisture regime is permitted than in other Torripsamments. Small areas of Lithic Torripsamments are in the mountains in the Western United States and are used for grazing.

Rhodic Torripsamments.—These soils have dark red colors. They do not have a lithic contact within 50 cm of the soil surface or a moisture regime that borders on ustic or xeric. They are in areas of an isohyperthermic soil temperature regime in India. Some of these soils are used for the production of cashews.

Ustic Torripsamments.—These soils have an aridic moisture regime that borders on ustic. Most of the soils in this subgroup have two short rainy seasons and two long dry seasons each year. The longer rainy season is less than 3 months, or it has only showers of erratic distribution, so that the moisture control section dries between rains. Many of these soils support more vegetation than other soils with an aridic moisture regime that borders on ustic, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an aridic moisture regime. Some water is stored below the soil moisture control section. Ustic Torripsamments are extensive in the Western United States. They are used mainly for grazing.

Vitrandic Torripsamments.—These soils have a significant volcanic influence in one or more layers 18 cm or more thick within 75 cm of the mineral soil surface. They are in California and Oregon. Most are used as rangeland, but some are mined for pumice or are irrigated and used for alfalfa.

Xeric Torripsamments.—These soils have an aridic moisture regime that borders on xeric. The rainy season is in winter, and summer is very dry. The supply of winter moisture is dependable, however, and the soils can support more vegetation than the soils of the Typic subgroup. The level of organic matter may be higher than in Typic Torripsamments but does not need to be higher in the soils on shifting dunes. Many of the Xeric Torripsamments support more brushy vegetation than other soils with an aridic moisture regime that borders on xeric, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an aridic moisture regime. Some water is stored deep below the soil moisture control section. Xeric Torripsamments are moderately extensive in the Western United States. They are used mainly for grazing. Some of the soils are used as irrigated cropland.

Udipsamments

These are the Psamments that are of humid regions and have a temperature regime warmer than cryic. The soils have a udic moisture regime, and they average more than 10 percent weatherable minerals (in the 0.02 to 2.0 mm fraction) in the particle-size control section. They are predominantly in areas of late-Pleistocene or more recent deposits and are mostly brownish and freely drained. Most of the soils have supported forest vegetation, but a few have been cultivated ever since the sands were deposited. Others have been cultivated for a very long time. Udipsamments are extensive in the United States. Many are used as forest. Large areas, mostly with mesic or warmer temperature regimes, have been cleared and are used as cropland or pasture.

Definition

Udipsamments are the Psamments that:

1. Have a soil temperature regime warmer than cryic;

2. Have a udic moisture regime; *and*

3. Average less than 90 percent resistant minerals in the 0.02 to 2.0 mm fraction within the particle-size control section.

Key to Subgroups

LCFA. Udipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Udipsamments

LCFB. Other Udipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Udipsamments

LCFC. Other Udipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Udipsamments

LCFD. Other Udipsamments that have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Udipsamments

LCFE. Other Udipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Udipsamments

LCFF. Other Udipsamments that have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Plagganthreptic Udipsamments

LCFG. Other Udipsamments.

Typic Udipsamments

Definition of Typic Udipsamments

Typic Udipsamments are the Udipsamments that:

1. Do not have lamellae within 200 cm of the soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 30 or more cumulative days or 20 or more consecutive days in normal years;

4. Do not have a lithic contact within a depth of 50 cm;

5. Do not have a horizon, 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon; *and*

6. Do not have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Description of Subgroups

Typic Udipsamments.—The Typic subgroup of Udipsamments is centered on soils that are moderately deep or deeper to a lithic contact, have deep ground water, do not have a weak accumulation of amorphous materials, do not have lamellae within 200 cm of the soil surface, and do not have an epipedon (less than 50 cm thick) that meets all of the requirements for a plaggen epipedon except thickness.

Soils that have a lithic contact within 50 cm of the soil surface are excluded from the Typic subgroup, a convention used throughout this taxonomy. Soils that are saturated with water within a depth of 100 cm and have redox depletions with low chroma (2 or less) are considered intergrades to Psammaquents. Soils that have weak accumulations of amorphous materials are considered intergrades to Spodosols. In the United States, such soils are mostly intergrades to Orthods. Lamellae are used as criteria for the Lamellic subgroup and indicate a transition to Alfisols or Ultisols. A thin surface mantle that meets all of the requirements for a plaggen epipedon except thickness is considered a transition to Plagganthrepts.

Typic Udipsamments are extensive in the Eastern United States. They are used mainly as forest, but large areas have been cleared and are used as cropland or pasture.

Aquic Udipsamments.—These soils are saturated with water at some time of the year and have redox depletions with low chroma (2 or less) within 100 cm of the soil surface, and they are permitted, but not required, to have lamellae within 200 cm of the surface. They are otherwise like Typic Udipsamments. Aquic Udipsamments are of moderate extent in the Eastern United States. They are used mainly as forest, but some areas have been cleared and are used as cropland or pasture.

Lamellic Udipsamments.—These soils have lamellae in which clay has accumulated as oriented coatings on sand grains. These soils are of moderate extent in the Eastern United States. They are used mainly as forest, but some have been cleared and are used as cropland or pasture.

Lithic Udipsamments.—These soils have a lithic contact within 50 cm of the soil surface but are otherwise like Typic Udipsamments. Lithic Udipsamments are of very small extent in the Eastern United States. They are used mainly as forest.

Oxyaquic Udipsamments.—These soils are saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years; do not have redox depletions with low chroma (2 or less) within 100 cm of the soil surface; and are permitted, but not required, to have lamellae within 200 cm of the surface. They are otherwise like Typic Udipsamments. Oxyaquic Udipsamments are of moderately small extent in the Eastern United States. They are used mainly as forest, but some have been cleared and are used as cropland or pasture.

Plagganthreptic Udipsamments.—These soils have a surface horizon between 25 and 50 cm thick that meets all of the requirements for a plaggen epipedon except thickness. They are not known to occur in the United States, but the subgroup is provided for use in other countries.

Spodic Udipsamments.—These soils have weak accumulations of amorphous materials. They are considered to be developing toward Spodosols or to be more or less in equilibrium between Psamments and Spodosols, generally Orthods in the United States. Spodic Udipsamments are of small extent in the Eastern United States. They are used mainly as forest, but some have been cleared and are used as cropland or pasture.

Ustipsamments

These are the Psamments that have an ustic moisture regime. They can have any temperature regime warmer than cryic. These soils support mostly grass or savanna vegetation. A few are in drought-tolerant forests of small, scattered trees. Many support as much vegetation as or more vegetation than other soils with an ustic moisture regime, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an ustic moisture regime. Some water is stored below the soil moisture control section. Ustipsamments are used mainly for grazing. Few of them are cultivated because they are subject to soil blowing if they are cultivated. Ustipsamments are extensive soils on the Great Plains in the United States.

Definition

Ustipsamments are the Psamments that:

1. Have a soil temperature regime warmer than cryic;

2. Have an ustic soil moisture regime; *and*

3. Average less than 90 percent resistant minerals (in the 0.02 to 2.0 mm fraction) in the particle-size control section.

Key to Subgroups

LCDA. Ustipsamments that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Ustipsamments

LCDB. Other Ustipsamments that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Ustipsamments

LCDC. Other Ustipsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Ustipsamments

LCDD. Other Ustipsamments that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for less than 180 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Aridic Ustipsamments

LCDE. Other Ustipsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Ustipsamments

LCDF. Other Ustipsamments that have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Ustipsamments

LCDG. Other Ustipsamments.

Typic Ustipsamments

Definition of Typic Ustipsamments

Typic Ustipsamments are the Ustipsamments that:

1. Do not have lamellae within 200 cm of the soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 30 or more cumulative days or 20 or more consecutive days in normal years;

4. Do not have a lithic contact within 50 cm of the surface;

5. Are either irrigated or fallowed to store moisture or have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that, in normal years, is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that, in normal years, is dry in some part for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that, in normal years, is moist in some or all parts for 180 or more cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

6. Do not have, in all horizons from a depth of 25 to 100 cm, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A color value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Description of Subgroups

Typic Ustipsamments.—The central concept or Typic subgroup of Ustipsamments is fixed on sands that have deep ground water and a thick regolith and do not have lamellae within 200 cm of the soil surface. Some of these soils are shallow to a paralithic contact. Commonly, the sands are a mixture of quartz and feldspars.

Soils that have lamellae in which silicate clays have accumulated are excluded from the Typic subgroup because the lamellae are considered to indicate intergrades to soils that have an argillic horizon. Soils that have a lithic contact within 50 cm of the surface are excluded from the Typic subgroup, a convention used throughout this taxonomy. Redoximorphic features and the presence of ground water within 100 cm of the surface at some time of the year cause soils to be excluded because these features are considered to indicate intergrades to Psammaquents.

Typic Ustipsamments are freely drained sands. They support mostly grass or savanna vegetation. A few are in drought-tolerant forests of small, scattered trees. Many support as much vegetation as or more vegetation than other soils with an ustic moisture regime, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an ustic moisture regime. Some water is stored below the soil moisture control section. Typic Ustipsamments are extensive on the Great Plains in the United States. They are used mainly for grazing. Few of them are cultivated because they are subject to soil blowing if they are cultivated.

Aquic Ustipsamments.—These soils are saturated with water at some time of the year and have redoximorphic features of low or high chroma within 100 cm of the soil surface. The soils are otherwise like the soils of the Typic subgroup. They are of small extent in the United States.

Aridic Ustipsamments.—These soils are drier than Typic Ustipsamments. They are intergrades between Ustipsamments and Torripsamments. They are moderately extensive in the southern part of the Great Plains in the United States. Slopes are gentle to steep. These soils are freely drained sands. They support mostly grass or savanna vegetation. A few are in drought-tolerant forests of small, scattered trees. Many support as much vegetation as or more vegetation than other soils with an ustic moisture regime, perhaps because of rapid infiltration and a low available water capacity, which cause the precipitation to moisten the soils to a greater depth than in most other soils with an ustic moisture regime. Some water is stored below the soil moisture control section. Most of the Aridic Ustipsamments are used for grazing. Few of them are cultivated because they are subject to soil blowing if they are cultivated.

Lamellic Ustipsamments.—These soils have lamellae within 200 cm of the soil surface. They are of small extent in the United States. They are used mainly as rangeland. Few of them are cultivated because they are subject to soil blowing if they are cultivated.

Lithic Ustipsamments.—These soils have a lithic contact within 50 cm of the soil surface. They support grass or savanna vegetation. Small areas of these soils are known to occur in the United States.

Oxyaquic Ustipsamments.—These soils are saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years; do not have redox depletions with low chroma (2 or less) within 100 cm of the soil surface; and are permitted, but not required, to have lamellae within 200 cm of the surface. They are otherwise like Typic Ustipsamments. Oxyaquic Ustipsamments are of small extent in the United States. They are used mainly as rangeland.

Rhodic Ustipsamments.—These soils have dark red colors. They do not have a lithic contact within 50 cm of the soil surface, lamellae, or a moisture regime that borders on aridic. They are known to occur only in areas of an isohyperthermic soil temperature regime in India. These soils commonly are used for the production of cashews.

Xeropsamments

These are the Psamments that are of Mediterranean climates and that have weatherable minerals, commonly feldspars, in the sand fraction. These soils are moist in winter and dry in summer. They have a frigid, mesic, or thermic temperature regime. Most Xeropsamments formed in deposits of late-Wisconsinan or more recent age. Some are on terraces and glacial outwash plains. Others are on dunes. Because the supply of winter moisture is reliable, few of the dunes are shifting. Some of these soils have supported a coniferous vegetation, but most have supported and still support a mixture of grasses and xerophytic shrubs or trees. Xeropsamments are moderately extensive in parts of the Western United States.

Definition

Xeropsamments are the Psamments that:

1. Have a xeric moisture regime and a frigid, mesic, or thermic soil temperature regime; *and*

2. Have, in the 0.02 to 2.0 mm fraction within the particle-size control section, 90 percent or less (by weighted average) resistant minerals.

Key to Subgroups

LCEA. Xeropsamments have a lithic contact within 50 cm of the mineral soil surface.

Lithic Xeropsamments

LCEB. Other Xeropsamments that have *both*:

1. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Aquic Durinodic Xeropsamments

LCEC. Other Xeropsamments that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Xeropsamments

LCED. Other Xeropsamments that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Xeropsamments

LCEE. Other Xeropsamments that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is 30 or more.

Vitrandic Xeropsamments

LCEF. Other Xeropsamments that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Durinodic Xeropsamments

LCEG. Other Xeropsamments that have lamellae within 200 cm of the mineral soil surface.

Lamellic Xeropsamments

LCEH. Other Xeropsamments that have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm below the mineral soil surface.

Dystric Xeropsamments

LCEI. Other Xeropsamments.

Typic Xeropsamments

Definition of Typic Xeropsamments

Typic Xeropsamments are the Xeropsamments that:

1. Do not have lamellae within 200 cm of the soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 30 or more cumulative days or 20 or more consecutive days in normal years;

4. Do not have a horizon within 100 cm of the surface that is more than 15 cm thick and that either has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist;

5. Do not have a lithic contact within 50 cm of the soil surface;

6. Have a base saturation (by NH_4OAc) of 60 percent or more in some part at a depth between 25 and 75 cm below the soil surface; *and*

7. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction containing 5 percent or more volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is less than 30.

Description of Subgroups

Typic Xeropsamments.—The Typic subgroup of Xeropsamments is centered on sands that have no ground water within a depth of 100 cm, that do not have evident cementation with silica, and that do not have lamellae in which silicate clay has accumulated. These soils are more than 50 cm deep to any lithic contact. Normally, the sands are deep and are a mixture of quartz and feldspars and little volcanic glass.

These soils have no lamellae within 200 cm of the soil surface because the lamellae are considered to indicate intergrades to soils that have an argillic horizon, generally Xeralfs. Soils that have a lithic contact within a depth of 50 cm are excluded from the Typic subgroup, a convention used throughout this taxonomy. Soils that have ground water within 100 cm of the surface at some time of the year are excluded because they are considered to indicate intergrades to Psammaquents. Partial cementation by silica is considered to indicate intergrades to great groups that have duripans.

Typic Xeropsamments are of moderate extent in the Western United States, mostly in California, Washington, and Nevada. The soils that are frigid or mesic are used mostly as forest, but some areas have been cleared and are used as cropland. The soils that are thermic are used mostly as cropland or rangeland.

Aquic Durinodic Xeropsamments.—These soils show evidence of weak cementation by silica in the form of durinodes or of a horizon more than 15 cm thick that is brittle and has a firm rupture-resistance class when moist. The soils normally have an appreciable amount of pyroclastics in the sand fraction. In addition, they are saturated with water at some time during the year and have distinct or prominent redox concentrations within 100 cm of the soil surface.

Aquic Xeropsamments.—These soils are saturated with water at some time during the year and have distinct or prominent redox concentrations within 100 cm of the soil surface. They are not extensive soils in the United States.

Durinodic Xeropsamments.—These soils show evidence of weak cementation by silica in the form of durinodes or of a horizon more than 15 cm thick that is brittle and has a firm rupture-resistance class when moist. The soils are not known to occur in the United States.

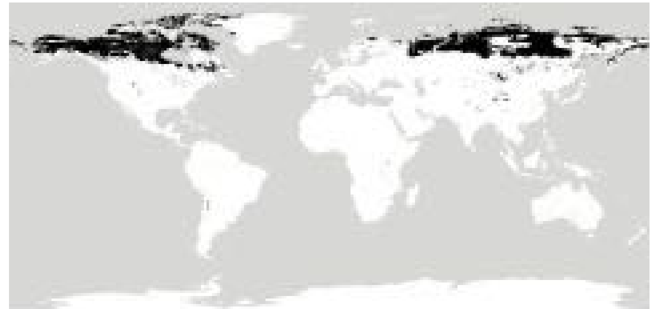
Dystric Xeropsamments.—These soils receive relatively high amounts of rainfall during the winter months. As a consequence, the base saturation is lower than that in the soils of the Typic subgroup. Dystric Xeropsamments are not extensive. In the United States, they are mostly in California and Washington, where they support forest vegetation.

Lamellic Xeropsamments.—These soils have lamellae within 200 cm of the soil surface. They are not extensive. They are mostly in California, Washington, and Idaho in the United States. They are used mainly as forest.

Lithic Xeropsamments.—These soils have a lithic contact within 50 cm of the surface. They are not extensive. They are mostly in California, Oregon, and Idaho in the United States. They are used mainly as forest.

Oxyaquic Xeropsamments.—These soils are saturated with water at some time during the year. The saturation occurs within 100 cm of the soil surface. These soils are not extensive in the United States.

Vitrandic Xeropsamments.—These soils consist of volcanic deposits or have a layer of pyroclastic materials, 18 cm or more thick, in the upper 75 cm. The soils are of minor extent, mostly in California. They are used mainly as forest.



CHAPTER 13

Gelisols[1]

The central concept of Gelisols is that of soils with gelic materials underlain by permafrost. Freezing and thawing are important processes in Gelisols. Diagnostic horizons may or may not be present. Permafrost influences pedogenesis by acting as a barrier to the downward movement of the soil solution.

Cryoturbation (frost mixing) is an important process in many Gelisols and results in irregular or broken horizons, involutions, organic matter accumulation on the permafrost table, oriented rock fragments, and silt caps on rock fragments. Cryoturbation occurs when two freezing fronts, one from the surface and the other from the permafrost, merge during freeze-back in the autumn. Ice segregation is an important property of gelic materials and occurs when the soil solution migrates toward ice, increasing the volume of ice. Volume changes also occur as the water freezes. In the drier areas, cryoturbation is less pronounced or does not occur, but the soils still have gelic materials, as manifested by sand wedges and ice crystals.

Diagnostic horizons, including ochric, mollic, umbric, and histic epipedons and argillic, salic, gypsic, and calcic horizons, have been observed in Gelisols. The importance of these diagnostic horizons, however, is overshadowed by the properties of the gelic materials and the associated permafrost. In some Gelisols the effects of cryoturbation are so well expressed that no diagnostic horizons are observed.

Definition of Gelisols and Limits Between Gelisols and Soils of Other Orders

Gelisols are soils that have *one or more* of the following:

1. Permafrost within 100 cm of the soil surface; *or*

2. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Limits Between Gelisols and Other Soil Orders

The definition of Gelisols must provide criteria that separate Gelisols from all other orders. The aggregate of these criteria defines the limits of Gelisols in relation to all other known soils.

Unlike the other soil orders, Gelisols have *one or both* of the following:

1. Permafrost within 100 cm of the soil surface; *or*

2. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

Representative Pedon and Data

Following is a description of a representative Gelisol. Data for the pedon identified in this description are given in the table "Characterization Data for a Gelisol."

Classification: Loamy, mixed, superactive Typic Molliorthel
Site identification number: 94P0668
Location: Lower Kolymar, Russia
Latitude: 68 degrees 43 minutes 56 seconds N.
Longitude: 161 degrees 31 minutes 49 seconds E.
Slope: 3 percent
Aspect: 270 degrees
Horizontal shape: Convex
Vertical shape: Convex
Total slope length: 200 m, 30 m of which is above the sample site
Elevation: 140 m
Landscape: Plains
Landform: Pediment
Annual precipitation: 190 mm
Soil moisture regime: Udic
Land use: Forest land (not grazed)
Permeability class: Moderate
Natural drainage class: Well drained
Parent material: Loess and moderately weathered local colluvium derived from acidic schist and diorite
Particle-size control section: 25 to 100 cm
Diagnostic features: An mollic epipedon from a depth of 0 to 38 cm and permafrost at a depth of 94 cm

Notes: An ice-rich permafrost table is at a depth of 94 cm. The frozen layer from a depth of 78 to 94 cm is thought to be part of the active layer in some years. Charcoal is mixed to a depth of 25 cm. Rock fragments are diorite.

[1] This chapter is based on recommendations by the International Committee on Permafrost-Affected Soils (ICOMPAS), chaired by Dr. James G. Bockheim, University of Wisconsin.

Characterization Data for a Gelisol

SITE IDENTIFICATION NO.: 94P0668
CLASSIFICATION: LOAMY, MIXED, SUPERACTIVE TYPIC MOLLORTHEL
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO_3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS (mm) WEIGHT 2 -5	WEIGHT 5 -20	WEIGHT 20 -75	.1- 75	(>2mm) WT PCT OF WHOLE SOIL
			<- Pct of <2mm (3A1)											->	<- Pct of <75mm(3B1)			->	
94P5015	0- 7	A	23.7	61.3	15.0	11.2		31.1	30.2	8.4	3.3	0.6	0.4	2.3	4	2	3V	15	9
94P5016	7- 12	AB	8.7	72.9	18.4	4.5		34.4	38.5	12.1	1.7	1.4	1.5	1.7	2	1	5V	14	8
94P5017	12- 38	Bw1	13.0	70.1	16.9	5.6		33.1	37.0	13.4	1.3	0.9	0.7	0.6	1	1	5V	10	7
94P5018	38- 59	Bw2	15.5	68.3	16.2	9.6		31.9	36.4	14.1	1.1	0.4	0.4	0.2	TR	1	5V	8	6
94P5019	59- 78	Bw3	15.4	68.9	15.7	8.1		29.8	39.1	14.0	1.1	0.2	0.3	0.1	TR	TR	5V	7	5
94P5020	78- 94	Bw4	15.2	70.3	14.5	7.3		29.8	40.5	12.5	1.0	0.3	0.3	0.4	TR	TR	5V	7	5
94P5021	94-110	Cf	13.5	75.6	10.9	6.7		29.1	46.5	9.7	0.6	0.2	0.2	0.2	TR	1	5V	7	6

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B4a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3c	DITH-CIT EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG - LIMITS -) LL 4F1	PI 4F	BULK DENSITY FIELD MOIST 4A5	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
	Pct	<2mm	ppm	<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 7	7.54	0.331		TR				1.25	0.95				0.73	1.04	0.121			38.3	22.5	0.11
7- 12	0.65	0.064	1	--	1.4	0.1	TR	1.31	0.67				1.65	1.65	--			18.5	5.8	0.20
12- 38	0.56	0.065	TR	--	1.6	0.1	TR	0.97	0.50										6.5	
38- 59	0.48	0.065	1	--	1.8	0.1	TR	0.95	0.57										8.8	
59- 78	0.44	0.066	2	--	1.7	0.1	TR	0.88	0.54				1.54	1.66	0.024			20.8	8.3	0.19
78- 94	0.44	0.068	1	--	1.6	0.1	TR	0.86	0.51				1.73	1.79	0.011			18.3	7.7	0.18
94-110	0.39	0.059	1	--	1.5	0.1	TR	0.83	0.51										6.9	

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 6N2e	Mg 6O2d	Na 6P2b	K 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9d	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8c	BASES + Al 5A3b	Al SAT 5G1	BASE SAT SUM 5C3	BASE SAT NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	PH KCl IN 8C1g	PH $CaCl_2$ .01M 8C1f 1:2	PH H_2O 8C1f 1:1
	<- meq / 100 g									->	<- Pct		->						
0- 7	11.1	4.9	0.6	0.4	17.0	28.0		45.0	29.7			38	57				3.8	4.6	5.2
7- 12	6.0	2.8	0.3	0.1	9.2	7.5	0.3	16.7	11.4	9.5	3	55	81				4.1	4.9	5.7
12- 38	7.4	3.7	0.2	0.1	11.4	5.4	TR	16.8	12.6			68	90				4.7	5.6	6.6
38- 59	9.5	4.9	0.4	0.2	15.0	5.1		20.1	14.7			75	100				5.4	6.1	6.8
59- 78	9.2	4.6	0.2	0.2	14.2	3.8		18.0	13.5			79	100				5.6	6.3	6.8
78- 94	8.0	4.1	0.2	0.2	12.5	3.7		16.2	13.1			77	95				5.8	6.4	7.3
94-110	7.5	3.8	0.2	0.2	11.7	2.4		14.1	11.2			83	100				5.8	6.5	7.3

SAMPLE NO.	HZ NO	ACID OXALATE EXTRACTION OPT DEN 8J	Fe 6C9b	Si 6V2b	Al 6G12b	PHOSPHORUS RET 6S4	CIT-ACID 6S5	KCl Mn 6D3b	TOTAL C 6A2e	WATER CONTENT 0.06 BAR 4B1c	1- BAR 4B1a	2- BAR 4B1a	15 BAR 4B2b	WATER DISPERSIBLE PIPETTE CLAY 3A1c	SILT 3A1c	SAND 3A1c	HYDROMETER CLAY SML	SILT SML	SAND SML	MIN SOIL CONT 8F1	AGGRT STABL <5mm 4G1
			<- Pct of <2mm ->			<- ppm		->	<- Percent of <2mm											->	Pct>
94P5015	1											30.8								90	
94P5016	2	0.06	0.48	0.03	0.13	32		0.5				11.0									
94P5017	3	0.05	0.42	0.05	0.14	31		0.6				12.3									
94P5018	4	0.04	0.37	0.05	0.15	28						12.7									
94P5019	5	0.04	0.36	0.06	0.15	23						12.5									
94P5020	6	0.04	0.33	0.06	0.12	28						14.1									
94P5021	7	0.03	0.28	0.06	0.11	28						10.7									

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i (Peak size)					THERMAL DTA 7A6b (Percent)	TGA 7A4c (Percent)	ELEMENTAL 7C4a (Percent) SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 (mg/g)	INTERPRETATION
94P5017	TCLY	VR 3	MI 3	KK 2	QZ 2	FD 2											
94P5017		VM 1															
94P5019	TCLY	MI 3	VR 3	KK 2	QZ 1	FD 1											
94P5021	TCLY	MI 3	VR 2	KK 2	QZ 1	FD 1											

Characterization Data for a Gelisol--Continued

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	SAND - SILT MINERALOGY (2.0-0.002mm)																			
	FRAC-	X-RAY				THERMAL				OPTICAL										INTER-
SAMPLE	TION					DTA		TGA		TOT RE	GRAIN COUNT									PRETA-
		7A2i				7A3c		7A4c		7B1a										TION
NUMBER		Peak Size				Percent				Percent										
94P5017	CSi									39	QZ38	FK25	AR19	FP 5	MS 4	CM 4				
94P5017	CSi										PR 2	HN 1	FE 1	OPtr	POtr	BYtr				
94P5017	CSi										GNtr	RUtr	GStr	ZRtr	APtr	BYtr				
94P5018	CSi									48	QZ46	FK22	AR17	FP 7	PR 2	HN 2				
94P5018	CSi										FE 2	MS 1	BT 1	CM 1	OPtr	APtr				
94P5018	CSi										MZtr	BYtr	ZRtr	RUtr	GNtr	GStr				
94P5018	CSi										FZtr	ZEtr								
94P5019	CSi									43	QZ42	AR24	FK15	FP 5	HN 4	MS 2				
94P5019	CSi										CM 2	FE 1	BT 1	PRtr	OPtr	FZtr				
94P5019	CSi										GNtr	ZEtr	CTtr	BYtr	ZRtr	APtr				
94P5019	CSi										RUtr									
94P5020	CSi									46	QZ46	AR19	FK17	FP 6	MS 4	CM 3				
94P5020	CSi										HN 3	PR 1	FEtr	BTtr	BYtr	RUtr				
94P5020	CSi										OPtr	APtr	TMtr	POtr	GStr	ZRtr				
94P5020	CSi										GNtr									
94P5021	CSi									46	QZ45	FK20	AR20	FP 5	CM 4	HU 2				
94P5021	CSi										MS 1	BT 1	PR 1	FE 1	OPtr	RUtr				
94P5021	CSi										ZRtr	BYtr	APtr	GNtr						

The chemical data are based on the fraction less than 2 mm in size.
V in tier 1, column 18, indicates volume estimates.
Fraction interpretation: TCLY, total clay, <0.002 mm; CSi, coarse silt, 0.02-0.05 mm.
Mineral interpretation: VR, vermiculite; MI, mica; KK, kaolinite; QZ, quartz; FD, feldspar; VM, vermiculite-mica; FK, potassium feldspar; AR, weathered aggregate; FP, plagioclase feldspar; MS, muscovite; CM, chlorite-mica; PR, pyroxene; HN, hornblende; FE, iron oxides; OP, opaques; PO, plant opal; BY, beryl; GN, garnet; RU, rutile; GS, glass; ZR, zircon; AP, apatite; BT, biotite; MZ, monazite; FZ, feldspathoid; ZE, zeolite; CT cassiterite; TM, tourmaline.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.
Family mineralogy: Mixed.

In the following pedon description, colors are for moist soil unless otherwise indicated.

A—0 to 7 cm; dark reddish brown (5YR 2/2) silt loam, dark reddish brown (5YR 3/2) dry; weak thin platy and moderate very fine subangular blocky structure; many very fine roots throughout; 1 percent angular gravel; very strongly acid; abrupt wavy boundary.

AB—7 to 12 cm; dark grayish brown (10YR 4/2) silt loam, light olive brown (2.5Y 5/3) dry; weak thin platy and moderate very fine subangular blocky structure; firm, slightly sticky and slightly plastic; common very fine to medium roots throughout; common fine high-continuity tubular pores; 9.0 percent clay; 3 percent angular gravel; very strongly acid; abrupt wavy boundary.

Bw1—12 to 38 cm; dark brown (10YR 3/3) silt loam, light olive brown (2.5Y 5/3) dry; moderate thin platy and moderate fine subangular blocky structure; friable, slightly sticky and slightly plastic; common very fine to medium roots throughout; many medium vesicular and many very fine high-continuity tubular pores; 10.0 percent clay; 3 percent angular gravel; very strongly acid; clear wavy boundary.

Bw2—38 to 59 cm; very dark grayish brown (10YR 3/2) silt loam, light olive brown (2.5Y 5/3) dry; strong very fine subangular blocky structure; very friable, slightly sticky and plastic; common very fine to medium roots throughout; many very fine and fine high-continuity tubular pores; 15.0 percent clay; 3 percent angular gravel; very strongly acid; clear wavy boundary.

Bw3—59 to 78 cm; very dark grayish brown (2.5Y 3/2) silt loam, light olive brown (2.5Y 5/3) dry; moderate very thin platy and moderate very fine subangular blocky structure; friable, slightly sticky and plastic; 15.0 percent clay; 3 percent angular gravel; strongly acid; gradual wavy boundary.

Bw4—78 to 94 cm; dark grayish brown (2.5Y 4/2) silt loam, grayish brown (2.5Y 5/2) dry; strong medium platy and moderate fine subangular blocky structure; extremely firm, sticky and plastic; few very fine and fine roots; common very fine and fine moderate-continuity tubular pores; 17.0 percent clay; 2 percent angular cobbles and 3 percent angular gravel; strongly acid; clear wavy boundary.

Cf—94 to 110 cm; dark grayish brown (2.5Y 4/2) silt loam; massive; extremely firm, sticky and plastic; 17.0 percent clay; 2 percent angular cobbles and 3 percent angular gravel; strongly acid.

Key to Suborders

AA. Gelisols that have organic soil materials that meet *one or more* of the following:

1. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

2. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

3. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained) and have 80 percent or more, by volume, organic soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest.

Histels, p. 448

AB. Other Gelisols that have one or more horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.

Turbels, p. 462

AC. Other Gelisols.

Orthels, p. 452

Histels

These are the Gelisols with large amounts of organic carbon that commonly accumulate under anaerobic conditions, or the organic matter at least partially fills voids in fragmental, cindery, or pumiceous materials. Cold temperatures contribute to the accumulation of organic matter.

Definition

Histels are the Gelisols that have organic soil materials that meet *one or more* of the following:

1. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

2. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

3. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained) and have 80 percent or more, by volume, organic soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest.

Key to Great Groups

AAA. Histels that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Folistels, p. 449

AAB. Other Histels that are saturated with water for 30 or more cumulative days during normal years and that have *both*:

1. A glacic layer with its upper boundary within 100 cm of the soil surface; *and*

2. Less than three-fourths (by volume) *Sphagnum* fibers in the organic soil materials to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallower.

Glacistels, p. 450

AAC. Other Histels that have more thickness of fibric soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Fibristels, p. 448

AAD. Other Histels that have more thickness of hemic soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Hemistels, p. 450

AAE. Other Histels.

Sapristels, p. 451

Fibristels

These are wet Histels in which the organic materials are slightly decomposed. Most of the fiber is not destroyed by rubbing between the thumb and fingers. The botanical origin of much of the materials can be readily determined.

Many Fibristels have ground water near the surface nearly all the time. These soils are of small extent in Alaska, Canada, and Siberia. They occur in depressional or level areas, commonly to adjacent water bodies.

Definition

Fibristels are the Histels that:

1. Are saturated with water for 30 or more cumulative days during normal years;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface; *and*

3. Have more thickness of fibric soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Key to Subgroups

AACA. Fibristels that have a lithic contact within 100 cm of the soil surface.

Lithic Fibristels

AACB. Other Fibristels that have a mineral layer 30 cm or more thick within 100 cm of the soil surface.

Terric Fibristels

AACC. Other Fibristels that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Fibristels

AACD. Other Fibristels in which three-fourths or more of the fibric material is derived from *Sphagnum* to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Sphagnic Fibristels

AACE. Other Fibristels.

Typic Fibristels

Definition of Typic Fibristels

Typic Fibristels are the Fibristels that:

1. Do not have a lithic contact within 100 cm of the soil surface;

2. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within 100 cm of the soil surface;

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary within 100 cm of the soil surface; *and*

4. Have less than three-fourths of their fibric material derived from *Sphagnum* to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Description of Subgroups

Typic Fibristels.—The Typic subgroup is fixed on soils that do not have a lithic contact within 100 cm of the soil surface and are not composed largely of *Sphagnum*. A lithic contact is used in classifying soils in lithic subgroups. Thick or thin mineral layers as well as intermittent layers that are within 100 cm of the soil surface cause soils to be excluded from the Typic subgroup. Typic Fibristels are of small extent in the world but are known to occur in northern Russia and in Alaska and Canada.

Fluvaquentic Fibristels.—These soils differ from the Typic Fibristels because they have, within 100 cm of the soil surface, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness. These soils are relatively rare but occur in Canada and Siberia.

Lithic Fibristels.—These soils differ from Typic Fibristels because they have a lithic contact within 100 cm of the soil surface.

Sphagnic Fibristels.—These soils differ from Typic Fibristels because three-fourths or more of their fibric materials is derived from *Sphagnum* to a depth of 50 cm. These soils occur in Alaska, Siberia, and Canada.

Terric Fibristels.—These soils differ from Typic Fibristels because they have a mineral layer 30 cm or more thick within 100 cm of the soil surface. These soils occur in Alaska, Canada, and Siberia.

Folistels

These are the more or less freely drained Histels that consist primarily of O horizons derived from plant litter resting on rock or on fragmental materials that consist of gravel or larger rock fragments in which the interstices are partly filled or filled with organic materials. Plant roots grow in the organic materials. These soils are rare in the world.

Definition

Folistels are the Histels that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Key to Subgroups

AAAA. Folistels that have a lithic contact within 50 cm of the soil surface.

Lithic Folistels

AAAB. Other Folistels that have a glacic layer with its upper boundary within 100 cm of the soil surface.

Glacic Folistels

AAAC. Other Folistels.

Typic Folistels

Definition of Typic Folistels

Typic Folistels are the Folistels that:

1. Do not have a lithic contact within 50 cm of the soil surface; *and*

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Folistels.—The concept of the Typic Folistels is that of soils with organic materials that are filling or partially filling interstices in fragmental materials. Typic Folistels do not have either a glacic layer within 100 cm of the soil surface or a lithic contact within 50 cm of the soil surface.

Glacic Folistels.—These are the Folistels that have a layer of ice 30 cm or more thick within 100 cm of the soil surface.

Lithic Folistels.—These are the Folistels that have organic materials resting on a lithic contact within 50 cm of the soil surface.

Glacistels

Glacistels are the Histels that have 30 cm or more of ice within 100 cm of the soil surface. Disturbance of the surface-insulating layer causes the ice layer to melt and the soils to collapse. These soils occur in Alaska, Canada, and Siberia.

Definition

Glacistels are the Histels that:

1. Are saturated with water for 30 or more cumulative days during normal years;

2. Have a glacic layer with its upper boundary within 100 cm of the soil surface; *and*

3. Have less than three-fourths (by volume) *Sphagnum* fibers to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Key to Subgroups

AABA. Glacistels that have more thickness of hemic materials than any other kind of organic soil material in the upper 50 cm.

Hemic Glacistels

AABB. Other Glacistels that have more thickness of sapric materials than any other kind of organic soil material in the upper 50 cm.

Sapric Glacistels

AABC. Other Glacistels

Typic Glacistels

Definition of Typic Glacistels

Typic Glacistels are the Glacistels that have more thickness of fibric material than any other kind of organic material in the upper 50 cm.

Description of Subgroups

Typic Glacistels.—These are the Glacistels that are dominated by fibric materials. The Typic concept of Glacistels is centered on a dominance of fibric material. The cold temperature and high water tables associated with these soils inhibit the breakdown of organic matter.

Hemic Glacistels.—These are the Glacistels that are dominated by hemic materials. The botanical origin of much of the material cannot be readily determined. Water is at or very close to the surface of these soils much of the time, unless drainage has been provided.

Sapric Glacistels.—These are the Glacistels that are dominated by sapric materials. Although water is at or near the surface for much of the year, the organic material is decomposed to the degree that the original plant material is unrecognizable.

Hemistels

These are wet Histels in which the organic materials are moderately decomposed. The botanical origin of much of the organic material is between one-sixth and two-thirds after rubbing between the fingers. Water is at or very close to the surface of these soils much of the time, unless artificial drainage has been provided. The level of ground water may fluctuate but seldom drops much below the surface tier.

Hemistels occur in depressional areas or the adjacent water bodies. These soils are known to occur in Siberia, Canada, and Alaska.

Definition

Hemistels are the Histels that:

1. Are saturated with water for 30 or more cumulative days during normal years (and are not artificially drained);

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface; *and*

3. Have more thickness of hemic soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Key to Subgroups

AADA. Hemistels that have a lithic contact within 100 cm of the soil surface.

Lithic Hemistels

AADB. Other Hemistels that have a mineral layer 30 cm or more thick within 100 cm of the soil surface.

Terric Hemistels

AADC. Other Hemistels that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Hemistels

AADD. Other Hemistels.

Typic Hemistels

Definition of Typic Hemistels

Typic Hemistels are the Hemistels that:

1. Do not have a lithic contact within 100 cm of the soil surface;

2. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within 100 cm of the soil surface; *and*

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Hemistels.—These are the Hemistels that do not have a lithic contact within 100 cm of the soil surface. These soils also do not have thick or thin mineral layers within 100 cm of the soil surface. Typic Hemistels occur in Alaska, Siberia, and Canada.

Fluvaquentic Hemistels.—These are the Hemistels that have one or more thin layers of mineral soil material within 100 cm of the soil surface. The mineral soil material commonly is deposited by floodwaters or ponded waters. These soils occur in Alaska, Canada, and Siberia.

Lithic Hemistels.—These are the Hemistels that have a lithic contact within 100 cm of the soil surface. These soils are relatively rare in the world.

Terric Hemistels.—These are the Hemistels that have a thick mineral layer within 100 cm of the soil surface. The thick mineral layer may have been deposited under hydrologic conditions that differ from those of the present. These soils occur in Alaska, Canada, and Siberia.

Sapristels

These are wet Histels in which the organic materials are well decomposed. The botanical origin of the organic material is difficult to determine in most of these soils. The fiber content of most of the organic material is less than one-sixth after rubbing between the fingers.

Sapristels occur in areas where ground water tables tend to fluctuate within the soils or where the soils were aerobic during drier periods in the past. When drained, fibric and hemic materials commonly decompose to form sapric materials.

Definition

Sapristels are the Histels that:

1. Are saturated with water for 30 or more cumulative days during normal years (and are not artificially drained);

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface; *and*

3. Have more thickness of sapric soil materials than any other kind of organic soil material to a depth of 50 cm or to a densic, lithic, or paralithic contact, whichever is shallowest.

Key to Subgroups

AAEA. Sapristels that have a lithic contact within 100 cm of the soil surface.

Lithic Sapristels

AAEB. Other Sapristels that have a mineral layer 30 cm or more thick within 100 cm of the soil surface.

Terric Sapristels

AAEC. Other Sapristels that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more layers of any thickness within 100 cm of the soil surface.

Fluvaquentic Sapristels

AAED. Other Sapristels.

Typic Sapristels

Definition of Typic Sapristels

Typic Sapristels are the Sapristels that:

1. Do not have a lithic contact within 100 cm of the soil surface;

2. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within 100 cm of the soil surface; *and*

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Sapristels.—These are the Sapristels that do not have a lithic contact within 100 cm of the soil surface. These soils also do not have thick or thin mineral layers within 100 cm of the soil surface. Typic Sapristels occur in Alaska, Siberia, and Canada.

Fluvaquentic Sapristels.—These are the Sapristels that have one or more thin layers of mineral soil material within 100 cm of the soil surface. The mineral soil material commonly is deposited by floodwaters or ponded waters. These soils occur in Alaska, Canada, and Siberia.

Lithic Sapristels.—These are the Sapristels that have a lithic contact within 100 cm of the soil surface. These soils are relatively rare in the world.

Terric Sapristels.—These are the Sapristels that have a thick mineral layer within 100 cm of the soil surface. The thick mineral layer may have been deposited under hydrologic conditions that differ from those of the present. These soils occur in Alaska, Canada, and Siberia.

Orthels

Orthels are the Gelisols that show little or no evidence of cryoturbation and are the second most abundant suborder of Gelisols. These soils occur primarily within the zone of widespread permafrost or in areas of coarse textured materials in the continuous zone of permafrost. Orthels are generally drier than Turbels and Histels. They occur in the southern Andes and the high latitudes of the Northern Hemisphere.

Definition

Orthels are the Gelisols that:

1. Do not have organic soil materials that meet *any* of the following:

   a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

   b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

   c. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained) and have 80 percent or more, by volume, organic soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest; *and*

2. Do not have any horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.

Key to Great Groups

ACA. Orthels that have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm.
Historthels, p. 457

ACB. Other Orthels that have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (or artificial drainage).
Aquorthels, p. 453

ACC. Other Orthels that have anhydrous conditions.
Anhyorthels, p. 452

ACD. Other Orthels that have a mollic epipedon.
Mollorthels, p. 457

ACE. Other Orthels that have an umbric epipedon.
Umbrorthels, p. 460

ACF. Other Orthels that have an argillic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Argiorthels, p. 455

ACG. Other Orthels that have, below the Ap horizon or below a depth of 25 cm, whichever is deeper, less than 35 percent (by volume) rock fragments and have a texture of loamy fine sand or coarser in the particle-size control section.
Psammorthels, p. 459

ACH. Other Orthels.
Haplorthels, p. 456

Anhyorthels

These are the Orthels that have anhydrous conditions. They often have dry permafrost (i.e., insufficient moisture for interstitial ice to occur). The cold deserts commonly receive less than 30 mm of annual precipitation. These soils support little or no vegetation.

These soils are limited in extent but are known to occur in continental Antarctica, the High Arctic (northern Greenland and Ellesmere Island), and the cold, dry mountains of Eurasia at elevations of more than 3,700 m.

Definition

Anhyorthels are the Orthels that:

1. Have anhydrous conditions;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm; *and*

3. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ACCA. Anhyorthels that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Anhyorthels

ACCB. Other Anhyorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.
Glacic Anhyorthels

ACCC. Other Anhyorthels that have a petrogypsic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrogypsic Anhyorthels

ACCD. Other Anhyorthels that have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Gypsic Anhyorthels

ACCE. Other Anhyorthels that have a horizon 15 cm or more thick that contains 12 cmol(-)/L in 1:5 soil:water nitrate and in which the product of its thickness (in cm) and its nitrate concentration is 3,500 or more.

Nitric Anhyorthels

ACCF. Other Anhyorthels that have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Salic Anhyorthels

ACCG. Other Anhyorthels that have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface.

Calcic Anhyorthels

ACCH. Other Anhyorthels.

Typic Anhyorthels

Definition of Typic Anhyorthels

These are the Anhyorthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer or a petrogypsic, gypsic, salic, or calcic horizon with its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a horizon 15 cm or more thick that has 12 cmol(-)/L nitrate in 1:5 soil:water extract and in which the product of its thickness (in cm) and its nitrate concentration is 3,500 or more.

Description of Subgroups

Typic Anhyorthels.—These are the Anhyorthels that commonly have accumulations of salts, including gypsum and calcium carbonate, but insufficient quantities to meet the criteria for a calcic, gypsic, petrogypsic, or salic horizon. These soils also do not contain large amounts of nitrate. Typic Anhyorthels do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Calcic Anhyorthels.—These are the Anhyorthels that have a calcic horizon within 100 cm of the mineral soil surface. These soils commonly have other more soluble salts, but not in sufficient quantity to meet the criteria for a petrogypsic, gypsic, or salic horizon. These soils also lack sufficient quantities of nitrate, a glacic layer, and a lithic contact.

Glacic Anhyorthels.—These are the Anhyorthels that have a glacic layer with its upper boundary within 100 cm of the mineral soil surface. These soils commonly have accumulations of salts, including calcium carbonate and gypsum, but do not have a lithic contact within 50 cm of the mineral soil surface.

Gypsic Anhyorthels.—These are the Anhyorthels that have a gypsic horizon within 100 cm of the mineral soil surface. They commonly have other salts, including calcium carbonate. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Lithic Anhyorthels.—These are the Anhyorthels that have a lithic contact within 50 cm of the mineral soil surface. They commonly have accumulations of salts, including calcium carbonate and gypsum.

Nitric Anhyorthels.—These are the Anhyorthels that have large accumulations of nitrate. They commonly have accumulations of other salts, but do not have gypsic or petrogypsic horizons. Nitric Anhyorthels also do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Petrogypsic Anhyorthels.—These are the Anhyorthels that have a petrogypsic horizon within 100 cm of the mineral soil surface. They can have accumulations of other salts, but they do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Salic Anhyorthels.—These are the Anhyorthels that have a salic horizon with or without a calcic horizon. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. They also do not have gypsic or petrogypsic horizons or large accumulations of nitrates within 100 cm of the mineral soil surface.

Aquorthels

These are the Orthels that are saturated and reduced close to the surface for at least part of the year. These soils have redox depletions with chroma of 2 or less. Aquorthels do not have high amounts of organic carbon at the surface. These soils are common in the centers of large-scale, low-centered polygons along the North Slope of the Brooks Range in Alaska.

Definition

Aquorthels are the Orthels that:

1. Have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years; *and*

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the mineral soil surface to a depth of 50 cm.

Key to Subgroups

ACBA. Aquorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Aquorthels

ACBB. Other Aquorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Aquorthels

ACBC. Other Aquorthels that have a sulfuric horizon or sulfidic materials with an upper boundary within 100 cm of the mineral soil surface.

Sulfuric Aquorthels

ACBD. Other Aquorthels that have *either*:

1. Organic soil materials that are discontinuous at the surface; *or*

2. Organic soil materials at the surface that change in thickness fourfold or more within a pedon.

Ruptic-Histic Aquorthels

ACBE. Other Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Aquorthels

ACBF. Other Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Aquorthels

ACBG. Other Aquorthels that have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Salic Aquorthels

ACBH. Other Aquorthels that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section.

Psammentic Aquorthels

ACBI. Other Aquorthels.

Typic Aquorthels

Definition of Typic Aquorthels

These are the Aquorthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have *either*:

   a. Organic soil materials that are discontinuous at the surface; *or*

   b. Organic soil materials at the surface that change in thickness fourfold or more within a pedon;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

   a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

   b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Do not have a salic or sulfuric horizon or sulfidic materials with an upper boundary within 100 cm of the mineral soil surface; *and*

7. Have 35 percent (by volume) or more rock fragments or a texture finer than loamy fine sand in at least one layer within the particle-size control section.

Description of Subgroups

Typic Aquorthels.—The concept of Typic Aquorthels is centered on soils without special characteristics. The Typic subgroup does not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils also do not have salic or sulfuric horizons or sulfidic materials within 100 cm of the mineral soil surface. Textures are finer than loamy fine sand or are skeletal in at least some layers of the particle-size control section. If these soils have organic soil materials at the surface, the layer is continuous and does not change much in thickness within a pedon. These soils do have the andic soil properties or volcanic glass associated with the Vitrandic Aquorthels.

Andic Aquorthels.—These are the Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Andic Aquorthels are commonly in areas that receive volcanic ejecta, but this is not required.

Glacic Aquorthels.—These are the Aquorthels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Commonly, these soils have organic soil materials at the surface. Disturbance of the surface horizon removes the insulating layer; the glacic layer then melts, and the soil collapses.

Lithic Aquorthels.—These are the Aquorthels that have a lithic contact within 50 cm of the mineral soil surface. These soils are rare in the world.

Psammentic Aquorthels.—These are the sandy Aquorthels that do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. They also do not have a salic or sulfuric horizon or sulfidic materials with an upper boundary within 100 cm of the mineral soil surface. These soils commonly have thin organic layers and do not have andic soil properties.

Ruptic-Histic Aquorthels.—These are the Aquorthels that have an organic layer at the surface that is either discontinuous or thins and thickens because of periglacial microrelief. These soils are common in Alaska, Canada, and Siberia.

Salic Aquorthels.—These are the Aquorthels that have a salic horizon with its upper boundary within 100 cm of the mineral soil surface. These soils do not have a glacic layer, a sulfuric horizon, or sulfidic materials with an upper boundary within 100 cm or a lithic contact within 50 cm of the mineral soil surface. Salic Aquorthels do not have an organic layer at the surface that thins and thickens in relationship to microrelief. These soils do not have andic soil properties.

Sulfuric Aquorthels.—These are the Aquorthels that have a sulfuric horizon or sulfidic materials within 100 cm of the mineral soil surface. They do not have a lithic contact within 50 cm of the mineral soil surface and do not have a glacic layer within 100 cm of the mineral soil surface. These soils occur in cold coastal areas of the world.

Vitrandic Aquorthels.—These are Aquorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Aquorthels are not so weathered as the Andic Aquorthels. They do not have a lithic contact within 50 cm or a glacic layer, a sulfuric horizon, or sulfidic materials with an upper boundary within 100 cm of the mineral soil surface.

Argiorthels

These are the Orthels that have an argillic horizon. These soils do not have a mollic or umbric epipedon or anhydrous conditions. Argiorthels do not have the wet conditions conducive to the accumulation of organic matter close to the surface. The argillic horizon in these soils commonly is weakly expressed. These soils are rare in the world but are known to occur in northern Siberia.

Definition

Argiorthels are the Orthels that:

1. Have an argillic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

3. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years;

4. Do not have anhydrous conditions; *and*

5. Do not have a mollic or umbric epipedon.

Key to Subgroups

ACFA. Argiorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiorthels

ACFB. Other Argiorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.
Glacic Argiorthels

ACFC. Other Argiorthels that have a natric horizon.
Natric Argiorthels

ACFD. Other Argiorthels.
Typic Argiorthels

Definition of Typic Argiorthels

Typic Argiorthels are the Orthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a natric horizon.

Description of Subgroups

Typic Argiorthels.—These are the Argiorthels that have no special characteristics. Commonly, the argillic horizon is weakly developed in these soils. Typic Argiorthels do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils also do not have the sodium associated with natric horizons. Typic Argiorthels are on stable surfaces with tundra vegetation.

Glacic Argiorthels.—These are the Argiorthels that have a glacic layer with its upper boundary within 100 cm of the mineral soil surface. Glacic Argiorthels do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the insulating surface layer causes the ice to melt and the soil to collapse.

Lithic Argiorthels.—These are the Argiorthels that have a lithic contact within 50 cm of the mineral soil surface. Lithic Argiorthels are associated with stable, bedrock-controlled landscapes.

Natric Argiorthels.—These are the Argiorthels that have a natric horizon. Natric Argiorthels do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils commonly are derived from sodium-rich marine deposits.

Haplorthels

Haplorthels are the Orthels that have an ochric epipedon and commonly a cambic horizon but have insufficient moisture prior to freezing to produce cryoturbation. These soils are not sufficiently wet for the development of thick organic layers at the surface. They are not sandy throughout the particle-size control section. They occur in Alaska, Canada, and Siberia.

Definition

Haplorthels are the Orthels that:

1. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

2. Do not have anhydrous conditions;

3. Do not have a mollic or umbric epipedon;

4. Do not have an argillic horizon that has its upper boundary within 100 cm of the mineral soil surface;

5. Have 35 percent or more (by volume) rock fragments or a texture finer than loamy fine sand in at least one layer within the particle-size control section; *and*

6. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ACHA. Haplorthels that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Haplorthels

ACHB. Other Haplorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.
Glacic Haplorthels

ACHC. Other Haplorthels that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time during normal years (or artificial drainage).
Aquic Haplorthels

ACHD. Other Haplorthels.
Typic Haplorthels

Definition of Typic Haplorthels

Typic Haplorthels are the Orthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Haplorthels.—These are the Haplorthels that do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. The Typic subgroup does not have the redoximorphic features associated with the Aquic subgroup.

Aquic Haplorthels.—These are the Haplorthels that are saturated and reduced for some time during normal years. They do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils commonly have well expressed features related to cryoturbation.

Glacic Haplorthels.—These are the Haplorthels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the surface can cause the ice layer to melt and the soil to collapse.

Lithic Haplorthels.—These are the Haplorthels that have a lithic contact within 50 cm of the mineral soil surface. These soils are rare in the world.

Historthels

Historthels are the Orthels that have organic materials at the surface. Commonly, the organic materials are thicker in the lower positions on the landscape and thinner in the higher positions. These soils are commonly saturated at or near the surface for some time during normal years and have redoximorphic features.

Definition

Historthels are the Orthels that have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm.

Key to Subgroups

ACAA. Historthels that have a lithic contact within 50 cm of the soil surface.

Lithic Historthels

ACAB. Other Historthels that have a glacic layer that has its upper boundary within 100 cm of the soil surface.

Glacic Historthels

ACAC. Other Historthels that have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in 75 percent or less of the pedon.

Ruptic Historthels

ACAD. Other Historthels.

Typic Historthels

Definition of Typic Historthels

Typic Historthels are the Orthels that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface; *and*

3. Have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in more than 75 percent of the pedon.

Description of Subgroups

Typic Historthels.—These are the Historthels that do not have a glacic layer with an upper boundary within 100 cm or a lithic contact within 50 cm of the soil surface. Commonly, these soils have an organic layer at the surface that varies in thickness and are saturated for at least brief periods during normal years.

Glacic Historthels.—These are the Historthels that have a glacic layer with an upper boundary within 100 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the insulating organic layer causes the ice to melt and the soil to collapse.

Lithic Historthels.—These are the Historthels that have a lithic contact within 50 cm of the soil surface. These soils are rare in the world.

Ruptic Historthels.—These are the Historthels that have organic layers at the surface that vary in thickness. Commonly, the thickness is related to the position on the landscape. A pattern of high and low areas repeats itself over relatively short distances. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the soil surface.

Mollorthels

Mollorthels are the Orthels that have a mollic epipedon. These soils are not wet for long periods and, unlike Historthels, do not have organic materials at the surface. They are known to occur in Alaska, Canada, and Siberia. On the North Slope of the Brooks Range in Alaska, they support vegetation that differs from that on Umbrorthels.

Definition

Mollorthels are the Orthels that:

1. Have a mollic epipedon;

2. Do not have anhydrous conditions;

3. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm; *and*

4. Do not have, within 50 cm of the mineral soil surface,

redox depletions with chroma of 2 or less and aquic conditions during normal years.

Key to Subgroups

ACDA. Mollorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Mollorthels

ACDB. Other Mollorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Mollorthels

ACDC. Other Mollorthels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest.

Vertic Mollorthels

ACDD. Other Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Mollorthels

ACDE. Other Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Mollorthels

ACDF. Other Mollorthels that have:

1. A mollic epipedon 40 cm or more thick with a texture finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Mollorthels

ACDG. Other Mollorthels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Mollorthels

ACDH. Other Mollorthels.

Typic Mollorthels

Definition of Typic Mollorthels

Typic Mollorthels are the Mollorthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have *either* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Have *either*:

a. A mollic epipedon that is less than 40 cm thick, unless the texture is loamy fine sand or coarser; *or*

b. A slope of 25 percent or more; *and*

7. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Mollorthels.—These are the Mollorthels without any special features. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic Mollorthels and do not have the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Mollorthels. Typic Mollorthels have a mollic epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both, and do not have evidence of wetness and distinct or prominent redox concentrations within 100 cm of the mineral soil surface.

Andic Mollorthels.—These are the Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They also do not have the high shrink-swell potential associated with the Vertic Mollorthels. Andic Mollorthels are commonly in areas that receive volcanic ejecta, but this is not required.

Aquic Mollorthels.—These are the Mollorthels with aquic conditions and distinct or prominent redox concentrations within 100 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic Mollorthels or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Mollorthels. Aquic Mollorthels have a mollic epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both.

Cumulic Mollorthels.—These are the Mollorthels that have a mollic epipedon that is 40 cm or more thick, a texture finer than loamy fine sand, and a slope of less than 25 percent. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Cumulic Mollorthels do not have the potential to shrink and swell characteristic of the Vertic Mollorthels or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Mollorthels.

Glacic Mollorthels.—These are the Mollorthels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils do not have a lithic contact with its upper boundary within 50 cm of the mineral soil surface. Disturbance of the insulating surface layer causes the ice to melt and the soil to collapse.

Lithic Mollorthels.—These are the Mollorthels that have a lithic contact within 50 cm of the mineral soil surface.

Vertic Mollorthels.—These are the Mollorthels that show physical evidence of high shrink-swell in the form of cracks and slickensides or wedge-shaped aggregates or have the potential to shrink and swell. This potential is determined by the linear extensibility. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Vitrandic Mollorthels.—These are the Mollorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Mollorthels are not so weathered as the Andic Mollorthels, do not have the shrink-swell potential associated with the Vertic Mollorthels, and do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Psammorthels

Psammorthels are the Orthels that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section. These soils commonly have an ochric epipedon but not an umbric or mollic epipedon or an argillic horizon. Unlike Historthels, Psammorthels do not have organic materials close to the surface. They also do not have aquic conditions within 50 cm of the mineral soil surface or anhydrous conditions.

Definition

Psammorthels are the Orthels that:

1. Have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

3. Do not have an argillic horizon with its upper boundary within 100 cm of the mineral soil surface;

4. Do not have anhydrous conditions;

5. Do not have a mollic or umbric epipedon; *and*

6. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ACGA. Psammorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammorthels

ACGB. Other Psammorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Psammorthels

ACGC. Other Psammorthels that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammorthels

ACGD. Other Psammorthels.

Typic Psammorthels

Definition of Typic Psammorthels

Typic Psammorthels are the Psammorthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a horizon 5 cm or more thick that has *any* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Description of Subgroups

Typic Psammorthels.—These are the Psammorthels that do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. Typic Psammorthels do not have accumulations of sesquioxides.

Glacic Psammorthels.—These are the Psammorthels that have a glacic layer with its upper boundary within 100 cm of the mineral soil surface but do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the surface commonly thaws the ice layer, after which the soil collapses.

Lithic Psammorthels.—These are the Psammorthels that have a lithic contact within 50 cm of the mineral soil surface.

Spodic Psammorthels.—These are the Psammorthels that grade toward Spodosols. Spodic Psammorthels have an E horizon and a B horizon with accumulations of organic matter, aluminum, and iron. They do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Umbrorthels

Umbrorthels are the Orthels that have an umbric epipedon. These soils are not wet for long periods, nor are they dry throughout the growing season. Unlike Historthels, Umbrorthels do not have organic materials at the surface. They are known to occur in Alaska, Canada, and Siberia. On the North Slope of the Brooks Range in Alaska, they support vegetation that differs from that on Mollorthels.

Definition

Umbrorthels are the Orthels that:

1. Have an umbric epipedon;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

3. Do not have anhydrous conditions; *and*

4. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ACEA. Umbrorthels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Umbrorthels

ACEB. Other Umbrorthels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Umbrorthels

ACEC. Other Umbrorthels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest.

Vertic Umbrorthels

ACED. Other Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Umbrorthels

ACEE. Other Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbrorthels

ACEF. Other Umbrorthels that have:

1. An umbric epipedon 40 cm or more thick with a texture finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Umbrorthels

ACEG. Other Umbrorthels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Umbrorthels

ACEH. Other Umbrorthels.

Typic Umbrorthels

Definition of Typic Umbrorthels

Typic Umbrorthels are the Umbrorthels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Have *neither* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *nor*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Have *either*:

a. An umbric epipedon that is less than 40 cm thick, unless the texture is loamy fine sand or coarser; *or*

b. A slope of 25 percent or more; *and*

7. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Umbrorthels.—These are the Umbrorthels without any special features. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic Umbrorthels or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Umbrorthels. Typic Umbrorthels have an umbric epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both, and do not have evidence of wetness and distinct or prominent redox concentrations within 100 cm of the mineral soil surface.

Andic Umbrorthels.—These are the Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. They also do not have the high shrink-swell potential associated with the Vertic Umbrorthels. Andic Umbrorthels are commonly in areas that receive volcanic ejecta, but this is not required.

Aquic Umbrorthels.—These are the Umbrorthels with aquic conditions and distinct or prominent redox concentrations within 100 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic Umbrorthels or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Umbrorthels. Aquic Umbrorthels have an umbric epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both.

Cumulic Umbrorthels.—These are the Umbrorthels that have an umbric epipedon that is 40 cm or more thick, a texture finer than loamy fine sand, and a slope of less than 25 percent. These soils do not have a lithic contact within 50 cm or a glacic layer with its upper boundary within 100 cm of the mineral soil surface. Cumulic Umbrorthels do not have the potential to shrink and swell characteristic of the Vertic Umbrorthels or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic Umbrorthels.

Glacic Umbrorthels.—These are the Umbrorthels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils do not have a lithic contact with its upper boundary within 50 cm of the mineral soil surface. Disturbance of the insulating surface layer causes the ice to melt and the soil to collapse.

Lithic Umbrorthels.—These are the Umbrorthels that have a lithic contact within 50 cm of the mineral soil surface.

Vertic Umbrorthels.—These are the Umbrorthels that show physical evidence of high shrink-swell in the form of cracks and slickensides or wedge-shaped aggregates or have the potential to shrink and swell. This potential is determined by the linear extensibility. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Vitrandic Umbrorthels.—These are the Umbrorthels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

    a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

    b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbrorthels are not so weathered as the Andic Umbrorthels, do not have the shrink-swell potential associated with the Vertic Umbrorthels, and do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Turbels

These are the Gelisols that have one or more horizons with evidence of cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.

Cryoturbation occurs only in soils with sufficient moisture. Cryoturbated horizons in soils that are dry for most of the year likely were more moist in the past.

Turbels are the dominant suborder of Gelisols. They account for about half the Gelisols on a global basis. These soils are common in the High and Middle Arctic vegetation regions of North America and Eurasia at latitudes of 65° N. or more.

Definition

Turbels are the Gelisols that:

1. Do not have organic soil materials that meet *one or more* of the following:

    a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

    b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained) and have 80 percent or more, by volume, organic soil materials from the soil surface to a depth of 50 cm or to a glacic layer or a densic, lithic, or paralithic contact, whichever is shallowest; *and*

2. Have one or more horizons with evidence of cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, the accumulation of organic matter on top of the permafrost, ice or sand wedges, and oriented rock fragments.

Key to Great Groups

ABA. Turbels that have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm.

Histoturbels, p. 466

ABB. Other Turbels that have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (or artificial drainage).

Aquiturbels, p. 464

ABC. Other Turbels that have anhydrous conditions.

Anhyturbels, p. 463

ABD. Other Turbels that have a mollic epipedon.

Molliturbels, p. 466

ABE. Other Turbels that have an umbric epipedon.

Umbriturbels, p. 469

ABF. Other Turbels that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section.

Psammoturbels, p. 468

ABG. Other Turbels.

Haploturbels, p. 465

Anhyturbels

These are the Turbels that have anhydrous conditions and may have dry permafrost (i.e., insufficient moisture for interstitial ice to occur). The cold deserts commonly receive less than 30 mm of annual precipitation. These soils support little or no vegetation.

Anhyturbels are limited in extent but occur in continental Antarctica, northern Greenland, and the cold, dry mountains of Eurasia at elevations of more than 3,700 m.

These soils have undergone climatic periods in the past when more moisture was available.

Definition

Anhyturbels are the Turbels that:

1. Have anhydrous conditions;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm; *and*

3. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ABCA. Anhyturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Anhyturbels

ABCB. Other Anhyturbels that have a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Glacic Anhyturbels

ABCC. Other Anhyturbels that have a petrogypsic horizon with its upper boundary within 100 cm of the mineral soil surface.

Petrogypsic Anhyturbels

ABCD. Other Anhyturbels that have a gypsic horizon with its upper boundary within 100 cm of the mineral soil surface.

Gypsic Anhyturbels

ABCE. Other Anhyturbels that have a horizon 15 cm or more thick that contains 12 cmol(-)/L nitrate in 1:5 soil:water extract and in which the product of its thickness (in cm) and its nitrate concentration is 3,500 or more.

Nitric Anhyturbels

ABCF. Other Anhyturbels that have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Salic Anhyturbels

ABCG. Other Anhyturbels that have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Calcic Anhyturbels

ABCH. Other Anhyturbels.

Typic Anhyturbels

Definition of Typic Anhyturbels

These are the Anhyturbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer or a petrogypsic, gypsic, salic, or calcic horizon with its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a horizon 15 cm or more thick that has 12 cmol(-)/L nitrate in 1:5 soil:water extract and in which the product of its thickness (in cm) and its nitrate concentration is 3,500 or more.

Description of Subgroups

Typic Anhyturbels.—These are the Anhyturbels that commonly have accumulations of salts, including gypsum and calcium carbonate, but insufficient quantities to meet the criteria for a calcic, gypsic, petrogypsic, or salic horizon. These soils also do not contain large amounts of nitrate. They do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Calcic Anhyturbels.—These are the Anhyturbels that have a calcic horizon within 100 cm of the mineral soil surface. These soils commonly have other more soluble salts, but not in sufficient quantity to meet the criteria for a petrogypsic, gypsic, or salic horizon. The soils also lack sufficient quantities of nitrate, a glacic layer, and a lithic contact.

Glacic Anhyturbels.—These are the Anhyturbels that have a glacic layer with an upper boundary withi 100 cm of the mineral soil surface. These soils commonly have accumulations of salts, including calcium carbonate and gypsum, but do not have a lithic contact within 50 cm of the mineral soil surface.

Gypsic Anhyturbels.—These are the Anhyturbels that have a gypsic horizon within 100 cm of the mineral soil surface. They commonly have other salts, including calcium carbonate. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Lithic Anhyturbels.—These are the Anhyturbels that have a lithic contact within 50 cm of the mineral soil surface. They commonly have accumulations of salts, including calcium carbonate and gypsum.

Nitric Anhyturbels.—These are the Anhyturbels that have large accumulations of nitrate. They commonly have accumulations of other salts, but they do not have gypsic or petrogypsic horizons. They also do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Petrogypsic Anhyturbels.—These are the Anhyturbels that have a petrogypsic horizon within 100 cm of the mineral soil surface. They can have accumulations of other salts, but they do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Salic Anhyturbels.—These are the Anhyturbels that have a salic horizon with or without a calcic horizon. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They also do not have gypsic or petrogypsic horizons or large accumulations of nitrates within 100 cm of the mineral soil surface.

Aquiturbels

These are the Turbels that are saturated with water close to the surface. Saturation commonly occurs in spring, when water perches on the permafrost and temperatures are warm enough for iron reduction to occur. These soils can have mollic, umbric, or ochric epipedons. They occur in depressional areas in Alaska, Canada, and Eurasia.

Definition

Aquiturbels are the Turbels that:

1. Have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years (or artificial drainage); *and*

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm.

Key to Subgroups

ABBA. Aquiturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Aquiturbels

ABBB. Other Aquiturbels that have a glacic layer with its upper boundary within 100 cm of the mineral soil surface.

Glacic Aquiturbels

ABBC. Other Aquiturbels that have a sulfuric horizon or sulfidic materials with an upper boundary within 100 cm of the mineral soil surface.

Sulfuric Aquiturbels

ABBD. Other Aquiturbels that have *either*:

1. Organic soil materials that are discontinous at the surface; *or*

2. Organic soil materials at the surface that change in thickness fourfold or more within a pedon.

Ruptic-Histic Aquiturbels

ABBE. Other Aquiturbels that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section.

Psammentic Aquiturbels

ABBF. Other Aquiturbels.

Typic Aquiturbels

Definition of Typic Aquiturbels

Typic Aquiturbels are the Turbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Have *neither* of the following:

   a. Organic soil materials that are discontinous at the surface; *nor*

   b. Organic soil materials at the surface that change in thickness fourfold or more within a pedon;

4. Have neither a sulfuric horizon nor sulfidic materials with an upper boundary within 100 cm of the mineral soil surface; *and*

5. Have either 35 percent or more (by volume) rock fragments or a texture finer than loamy fine sand in one or more layers within the particle-size control section.

Description of Subgroups

Typic Aquiturbels.—The concept of Typic Aquiturbels is centered on Aquiturbels without special characteristics. The Typic subgroup does not have a lithic contact within 50 cm, a glacic layer with an upper boundary within 100 cm of the mineral soil surface, or a sulfuric horizon or sulfidic materials within 100 cm of the mineral soil surface. Textures are finer than loamy fine sand or are skeletal in at least some part of the particle-size control section. If these soils have organic soil materials at the surface, the layer is continuous and does not change much in thickness within a pedon.

Glacic Aquiturbels.—These are the Aquiturbels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Commonly, these soils have organic soil materials at the surface. Disturbance of the surface horizon removes the insulating layer; the glacic layer then melts, and the soil collapses.

Lithic Aquiturbels.—These are the Aquiturbels that have a lithic contact within 50 cm of the mineral soil surface. These soils are rare in the world.

Psammentic Aquiturbels.—These are the sandy Aquiturbels that do not have a lithic contact within 50 cm of the mineral soil surface or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils commonly have thin organic layers.

Ruptic-Histic Aquiturbels.—These are the Aquiturbels that have an organic layer at the surface that is either discontinuous or thins and thickens because of periglacial microrelief. These soils are common in Alaska, Canada, and Siberia.

Sulfuric Aquiturbels.—These are the Aquiturbels that have a sulfuric horizon or sulfidic materials within 100 cm of the mineral soil surface. These soils occur in cold coastal areas of the world.

Haploturbels

Haploturbels are the Turbels that have an ochric epipedon and have sufficient moisture to produce cryoturbation. These soils are not sufficiently wet for the development of thick organic layers at the surface or redox features. Haploturbels are not sandy throughout the particle-size control section. Commonly, the cryoturbation is not well expressed. These soils occur in Alaska, Canada, and Siberia.

Definition

Haploturbels are the Turbels that:

1. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

2. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years;

3. Do not have anhydrous conditions;

4. Do not have a mollic or umbric epipedon; *and*

5. Have 35 percent or more (by volume) rock fragments or a texture finer than loamy fine sand in at least one layer within the particle-size control section.

Key to Subgroups

ABGA. Haploturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploturbels

ABGB. Other Haploturbels that have a glacic layer that has an upper boundary within 100 cm of the mineral soil surface.

Glacic Haploturbels

ABGC. Other Haploturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Haploturbels

ABGD. Other Haploturbels.

Typic Haploturbels

Definition of Typic Haploturbels

Typic Haploturbels are the Turbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Haploturbels.—These are the Haploturbels that do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. The Typic subgroup does not have the redoximorphic features associated with the Aquic subgroup.

Aquic Haploturbels.—These are the Haploturbels that are saturated and reduced for some time during normal years. These soils commonly have well expressed features related to cryoturbation.

Glacic Haploturbels.—These are the Haploturbels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Disturbance of the surface can cause the ice layer to melt and the soil to collapse.

Lithic Haploturbels.—These are the Haploturbels that have a lithic contact within 50 cm of the mineral soil surface. These soils are rare in the world.

Histoturbels

Histoturbels are the Turbels that have organic materials at the surface. Commonly, the organic materials are thicker in the lower positions on the landscape and thinner in the higher positions. These soils are commonly saturated at or near the surface for some time during normal years. They commonly have redoximorphic features.

Definition

Histoturbels are the Turbels that have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm.

Key to Subgroups

ABAA. Histoturbels that have a lithic contact within 50 cm of the soil surface.

Lithic Histoturbels

ABAB. Other Histoturbels that have a glacic layer with its upper boundary within 100 cm of the soil surface.

Glacic Histoturbels

ABAC. Other Histoturbels that have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in 75 percent or less of the pedon.

Ruptic Histoturbels

ABAD. Other Histoturbels.

Typic Histoturbels

Definition of Typic Histoturbels

Typic Histoturbels are the Turbels that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the soil surface; *and*

3. Have more than 40 percent, by volume, organic soil materials from the soil surface to a depth of 50 cm in more than 75 percent of the pedon.

Description of Subgroups

Typic Histoturbels.—These are the Histoturbels that do not have a glacic layer with an upper boundary within 100 cm or a lithic contact within 50 cm of the soil surface. Commonly, these soils have an organic layer at the surface that varies in thickness. These soils are saturated for at least brief periods during normal years.

Glacic Histoturbels.—These are the Histoturbels that have a glacic layer with an upper boundary within 100 cm of the soil surface. They do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the insulating organic layer causes the ice to melt and the soil to collapse.

Lithic Histoturbels.—These are the Histoturbels that have a lithic contact within 50 cm of the soil surface. These soils are rare in the world.

Ruptic Histoturbels.—These are the Histoturbels that have organic layers at the surface that vary in thickness. Commonly, the thickness is related to the position on the landscape. A pattern of high and low areas repeats itself over relatively short distances. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the soil surface.

Molliturbels

Molliturbels are the Turbels that have a mollic epipedon. These soils are not wet for long periods and do not have the redoximorphic features associated with Aquiturbels or the organic materials at the surface associated with Histoturbels. They are known to occur in Alaska, Canada, and Siberia. On the North Slope of the Brooks Range in Alaska, they support vegetation that differs from that on the more acid Umbriturbels.

Definition

Molliturbels are the Turbels that:

1. Have a mollic epipedon;

2. Do not have anhydrous conditions;

3. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm; *and*

4. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years.

Key to Subgroups

ABDA. Molliturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Molliturbels

ABDB. Other Molliturbels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Molliturbels

ABDC. Other Molliturbels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest.

Vertic Molliturbels

ABDD. Other Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Molliturbels

ABDE. Other Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Molliturbels

ABDF. Other Molliturbels that have:

1. A mollic epipedon 40 cm or more thick with a texture finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Molliturbels

ABDG. Other Molliturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Molliturbels

ABDH. Other Molliturbels.

Typic Molliturbels

Definition of Typic Molliturbels

Typic Molliturbels are the Molliturbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have *either* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium

oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Have *either*:

a. A mollic epipedon that is less than 40 cm thick, unless the texture is loamy fine sand or coarser; *or*

b. A slope of 25 percent or more; *and*

7. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Molliturbels.—These are the Molliturbels without any special features. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic subgroup and do not have the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups. Typic Molliturbels have a mollic epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both, and do not have evidence of wetness and distinct or prominent redox concentrations within 100 cm of the mineral soil surface.

Andic Molliturbels.—These are the Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They also do not have the high shrink-swell potential associated with the Vertic subgroup. Andic Molliturbels are commonly in areas that receive volcanic ejecta, but this is not required.

Aquic Molliturbels.—These are the Molliturbels with aquic conditions and distinct or prominent redox concentrations within 100 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the surface. They do not have the potential to shrink and swell characteristic of the Vertic subgroup or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups. Aquic Molliturbels have a mollic epipedon that is less than 40 cm thick, unless they are sandy or on steep slopes.

Cumulic Molliturbels.—These are the Molliturbels that have a mollic epipedon that is 40 cm or more thick, a texture finer than loamy fine sand, and a slope of less than 25 percent. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the surface. Cumulic Molliturbels do not have the potential to shrink and swell characteristic of the Vertic subgroup or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups.

Glacic Molliturbels.—These are the Molliturbels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils do not have a lithic contact with its upper boundary within 50 cm of the mineral soil surface. Disturbance of the insulating surface layer causes the ice to melt and the soil to collapse.

Lithic Molliturbels.—These are the Molliturbels that have a lithic contact within 50 cm of the mineral soil surface.

Vertic Molliturbels.—These are the Molliturbels that show physical evidence of high shrink-swell in the form of cracks and slickensides or wedge-shaped aggregates or have the potential to shrink and swell. This potential is determined by the linear extensibility. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Vitrandic Molliturbels.—These are the Molliturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Molliturbels are not so weathered as the Andic subgroup, do not have the shrink-swell potential associated with the Vertic subgroup, and do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Psammoturbels

Psammoturbels are the Turbels that have less than 35 percent (by volume) rock fragments and a texture of loamy fine sand or coarser in all layers within the particle-size control section. These soils commonly have an ochric epipedon but not an umbric or mollic epipedon or anhydrous conditions. Psammoturbels do not have the redoximorphic features associated with Aquiturbels or the organic materials close to the surface associated with Histoturbels.

Definition

Psammoturbels are the Turbels that:

1. Have less than 35 percent (by volume) rock fragments and

a texture of loamy fine sand or coarser in all layers within the particle-size control section;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

3. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years;

4. Do not have anhydrous conditions; *and*

5. Do not have a mollic or umbric epipedon.

Key to Subgroups

ABFA. Psammoturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Psammoturbels

ABFB. Other Psammoturbels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Psammoturbels

ABFC. Other Psammoturbels that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^{1}/_{2}$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Psammoturbels

ABFD. Other Psammoturbels.

Typic Psammoturbels

Definition of Typic Psammoturbels

Typic Psammoturbels are the Psammoturbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a horizon 5 cm or more thick that has *any* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus $^{1}/_{2}$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Description of Subgroups

Typic Psammoturbels.—These are the Psammoturbels that do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Typic Psammoturbels do not have the accumulations of sesquioxides that are associated with the Spodic intergrade.

Glacic Psammoturbels.—These are the Psammoturbels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface but do not have a lithic contact within 50 cm of the mineral soil surface. Disturbance of the surface commonly thaws the ice layer, after which the soil collapses.

Lithic Psammoturbels.—These are the Psammoturbels that have a lithic contact within 50 cm of the mineral soil surface.

Spodic Psammoturbels.—These are the Psammoturbels that grade toward the Spodosols. They have an E horizon and a B horizon with accumulations of organic matter, aluminum, and iron. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the soil surface.

Umbriturbels

Umbriturbels are the Turbels that have an umbric epipedon. These soils are not wet for long periods and do not have the redoximorphic features associated with Aquiturbels, the organic materials at the surface associated with Histoturbels, or the anhydrous conditions associated with Anhyturbels. Umbriturbels are known to occur in Alaska, Canada, Greenland, and Siberia. On the North Slope of the Brooks Range in Alaska, they support vegetation that differs from that on Molliturbels.

Definition

Umbriturbels are the Turbels that:

1. Have an umbric epipedon;

2. Do not have in 30 percent or more of the pedon more than 40 percent, by volume, organic materials from the soil surface to a depth of 50 cm;

3. Do not have, within 50 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions during normal years; *and*

4. Do not have anhydrous conditions.

Key to Subgroups

ABEA. Umbriturbels that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Umbriturbels

ABEB. Other Umbriturbels that have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface.

Glacic Umbriturbels

ABEC. Other Umbriturbels that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest.

Vertic Umbriturbels

ABED. Other Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Umbriturbels

ABEE. Other Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbriturbels

ABEF. Other Umbriturbels that have:

1. An umbric epipedon 40 cm or more thick with a texture finer than loamy fine sand; *and*

2. A slope of less than 25 percent.

Cumulic Umbriturbels

ABEG. Other Umbriturbels that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years (or artificial drainage).

Aquic Umbriturbels

ABEH. Other Umbriturbels.

Typic Umbriturbels

Definition of Typic Umbriturbels

Typic Umbriturbels are the Umbriturbels that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a glacic layer that has its upper boundary within 100 cm of the mineral soil surface;

3. Have *neither* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time during normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *nor*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallowest;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *either* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Have *either*:

a. An umbric epipedon that is less than 40 cm thick, unless the texture is loamy fine sand or coarser; *or*

b. A slope of 25 percent or more; *and*

7. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time during normal years.

Description of Subgroups

Typic Umbriturbels.—These are the Umbriturbels without any special features. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic subgroup or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups. Typic Umbriturbels have an umbric epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both, and do not have evidence of wetness and distinct or prominent redox concentrations within 100 cm of the mineral soil surface.

Andic Umbriturbels.—These are the Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They also do not have the high shrink-swell potential associated with the Vertic subgroup. Andic Umbriturbels are commonly in areas that receive volcanic ejecta, but this is not required.

Aquic Umbriturbels.—These are the Umbriturbels with aquic conditions and distinct or prominent redox concentrations within 100 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. They do not have the potential to shrink and swell characteristic of the Vertic subgroup or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups. Aquic Umbriturbels have an umbric epipedon that is less than 40 cm thick, unless they are on steep slopes or are sandy, or both.

Cumulic Umbriturbels.—These are the Umbriturbels that have an umbric epipedon that is 40 cm or more thick, a texture finer than loamy fine sand, and a slope of less than 25 percent. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface. Cumulic Umbriturbels do not have the potential to shrink and swell characteristic of the Vertic subgroup or the volcanic glass or ammonium-extractable iron and aluminum characteristic of the Andic and Vitrandic subgroups.

Glacic Umbriturbels.—These are the Umbriturbels that have a glacic layer with an upper boundary within 100 cm of the mineral soil surface. These soils do not have a lithic contact with its upper boundary within 50 cm of the mineral soil surface. Disturbance of the insulating surface layer causes the ice to melt and the soil to collapse.

Lithic Umbriturbels.—These are the Umbriturbels that have a lithic contact within 50 cm of the mineral soil surface.

Vertic Umbriturbels.—These are the Umbriturbels that show physical evidence of high shrink-swell in the form of cracks and slickensides or wedge-shaped aggregates or have the potential to shrink and swell. This potential is determined by the linear extensibility. These soils do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.

Vitrandic Umbriturbels.—These are the Umbriturbels that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

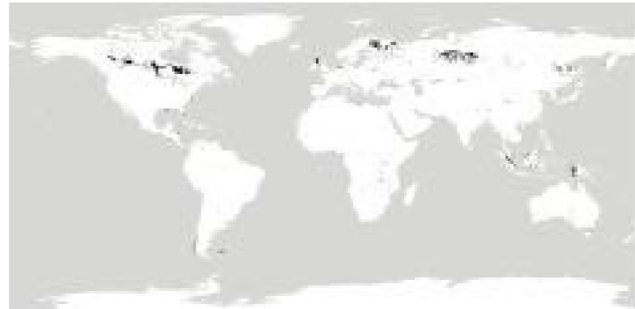
1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Umbriturbels are not so weathered as the Andic subgroup, do not have the shrink-swell potential associated with the Vertic subgroup, and do not have a lithic contact within 50 cm or a glacic layer with an upper boundary within 100 cm of the mineral soil surface.



CHAPTER 14

Histosols

The central concept of Histosols is that of soils forming in organic soil materials. The general rule is that a soil without permafrost is classified as a Histosol if half or more of the upper 80 cm is organic. A soil is also classified as a Histosol if the organic materials rest on rock or fill or partially fill voids in fragmental, cindery, or pumiceous materials. If the bulk density is very low, less than 0.1, three-fourths or more of the upper 80 cm must be organic.

Definition of Histosols and Limits Between Histosols and Soils of Other Orders

Histosols are soils that:

1. Do not have *either* of the following:

   a. Permafrost within 100 cm of the soil surface; *or*

   b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface; *and*

2. Do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower; *and*

3. Have organic soil materials that meet *one or more* of the following:

   a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

   b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

   c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

   d. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

      (1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

      (2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

Limits Between Histosols and Soils of Other Orders

The definition of Histosols must provide criteria that separate Histosols from all other orders. The aggregate of these criteria defines the limits of Histosols in relation to all other known soils.

1. Unlike Gelisols, Histosols do not have:

   a. Permafrost within 100 cm of the soil surface; *or*

   b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

2. Unlike Andisols, Histosols do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm, or a densic, lithic, or paralithic contact or duripan if shallower;

3. Unlike all other mineral soil orders, Histosols have organic soil materials that meet *one or more* of the following:

   a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[1] *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

   b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

   c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

   d. Constitute two-thirds or more of the total thickness of

[1] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent, by volume, voids that are filled with organic soil materials are considered to be organic soil materials.

the soil from the soil surface to 25 cm below the upper boundary of permafrost *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less within that depth; *or*

e. Are saturated with water for 30 or more cumulative days during normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

Key to Suborders

BA. Histosols that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Folists, p. 478

BB. Other Histosols that:

1. Have more thickness of fibric soil materials than any other kind of organic soil material *either*:

a. In the organic parts of the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

b. In the *combined* thickness of the organic parts of the surface and subsurface tiers if there is a continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *and*

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface; *and*

3. Do not have sulfidic materials within 100 cm of the soil surface.

Fibrists, p. 474

BC. Other Histosols that have more thickness of sapric soil materials than any other kind of organic soil materials *either*:

1. In the organic parts of the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

2. In the *combined* thickness of the organic parts of the surface and subsurface tiers if there is a continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier.

Saprists, p. 484

BD. Other Histosols.

Hemists, p. 480

Fibrists

These are the wet Histosols in which the organic materials are only slightly decomposed. More than two-fifths or more than three-fourths (depending on solubility in a sodium-pyrophosphate solution) of the soil consists of fibers that remain after rubbing between the thumb and fingers. The botanic origin of the materials can be readily determined. The bulk density is commonly less than 0.1 g/cm^3. Many Fibrists have ground water near the soil surface nearly all the time. A few areas of Fibrists are artificially drained. The level of the ground water fluctuates but seldom drops much below the bottom of the surface tier.

Fibrists are of relatively small extent but occur from the Equator to latitudes with a cryic temperature regime. They are in closed depressions and in broad flat areas, such as coastal plains. Most are under natural vegetation.

Definition

Fibrists are the Histosols that:

1. Are saturated for 30 or more cumulative days or are artificially drained; *and*

2. Have fibric soil materials that are:

a. Dominant in the organic part of the control section if there is a mineral layer (or layers) 40 cm or more thick that has its upper boundary in the subsurface tier, or if a densic, lithic, or paralithic contact occurs in the subsurface tier; *or*

b. Dominant in the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary in that tier; *and*

3. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface; *and*

4. Do not have sulfidic materials within 100 cm of the soil surface.

Key to Great Groups

BBA. Fibrists that have a cryic soil temperature regime.

Cryofibrists, p. 475

BBB. Other Fibrists in which fibric *Sphagnum* constitutes three-fourths or more of the volume to *either* a depth of 90 cm from the soil surface *or* to a densic, lithic, or paralithic contact, fragmental materials, or other mineral soil materials if at a depth of less than 90 cm.

Sphagnofibrists, p. 477

BBC. Other Fibrists.

Haplofibrists, p. 476

Cryofibrists

These are cold Fibrists. The fibers may be derived from any plant, woody or herbaceous. These soils may freeze during the winter, or they may have a climate in which the soils do not freeze during winter in normal years but are cold in summer. In either situation, the low temperatures limit the use of the soils. Most of these soils support native vegetation.

Definition

Cryofibrists are the Fibrists that have a cryic soil temperature regime.

Key to Subgroups

BBAA. Cryofibrists that have a layer of water within the control section, below the surface tier.

Hydric Cryofibrists

BBAB. Other Cryofibrists that have a lithic contact within the control section.

Lithic Cryofibrists

BBAC. Other Cryofibrists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Cryofibrists

BBAD. Other Cryofibrists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Cryofibrists

BBAE. Other Cryofibrists in which three-fourths or more of the fiber volume in the surface tier is derived from *Sphagnum*.

Sphagnic Cryofibrists

BBAF. Other Cryofibrists.

Typic Cryofibrists

Definition of Typic Cryofibrists

Typic Cryofibrists are the Cryofibrists that:

1. Do not have a layer of water within the control section, below the surface tier;

2. Have less than three-fourths of their fiber volume derived from *Sphagnum* in the surface tier;

3. Do not have a lithic contact within the control section;

4. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier; *and*

5. Do not have a mineral layer 30 cm or more thick that has its upper boundary below the surface tier and within the control section.

Description of Subgroups

Typic Cryofibrists.—The central concept or Typic subgroup of Cryofibrists is fixed on soils that do not have a lithic contact and have less than three-fourths of the fiber volume in the surface tier derived from *Sphagnum*.

A lithic contact is used in classifying lithic subgroups, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are within the control section, below the surface tier, cause soils to be excluded from the Typic subgroup. The presence of layers that are more decomposed than fibric materials is considered less important in cold soils than in the warmer soils. The cold soils are mostly in the State of Alaska in the United States and are used as woodland or wildlife habitat.

Fluvaquentic Cryofibrists.—These soils differ from Typic Cryofibrists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are not known to occur in the United States.

Hydric Cryofibrists.—These soils differ from Typic Cryofibrists because they have a layer of water within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as wildlife habitat.

Lithic Cryofibrists.—These soils differ from Typic Cryofibrists because they have a lithic contact within the control section. These soils are not known to occur in the United States.

Sphagnic Cryofibrists.—These soils differ from Typic Cryofibrists because three-fourths or more of the fiber volume in their surface tier is derived from *Sphagnum*. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat. The soils are an important source of mulch for gardening, and some are used as fuel.

Terric Cryofibrists.—These soils differ from Typic Cryofibrists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Haplofibrists

These are the Fibrists in which the temperature regime is warmer than cryic and less than three-fourths of the fiber volume is derived from *Sphagnum*. The fibers may have been derived from wood, grasses, sedges, mosses, and other herbaceous plants or from some combination of these. If these soils are drained and cultivated under the present technology, the organic materials will decompose either slowly or rapidly, depending on the management used and the temperature. Eventually, within some decades, the Haplofibrists that are drained and cultivated will be replaced first by Hemists and Saprists and then by mineral soils. Most of these soils in the United States support native vegetation.

Definition

Haplofibrists are the Fibrists that:

1. Have a soil temperature regime warmer than cryic;

2. Have less than three-fourths of their fiber volume derived from *Sphagnum* either in the upper 90 cm or more of the control section or in the soil above a densic, lithic, or paralithic contact, fragmental materials, or mineral soil materials shallower than 90 cm.

Key to Subgroups

BBCA. Haplofibrists that have a layer of water within the control section, below the surface tier.

Hydric Haplofibrists

BBCB. Other Haplofibrists that have a lithic contact within the control section.

Lithic Haplofibrists

BBCC. Other Haplofibrists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplofibrists

BBCD. Other Haplofibrists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplofibrists

BBCE. Other Haplofibrists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Haplofibrists

BBCF. Other Haplofibrists that have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Haplofibrists

BBCG. Other Haplofibrists.

Typic Haplofibrists

Definition of Typic Haplofibrists

Typic Haplofibrists are the Haplofibrists that:

1. Have a total of less than 25 cm hemic and sapric materials below the surface tier;

2. Do not have a limnic layer(s) 5 cm or more thick within the control section;

3. Do not have a lithic contact within the control section;

4. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier;

5. Do not have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier; *and*

6. Do not have a layer of water within the control section, below the surface tier.

Description of Subgroups

Typic Haplofibrists.—The central concept or Typic subgroup of Haplofibrists is fixed on soils that do not have a lithic contact and do not have a layer of water within the control section, below the surface tier.

A lithic contact is used in classifying lithic subgroups, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are within the surface tier cause soils to be excluded from the Typic subgroup. The presence of limnic materials and layers that are more decomposed than fibric materials also excludes soils from the Typic subgroup. Typic Haplofibrists are of small extent in the United States and are used mostly as wildlife habitat.

Fluvaquentic Haplofibrists.—These soils differ from Typic Haplofibrists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are not known to occur in the United States.

Hemic Haplofibrists.—These soils differ from Typic Haplofibrists because they have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more below the surface tier. These soils are not known to occur in the United States.

Hydric Haplofibrists.—These soils differ from Typic Haplofibrists because they have a layer of water within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as wildlife habitat.

Limnic Haplofibrists.—These soils differ from Typic Haplofibrists because they have one or more limnic layers with a total thickness of 5 cm or more within the control section. These soils are not known to occur in the United States.

Lithic Haplofibrists.—These soils differ from Typic Haplofibrists because they have a lithic contact within the control section. These soils are not known to occur in the United States.

Terric Haplofibrists.—These soils differ from Typic Haplofibrists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Sphagnofibrists

These are the Fibrists that were derived mainly from the various species of *Sphagnum* and associated herbaceous plants. At least three-fourths of the fibers, by volume, are *Sphagnum* in at least the upper 90 cm of the soil or throughout the soil if there is a densic, lithic, or paralithic contact shallower than 90 cm. A few of these soils have a mesic soil temperature regime that borders on frigid, but in general the soils are cool. Most of them have a frigid temperature regime. The structure of *Sphagnum*, with its water-holding cells, makes these soils unique, and for that reason they are grouped as Sphagnofibrists.

Definition

Sphagnofibrists are the Fibrists that:

1. Have three-fourths or more of their fiber volume derived from *Sphagnum* in the upper 90 cm or more of the control section, or above a densic, lithic, or paralithic contact, fragmental materials, or mineral soil shallower than 90 cm;

2. Have a mean annual soil temperature that is warmer than cryic.

Key to Subgroups

BBBA. Sphagnofibrists that have a layer of water within the control section, below the surface tier.

Hydric Sphagnofibrists

BBBB. Other Sphagnofibrists that have a lithic contact within the control section.

Lithic Sphagnofibrists

BBBC. Other Sphagnofibrists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Sphagnofibrists

BBBD. Other Sphagnofibrists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sphagnofibrists

BBBE. Other Sphagnofibrists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Sphagnofibrists

BBBF. Other Sphagnofibrists that have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Sphagnofibrists

BBBG. Other Sphagnofibrists.

Typic Sphagnofibrists

Definition of Typic Sphagnofibrists

Typic Sphagnofibrists are the Sphagnofibrists that:

1. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier;

2. Have a total of less than 25 cm hemic and sapric materials below the surface tier;

3. Do not have a layer of water within the control section, below the surface tier;

4. Do not have a limnic layer(s) 5 cm or more thick within the control section;

5. Do not have a lithic contact within the control section; *and*

6. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier.

Description of Subgroups

Typic Sphagnofibrists.—The central concept or Typic subgroup of Sphagnofibrists is fixed on thick, continuous fibric organic materials that were derived primarily from *Sphagnum*. These soils do not have a lithic contact and do not have a layer of water within the control section, below the surface tier. At least three-fourths of the fibric materials, by volume, were derived from *Sphagnum*. These soils occur as raised bogs or high moors in closed depressions and as blanket bogs on more or less dissected landscapes.

Layers of organic material more decomposed than fibric materials affect the movement of water and indicate an intergrade to Hemists. Thin mineral layers normally affect the movement of water drastically. These layers normally are alluvial and define the Fluvaquentic subgroup. Thick mineral layers, rock, limnic layers, and water within the control section are used as bases for classifying terric, lithic, limnic, and hydric extragrades, respectively.

Typic Sphagnofibrists are used mostly as wildlife habitat. A few have been cleared and are used for specialty crops. These soils are of small extent in the United States.

Fluvaquentic Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are not known to occur in the United States.

Hemic Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have one or more layers of hemic and sapric materials with a total thickness of 25 cm or more below the surface tier. These soils are of small extent in the United States.

Hydric Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have a layer of water within the control section, below the surface tier. These soils are not known to occur in the United States.

Limnic Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have one or more limnic layers with a total thickness of 5 cm or more within the control section. These soils are not known to occur in the United States.

Lithic Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have a lithic contact within the control section. These soils are not known to occur in the United States.

Terric Sphagnofibrists.—These soils differ from Typic Sphagnofibrists because they have a mineral layer 30 cm or more thick with its upper boundary within the control section, below the surface tier. These soils are of small extent in the United States and are used as woodland or wildlife habitat.

Folists

These are the more or less freely drained Histosols that consist primarily of O horizons derived from leaf litter, twigs, and branches resting on rock or on fragmental materials that consist of gravel, stones, and boulders in which the interstices are filled or partly filled with organic materials. Plant roots grow only in the organic materials. Many of these soils are in very humid climates from the Tropics to high latitudes and high elevations. Some have an ustic or aridic (or torric) soil moisture regime. Most of the Folists in the United States are in Hawaii and Alaska. There are some Folists in the mountains in the western part of the United States, in the northern Lake States, and in the northeastern part of the United States.

Definition

Folists are the Histosols that are saturated with water for less than 30 cumulative days during normal years (and are not artificially drained).

Key to Great Groups

BAA. Folists that have a cryic soil temperature regime.

Cryofolists, p. 478

BAB. Other Folists that have an aridic (or torric) soil moisture regime.

Torrifolists, p. 479

BAC. Other Folists that have an ustic or xeric soil moisture regime.

Ustifolists, p. 479

BAD. Other Folists.

Udifolists, p. 479

Cryofolists

These are the cold Folists. In the United States they occur mostly in southeastern Alaska, where the climate is cool, oceanic, and very humid. They are on gentle to very steep slopes. Their vegetation is primarily coniferous forests, and the only part of the soils in which there are plant roots is the O horizon. Beneath the O horizon, there may be a few centimeters of mineral soil material or none on hard rock or there may be fragmental materials consisting of gravel, stones, and boulders with the interstices filled or partly filled with organic materials.

Definition

Cryofolists are the Folists that have a cryic temperature regime.

Key to Subgroups

BAAA. Cryofolists that have a lithic contact within 50 cm of the soil surface.

Lithic Cryofolists

BAAB. Other Cryofolists.

Typic Cryofolists

Definition of Typic Cryofolists

Typic Cryofolists are the Cryofolists that do not have a lithic contact within 50 cm of the surface.

Description of Subgroups

Typic Cryofolists.—The central concept or Typic subgroup of Cryofolists is fixed on soils that have organic materials resting on fragmental materials and filling or partly filling interstices in the fragmental materials, which consist of gravel, stones, and boulders. The soils on fragmental materials are not necessarily the most common in the great group, but they are classified as the Typic subgroup because the presence of shallow hard rock is used throughout this taxonomy to define lithic subgroups.

Lithic Cryofolists.—The Lithic subgroup of Cryofolists has organic materials that rest on a lithic contact within 50 cm of the soil surface. Lithic Cryofolists are of small extent. They occur on the Olympic Peninsula in the United States. These soils are used as either woodland or wildlife habitat.

Torrifolists

These are the Folists that have a temperature regime warmer than cryic and an aridic (or torric) soil moisture regime. They occur in Hawaii, chiefly on lava flows in areas that receive little rainfall. The vegetation is mostly fountaingrass mixed with shrubs.

Definition

Torrifolists are the Folists that have a temperature regime warmer than cryic and an aridic (or torric) soil moisture regime.

Key to Subgroups

BABA. Torrifolists that have a lithic contact within 50 cm of the soil surface.

Lithic Torrifolists

BABB. Other Torrifolists.

Typic Torrifolists

Definition of Typic Torrifolists

Typic Torrifolists are the Torrifolists that do not have a lithic contact within 50 cm of the soil surface.

Description of Subgroups

Typic Torrifolists.—The central concept or Typic subgroup of Torrifolists is fixed on soils that have organic materials resting on fragmental materials and filling or partly filling interstices in the fragmental materials, which consist of gravel, stones, and boulders. The soils on fragmental materials are not necessarily the most common in the great group, but they are classified as the Typic subgroup because the presence of shallow hard rock is used throughout this taxonomy to define lithic subgroups. These soils are of small extent in the State of Hawaii in the United States and are used as wildlife habitat.

Lithic Torrifolists.—The Lithic subgroup of Torrifolists has organic materials resting on a lithic contact within 50 cm of the soil surface. These soils are of small extent in the State of Hawaii in the United States and are used as wildlife habitat.

Udifolists

These are the Folists that have a temperature regime warmer than cryic and a udic (or perudic) soil moisture regime. They occur in Hawaii, chiefly on lava flows in areas that receive very high amounts of well-distributed rainfall. The vegetation is mostly forest mixed with tree ferns.

Definition

Udifolists are the Folists that have:

1. A temperature regime warmer than cryic;
2. A udic (or perudic) soil moisture regime.

Key to Subgroups

BADA. Udifolists that have a lithic contact within 50 cm of the soil surface.

Lithic Udifolists

BADB. Other Udifolists.

Typic Udifolists

Definition of Typic Udifolists

Typic Udifolists are the Udifolists that do not have a lithic contact within 50 cm of the surface.

Description of Subgroups

Typic Udifolists.—The central concept or Typic subgroup of Udifolists is fixed on soils that have organic materials resting on fragmental materials and filling or partly filling interstices in the fragmental materials, which consist of gravel, stones, and boulders. The soils on fragmental materials are not necessarily the most common in the great group, but they are classified as the Typic subgroup because the presence of shallow hard rock is used throughout this taxonomy to define lithic subgroups. These soils are of small extent in the State of Hawaii in the United States and are used as wildlife habitat.

Lithic Udifolists.—The Lithic subgroup of Udifolists has organic materials resting on a lithic contact within 50 cm of the soil surface. These soils are of small extent in the State of Hawaii and on the Olympic Peninsula of Washington in the United States and are used as wildlife habitat.

Ustifolists

These are the Folists that have a temperature regime warmer than cryic and an ustic or xeric soil moisture regime. These soils have an O horizon overlying or in fragmental materials or directly overlying bedrock that is less than 50 cm from the surface.

Definition

Ustifolists are the Folists that have a temperature regime warmer than cryic and an ustic or xeric soil moisture regime.

Key to Subgroups

BACA. Ustifolists that have a lithic contact within 50 cm of the soil surface.

Lithic Ustifolists

BACB. Other Ustifolists.

Typic Ustifolists

Definition of Typic Ustifolists

Typic Ustifolists are the Ustifolists that do not have a lithic contact within 50 cm of the surface.

Description of Subgroups

Typic Ustifolists.—The central concept or Typic subgroup of Ustifolists is fixed on soils that have organic materials resting on fragmental materials and filling or partly filling interstices in the fragmental materials, which consist of gravel, stones, and boulders. The soils on fragmental materials are not necessarily the most common in the great group, but they are classified as the Typic subgroup because the presence of shallow hard rock is used throughout this taxonomy to define lithic subgroups. These soils are of small extent in the State of Hawaii in the United States and are used as wildlife habitat.

Lithic Ustifolists.—The Lithic subgroup of Ustifolists has organic materials resting on a lithic contact within 50 cm of the soil surface. These soils are of small extent in the State of Hawaii in the United States and are used as wildlife habitat.

Hemists

These are wet Histosols in which the organic materials are moderately decomposed. The botanic origin of much of the organic material cannot be readily determined. The fiber content of much of the organic material is between one-sixth and two-thirds after rubbing between the thumb and fingers. The bulk density commonly is between 0.1 and 0.2 g/cm^3. Ground water is at or very close to the surface of these soils much of the time unless artificial drainage has been provided. The level of ground water may fluctuate but seldom drops much below the bottom of the surface tier.

Hemists occur from the Equator to latitudes with a cryic temperature regime. They are in closed depressions and in broad flat areas, such as coastal plains and outwash plains. Most Hemists are under natural vegetation and are used as woodland, rangeland, or wildlife habitat. Some large areas of Hemists are cleared, drained, and used as cropland.

Definition

Hemists are the Histosols that:

1. Are saturated with water for 30 or more cumulative days during normal years (unless artificially drained);

2. Do not have more thickness of fibric soil materials and do not have more thickness of sapric soil materials than any other kind of organic soil material *either*:

   a. In the organic parts of the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

   b. In the *combined* thickness of the organic parts of the surface *and* subsurface tiers if there is a continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

3. Have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface, *or* sulfidic materials within 100 cm of the soil surface, *and* more thickness of fibric soil material than any other kind of organic soil material *either*:

   a. In the organic parts of the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

   b. In the *combined* thickness of the organic parts of the surface and subsurface tiers if there is a continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier.

Key to Great Groups

BDA. Hemists that have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Sulfohemists, p. 483

BDB. Other Hemists that have sulfidic materials within 100 cm of the soil surface.

Sulfihemists, p. 483

BDC. Other Hemists that have a horizon 2 cm or more thick in which humilluvic materials constitute one-half or more of the volume.

Luvihemists, p. 483

BDD. Other Hemists that have a cryic temperature regime.

Cryohemists, p. 480

BDE. Other Hemists.

Haplohemists, p. 481

Cryohemists

These are the cold Hemists that do not have a sulfuric horizon with its upper boundary within 50 cm of the soil surface or sulfidic materials within 100 cm of the soil surface. They have a cryic temperature regime. The fibers in these soils are from many kinds of plant materials, including wood, moss, grass, and herbaceous materials. Some of these soils freeze during the winter, and some do not freeze. Those that do not freeze are insulated by snow cover or have a marine climate in which winters are mild and summers are very cool. Low soil temperatures in the summer limit the suitable crops where these soils are used as cropland. Most of these soils support native coniferous forest vegetation.

Definition

Cryohemists are the Hemists that:

1. Have a cryic temperature regime;

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the surface;

3. Do not have sulfidic materials within 100 cm of the surface;

4. Do not have a horizon 2 cm or more thick in which humilluvic materials constitute one-half or more of the volume.

Key to Subgroups

BDDA. Cryohemists that have a layer of water within the control section, below the surface tier.

Hydric Cryohemists

BDDB. Other Cryohemists that have a lithic contact within the control section.

Lithic Cryohemists

BDDC. Other Cryohemists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Cryohemists

BDDD. Other Cryohemists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Cryohemists

BDDE. Other Cryohemists.

Typic Cryohemists

Definition of Typic Cryohemists

Typic Cryohemists are the Cryohemists that:

1. Do not have a layer of water within the control section, below the surface tier;

2. Do not have a lithic contact within the control section;

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier; *and*

4. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier.

Description of Subgroups

Typic Cryohemists.—The central concept or Typic subgroup of Cryohemists is fixed on soils that do not have a lithic contact and do not have a layer of water within the control section, below the surface tier.

A lithic contact is used in classifying the Lithic subgroup, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are below the surface tier cause soils to be excluded from the Typic subgroup. The presence or absence of layers of materials either more or less decomposed than hemic materials is considered less important in the very cold soils than in other great groups of Hemists. These soils are mostly in the State of Alaska in the United States and are used mainly as woodland or wildlife habitat.

Fluvaquentic Cryohemists.—These soils differ from Typic Cryohemists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are not known to occur in the United States.

Hydric Cryohemists.—These soils differ from Typic Cryohemists because they have a layer of water within the control section, below the surface tier. These soils are not known to occur in the United States.

Lithic Cryohemists.—These soils differ from Typic Cryohemists because they have a lithic contact within the control section. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Terric Cryohemists.—These soils differ from Typic Cryohemists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Haplohemists

These are the Hemists that have a temperature regime warmer than cryic and that do not have a sulfuric horizon with its upper boundary within 50 cm of the soil surface or sulfidic materials within 100 cm of the soil surface. They are wet at the base of the surface tier for more than 30 cumulative days during normal years unless they have been drained. Most Haplohemists are saturated for considerably longer than 30 days per year. The organic materials in these soils are from many kinds of plant materials, including wood, moss, grass, and herbaceous materials. These soils do not have a layer of humilluvic materials 2 cm or more thick within 130 cm of the soil surface.

If these soils are drained and cultivated under the present technology, the organic materials decompose and disappear slowly or rapidly, depending on the management used and the temperature. Eventually, within some decades, the Haplohemists that are drained and cultivated will be replaced by Saprists and then by mineral soils. Most Haplohemists support native vegetation, mostly forest plants or shrubs and grasslike plants. Some large areas are cleared, drained, and used as cropland.

Definition

Haplohemists are the Hemists that:

1. Have a soil temperature regime warmer than cryic;

2. Do not have a layer of humilluvic materials 2 cm or more thick;

3. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface; *and*

4. Do not have sulfidic materials within 100 cm of the soil surface.

Key to Subgroups

BDEA. Haplohemists that have a layer of water within the control section, below the surface tier.

Hydric Haplohemists

BDEB. Other Haplohemists that have a lithic contact within the control section.

Lithic Haplohemists

BDEC. Other Haplohemists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplohemists

BDED. Other Haplohemists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplohemists

BDEE. Other Haplohemists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Haplohemists

BDEF. Other Haplohemists that have one or more layers of fibric materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Fibric Haplohemists

BDEG. Other Haplohemists that have one or more layers of sapric materials with a total thickness of 25 cm or more below the surface tier.

Sapric Haplohemists

BDEH. Other Haplohemists.

Typic Haplohemists

Definition of Typic Haplohemists

Typic Haplohemists are the Haplohemists that:

1. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier;

2. Have:

   a. Less than 25 cm of fibric materials below the surface tier; *and*

   b. Less than 25 cm of sapric materials below the surface tier;

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier;

4. Do not have a layer of water within the control section, below the surface tier;

5. Do not have a limnic layer(s) 5 cm or more thick within the control section; *and*

6. Do not have a lithic contact within the control section.

Description of Subgroups

Typic Haplohemists.—The central concept or Typic subgroup of Haplohemists is fixed on soils that do not have a lithic contact and do not have a layer of water within the control section, below the surface tier.

A lithic contact is used in classifying the Lithic subgroup, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are below the surface tier cause soils to be excluded from the Typic subgroup. The presence of layers of materials either more or less decomposed than hemic materials is used as differentia for the Fibric and Sapric subgroups, respectively. These soils are widely distributed in the United States, mostly in the Eastern States. They are used mainly as woodland, cropland, or wildlife habitat.

Fibric Haplohemists.—These soils differ from Typic Haplohemists because they have one or more layers of fibric materials with a total thickness of 25 cm or more below the surface tier. These soils are of very small extent in the United States.

Fluvaquentic Haplohemists.—These soils differ from Typic Haplohemists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are of very small extent in the United States.

Hydric Haplohemists.—These soils differ from Typic

Haplohemists because they have a layer of water within the control section, below the surface tier. These soils are of small extent in the United States.

Limnic Haplohemists.—These soils differ from Typic Haplohemists because they have one or more limnic layers with a total thickness of 5 cm or more within the control section. These soils are of small extent but occur in a broad geographic range from Puerto Rico to the Pacific Northwest. Many of the soils support natural vegetation, but some are used as cropland or for hay and pasture.

Lithic Haplohemists.—These soils differ from Typic Haplohemists because they have a lithic contact within the control section. These soils are of very small extent in the United States.

Sapric Haplohemists.—These soils differ from Typic Haplohemists because they have one or more layers of sapric materials with a total thickness of 25 cm or more below the surface tier. These soils are of very small extent in the United States.

Terric Haplohemists.—These soils differ from Typic Haplohemists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are widely distributed in the United States, mostly in the Eastern States. They are used mainly as woodland, cropland, or wildlife habitat.

Luvihemists

Luvihemists are not known to occur in the United States, but the great group is provided tentatively for use in other countries if needed. These are the Hemists that have, within the control section, a horizon 2 cm or more thick in which humilluvic materials constitute one-half or more of the volume. Because Luvihemists cannot be studied in the United States, a precise definition of these soils is not attempted here. It should be noted, however, that they are normally acid and have been cultivated for a long time.

Key to Subgroups

BDCA. All Luvihemists (provisionally).

Typic Luvihemists

Sulfihemists

These are the Hemists that have sulfidic materials within 100 cm of the surface. They are potentially extremely acid or ultra acid. Most Sulfihemists will develop a sulfuric horizon and become Sulfohemists if they are artificially drained to an extent that allows oxygen to reach the sulfidic materials. These soils are permitted to have more fiber than other Hemists. They are mainly in coastal marshes near the mouths of rivers or in the deltas of rivers that carry sediments having a low content of carbonates and are locally extensive. Most Sulfihemists support native vegetation, mainly forbs and grasslike plants.

Definition

Sulfihemists are the Hemists that:

1. Have sulfidic materials within 100 cm of the surface; *and*

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Key to Subgroups

BDBA. Sulfihemists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sulfihemists

BDBB. Other Sulfihemists.

Typic Sulfihemists

Definition of Typic Sulfihemists

Typic Sulfihemists are the Sulfihemists that do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier.

Description of Subgroups

Typic Sulfihemists.—The central concept or Typic subgroup of Sulfihemists is fixed on soils that do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier. These soils are widely distributed in the United States, mostly in the Eastern States. They generally support native vegetation, mostly sparse forbs and grasslike plants. They are used mainly as recreational areas or wildlife habitat.

Terric Sulfihemists.—These soils differ from Typic Sulfihemists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. They are mainly in coastal marshes near the mouths of rivers or in the deltas of rivers on the east coast of the United States. They are locally extensive. These soils support native vegetation, mostly forbs and grasslike plants. They are used mainly as recreational areas or wildlife habitat.

Sulfohemists

These are the Hemists that have a sulfuric horizon within 50 cm of the surface. The sulfuric horizon formed as a consequence of draining the sulfidic materials. These soils are extremely acid and are toxic to most plants. Most are nearly black and have straw-colored redoximorphic concentrations of iron sulfate (jarosite) within 50 cm of the surface. The soils are mainly in drained coastal marshes or deltas near the mouths of rivers that carry sediments having a low content of carbonates. Most of the soils have an appreciable amount of mineral material within the control section. These soils support sparse vegetation, mostly forbs and grasslike plants. They are used mainly as recreational areas or wildlife habitat.

Definition

Sulfohemists are the Hemists that have a sulfuric horizon that has its upper boundary within 50 cm of the surface.

Key to Subgroups

BDAA. All Sulfohemists (provisionally).

Typic Sulfohemists

Saprists

These are the wet Histosols in which the organic materials are well decomposed. The botanic origin of the organic material is difficult to determine in most of these soils. The fiber content is less than one-sixth after rubbing between the thumb and fingers. Most of these soils have a bulk density of more than 0.2 g/cm^3.

Saprists occur in areas where the ground water table tends to fluctuate within the soils or in areas where the soils were aerobic during drier periods in the past. They consist of the residue that remains after the aerobic decomposition of organic matter. When drained, fibric and hemic materials commonly decompose to form sapric materials. If the organic materials are deep and are drained either artificially or naturally, the Fibrists and Hemists are converted after some decades to Saprists.

Definition

Saprists are the Histosols that:

1. Are saturated with water for 30 or more cumulative days during normal years (unless artificially drained); *and*

2. Have more thickness of sapric soil materials than any other kind of organic soil materials *either*:

   a. In the organic parts of the subsurface tier if there is no continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier; *or*

   b. In the *combined* thickness of the organic parts of the surface *and* subsurface tiers if there is a continuous mineral layer 40 cm or more thick that has its upper boundary within the subsurface tier.

Key to Great Groups

BCA. Saprists that have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Sulfosaprists, p. 487

BCB. Other Saprists that have sulfidic materials within 100 cm of the soil surface.

Sulfisaprists, p. 486

BCC. Other Saprists that have a cryic temperature regime.

Cryosaprists, p. 484

BCD. Other Saprists.

Haplosaprists, p. 485

Cryosaprists

These are the cold Saprists that do not have a sulfuric horizon with its upper boundary within 50 cm of the soil surface and do not have sulfidic materials within 100 cm of the soil surface. They have a cryic temperature regime. These soils formed from many kinds of plant materials, including wood, moss, grass, and herbaceous materials. Some of these soils freeze during the winter, and some do not freeze. Those that do not freeze are insulated by snow cover or have a marine climate in which winters are mild and summers are very cool. Low soil temperatures in the summer limit the suitable crops where these soils are used as cropland. Most of these soils support native coniferous forest vegetation.

Definition

Cryosaprists are the Saprists that:

1. Have a cryic temperature regime; *and*

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface; *and*

3. Do not have sulfidic materials within 100 cm of the soil surface.

Key to Subgroups

BCCA. Cryosaprists that have a lithic contact within the control section.

Lithic Cryosaprists

BCCB. Other Cryosaprists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Cryosaprists

BCCC. Other Cryosaprists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Cryosaprists

BCCD. Other Cryosaprists.

Typic Cryosaprists

Definition of Typic Cryosaprists

Typic Cryosaprists are the Cryosaprists that:

1. Do not have a lithic contact within the control section;

2. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier; *and*

3. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier.

Description of Subgroups

Typic Cryosaprists.—The central concept or Typic subgroup of Cryosaprists is fixed on soils that do not have a lithic contact and do not have thick or thin mineral layers or intermittent mineral layers below the surface tier.

A lithic contact is used in classifying the Lithic subgroup, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are below the surface tier cause soils to be excluded from the Typic subgroup. The presence of layers of materials less decomposed than sapric materials is considered less important in these cold Saprists than in the other great groups. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Fluvaquentic Cryosaprists.—These soils differ from Typic Cryosaprists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Lithic Cryosaprists.—These soils differ from Typic Cryosaprists because they have a lithic contact within the control section. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Terric Cryosaprists.—These soils differ from Typic Cryosaprists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are of small extent, mostly in the State of Alaska in the United States, and are used as woodland or wildlife habitat.

Haplosaprists

These are the Saprists that have a temperature regime warmer than cryic and that do not have a sulfuric horizon with its upper boundary within 50 cm of the soil surface or sulfidic materials within 100 cm of the soil surface. These soils are wet at the base of the surface tier for more than 30 cumulative days during normal years unless they have been drained. The organic materials in these soils are from many kinds of plant materials, including wood, moss, grass, and herbaceous materials.

If these soils are drained and cultivated under the present technology, the organic materials decompose and disappear slowly or rapidly, depending on the management used and the temperature. Eventually, within some decades, the Haplosaprists that are drained and cultivated will be replaced by mineral soils. This conversion of some of the soils has been observed in the United States. Many Haplosaprists support native vegetation, mostly forest plants or shrubs and grasslike plants. Many areas are cleared, drained, and used as cropland.

Definition

Haplosaprists are the Saprists that:

1. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface;

2. Do not have sulfidic materials within 100 cm of the soil surface; *and*

3. Have a temperature regime warmer than cryic.

Key to Subgroups

BCDA. Haplosaprists that have a lithic contact within the control section.

Lithic Haplosaprists

BCDB. Other Haplosaprists that have one or more limnic layers with a total thickness of 5 cm or more within the control section.

Limnic Haplosaprists

BCDC. Other Haplosaprists that have *both*:

1. Throughout a layer 30 cm or thick that has its upper boundary within the control section, an electrical conductivity of 30 dS/m or more (1:1 soil:water) for 6 months or more during normal years; *and*

2. A mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Halic Terric Haplosaprists

BCDD. Other Haplosaprists that have throughout a layer 30 cm or more thick within the control section, an electrical conductivity of 30 dS/m or more (1:1 soil:water) for 6 months or more during normal years.

Halic Haplosaprists

BCDE. Other Haplosaprists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Haplosaprists

BCDF. Other Haplosaprists that have, within the organic materials, either one mineral layer 5 cm or more thick or two or more mineral layers of any thickness in the control section, below the surface tier.

Fluvaquentic Haplosaprists

BCDG. Other Haplosaprists that have one or more layers of fibric or hemic materials with a total thickness of 25 cm or more in the control section, below the surface tier.

Hemic Haplosaprists

BCDH. Other Haplosaprists.

Typic Haplosaprists

Definition of Typic Haplosaprists

Typic Haplosaprists are the Haplosaprists that:

1. Do not have a mineral layer between 5 and 30 cm thick or two or more thin, continuous mineral layers within the organic materials in the control section, below the surface tier;

2. Have a total of less than 25 cm fibric and hemic materials below the surface tier;

3. Do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier;

4. Do not have throughout a layer 30 cm or more thick within the control section, an electrical conductivity of 30 dS/m or more (1:1 soil:water) for 6 months or more during normal years;

5. Do not have a limnic layer(s) 5 cm or more thick within the control section; *and*

6. Do not have a lithic contact within the control section.

Description of Subgroups

Typic Haplosaprists.—The central concept or Typic subgroup of Haplosaprists is fixed on soils that do not have a lithic contact and do not have thick or thin mineral layers or intermittent mineral layers below the surface tier.

A lithic contact is used in classifying the Lithic subgroup, as it is throughout this taxonomy. In addition, thick or thin mineral layers as well as intermittent mineral layers that are below the surface tier cause soils to be excluded from the Typic subgroup. The presence of layers of materials less decomposed than sapric materials is used as differentia for the Hemic subgroup. These soils are widely distributed in the United States, mostly in the Eastern States. They are used mainly as woodland, cropland, or wildlife habitat.

Fluvaquentic Haplosaprists.—These soils differ from Typic Haplosaprists because they have, within the organic materials, either one mineral layer 5 to 30 cm thick or two or more mineral layers of any thickness in the control section, below the surface tier. These soils are of very small extent in the United States.

Halic Haplosaprists.—These are the Haplosaprists that have an electrical conductivity of 30 dS/m or more in a layer 30 cm or more thick within 130 cm of the soil surface. These soils do not have a lithic contact within a depth of 130 cm or limnic layers. Halic Haplosaprists commonly occur near coastal areas that are inundated by the ocean.

Halic Terric Haplosaprists.—These are the Haplosaprists that have an electrical conductivity of 30 dS/m or more in a layer 30 cm or more thick within 130 cm of the soil surface and have a mineral layer 30 cm or more thick. These soils do not have a lithic contact within a depth of 130 cm or limnic layers. Halic Terric Haplosaprists commonly occur near coastal areas that are inundated by the ocean.

Hemic Haplosaprists.—These soils differ from Typic Haplosaprists because they have one or more layers of fibric or hemic materials with a total thickness of 25 cm or more below the surface tier. These soils are of small extent, mostly in the Lake States in the United States.

Limnic Haplosaprists.—These soils differ from Typic Haplosaprists because they have one or more limnic layers with a total thickness of 5 cm or more within the control section. These soils are of small extent, mostly in the Lake States in the United States.

Lithic Haplosaprists.—These soils differ from Typic Haplosaprists because they have a lithic contact within the control section. These soils are of very small extent in the United States.

Terric Haplosaprists.—These soils differ from Typic Haplosaprists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. These soils are widely distributed in the United States, mostly in the Eastern States. They are used mainly as woodland, cropland, or wildlife habitat.

Sulfisaprists

These are the potentially acid sulfate soils (cat clays) that consist of organic soil materials. They have sulfidic materials within 100 cm of the soil surface and have not been drained. They occur mainly in coastal marshes near the mouths of rivers or in the deltas of rivers that carry sediments with a low content of carbonates. The soils are locally extensive in the coastal marshes and deltas of some large rivers that drain humid regions.

Definition

Sulfisaprists are the Saprists that:

1. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface; *and*

2. Have sulfidic materials within 100 cm of the soil surface.

Key to Subgroups

BCBA. Sulfisaprists that have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier.

Terric Sulfisaprists

BCBB. Other Sulfisaprists.
Typic Sulfisaprists

Definition of Typic Sulfisaprists

Typic Sulfisaprists are the Sulfisaprists that do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier.

Description of Subgroups

Typic Sulfisaprists.—The central concept or Typic subgroup of Sulfisaprists is fixed on soils that do not have a mineral layer 30 cm or more thick that has its upper boundary in the control section, below the surface tier. These soils are of small extent in the United States, mostly in the Eastern States. They generally support native vegetation, mostly sparse forbs and grasslike plants. They are used mainly as recreational areas or wildlife habitat.

Terric Sulfisaprists.—These soils differ from Typic Sulfisaprists because they have a mineral layer 30 cm or more thick that has its upper boundary within the control section, below the surface tier. They are mainly in coastal marshes near the mouths of rivers or in the deltas of rivers on the east coast of the United States. They are of small extent. These soils support native vegetation, mostly forbs and grasslike plants. They are used mainly as recreational areas or wildlife habitat.

Sulfosaprists

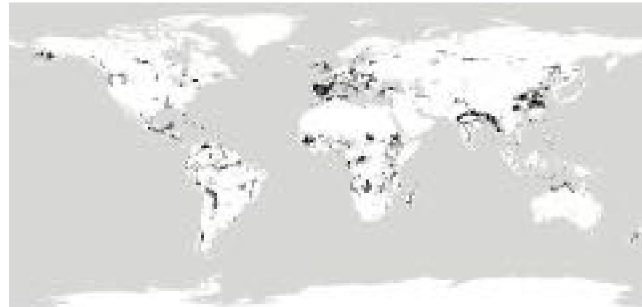
These are the acid sulfate soils (cat clays) that consist of organic soil materials. They have a sulfuric horizon that formed as a consequence of draining the sulfidic materials. They are extremely acid and are toxic to most plants. They are mainly in drained coastal marshes or deltas near the mouths of rivers that carry sediments containing few or no carbonates. Most of these soils have an appreciable amount of mineral material within the control section.

Definition

Sulfosaprists are the Saprists that have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Key to Subgroups

BCAA. All Sulfosaprists (provisionally).
Typic Sulfosaprists



CHAPTER 15
Inceptisols

The central concept of Inceptisols is that of soils that are of cool to very warm, humid and subhumid regions and that have a cambic horizon and an ochric epipedon. The order of Inceptisols includes a wide variety of soils. In some areas Inceptisols are soils with minimal development, while in other areas they are soils with diagnostic horizons that merely fail the criteria of the other soil orders.

Inceptisols have many kinds of diagnostic horizons and epipedons. They can have an anthropic, histic, mollic, ochric, plaggen, or umbric epipedon. Only a very few Inceptisols, however, have a mollic epipedon. The mollic epipedon is restricted to soils with low base saturation below the epipedon. The most common diagnostic horizons are ochric and umbric epipedons, a cambic horizon, and a fragipan. The most common horizon sequence is an ochric epipedon over a cambic horizon, with or without an underlying fragipan. Some Inceptisols have an umbric epipedon overlying a cambic horizon, with or without an underlying duripan or fragipan. A calcic or petrocalcic horizon or a duripan is common in subhumid areas. All soils that have a plaggen epipedon are Inceptisols, and any soil underlying the plaggen epipedon is considered to be buried.

The definition of Inceptisols is necessarily complicated. These soils range from very poorly drained to excessively drained. If the epipedon is ochric or anthropic, a diagnostic subsurface horizon or high exchangeable sodium also is required. Inceptisols typically have a cambic horizon, but one is not required if the soil has a mollic, umbric, histic, or plaggen epipedon or if there is a fragipan or duripan or any placic, calcic, petrocalcic, gypsic, petrogypsic, salic, or sulfuric horizon. Inceptisols cannot have an argillic, kandic, or natric horizon unless it is buried. An oxic horizon is permitted only if the upper boundary is deeper than 150 cm. A spodic horizon is permitted only if it is less than 10 cm thick or if the upper boundary is deeper than 50 cm below the mineral soil surface and none of the overlying layers have a sandy or sandy-skeletal particle-size class.

Inceptisols occur from equatorial to tundra regions. Soils that have permafrost within 100 cm of the soil surface are now classified as Gelisols. Inceptisols cannot have an aridic (torric) moisture regime. Soils with an aridic (torric) moisture regime are recognized as Aridisols if they have a cambic or other diagnostic horizon. Inceptisols commonly occur on landscapes that are relatively active, such as mountain slopes, where erosional processes are actively exposing unweathered materials, and river valleys, where relatively unweathered sediments are being deposited. Many of the Inceptisols in the United States formed in late-Pleistocene glacial drift. If the precipitation exceeds the potential evapotranspiration every month, Inceptisols occur in areas of old as well as young surfaces or deposits. If the soil temperature regime is frigid or cryic in these humid regions, Inceptisols form mainly in the more loamy and clayey parent materials and Spodosols and Entisols (Psamments) form in the sandy materials.

Definition of Inceptisols and Limits Between Inceptisols and Soils of Other Orders

The definition of Inceptisols provides criteria that separate Inceptisols from all other orders. The aggregate of these criteria defines the limits of Inceptisols in relation to other soil orders.

Inceptisols are mineral soils that meet *all* of the following:

1. Unlike Gelisols, Inceptisols do not have *either* of the following:

    a. Permafrost within 100 cm of the soil surface; *or*

    b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

2. Unlike Andisols, Inceptisols do not have andic soil properties in 60 percent or more of the thickness between the soil surface and either a depth of 60 cm or a densic, lithic, or paralithic contact or duripan if shallower;

3. Unlike Histosols, Inceptisols do not have organic soil materials that meet *one or more* of the following:

    a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

    b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

    c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact and have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more;

4. Unlike Spodosols, Inceptisols do not have *one or more* of the following:

a. A spodic horizon, an albic horizon in 50 percent or more of each pedon, and a cryic or pergelic soil temperature regime; *or*

b. An Ap horizon containing 85 percent or more spodic materials; *or*

c. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature regime; *or*

(e) A cryic or pergelic temperature regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy or sandy-skeletal particle-size class in at least some part between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface, *or* at the top of a duripan or fragipan, *or* at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth:

1) If the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime; *or*

2) If the soil has a cryic or pergelic temperature regime;

5. Unlike Oxisols, Inceptisols do not have an oxic horizon that has its upper boundary within 150 cm of the mineral soil surface;

6. Unlike Vertisols, Inceptisols do not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically;

7. Unlike Aridisols, Inceptisols do not have an aridic soil moisture regime and meet *all* of the following criteria:

a. Do not have a salic horizon; *and*

b. Are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

c. Do not have a moisture control section that is dry in some or all parts at some time in normal years; *and*

d. Have a sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface;

8. Unlike Alfisols and Ultisols, Inceptisols do not have an argillic, kandic, or natric horizon and do not have a fragipan with clay films 1 mm or more thick in one or more of its subhorizons;

9. Unlike Mollisols, Inceptisols do not have *both* of the following:

a. *Either*:

(1) A mollic epipedon; *or*

(2) *Both* a surface horizon that meets all of the requirements for a mollic epipedon, except for thickness,

after the soil has been mixed to a depth of 18 cm, *and* a subhorizon more than 7.5 cm thick, within the upper part of an argillic, kandic, or natric horizon, that meets the color, organic-carbon content, base saturation, and structure requirements for a mollic epipedon but is separated from the surface horizon by an albic horizon; *and*

b. A base saturation of 50 percent or more (by NH_4OAc) in all horizons *either* between the upper boundary of any argillic, kandic, or natric horizon and a depth of 125 cm below that boundary, *or* between the mineral soil surface and a depth of 180 cm, *or* between the mineral soil surface and a densic, lithic, or paralithic contact, whichever depth is shallower; *and*

10. Unlike Entisols, Inceptisols have *either*:

a. *One or more* of the following:

(1) A cambic horizon with its upper boundary within 100 cm of the mineral soil surface and its lower boundary at a depth of 25 cm or more below the mineral soil surface; *or*

(2) A calcic, petrocalcic, gypsic, petrogypsic, or placic horizon or a duripan with an upper boundary within 100 cm of the mineral soil surface; *or*

(3) A fragipan or an oxic, sombric, or spodic horizon with an upper boundary within 200 cm of the mineral soil surface; *or*

(4) A sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

(5) A cryic or pergelic temperature regime and a cambic horizon; *or*

b. No sulfidic materials within 50 cm of the mineral soil surface; *and both*

(1) In one or more horizons at a depth between 20 and 50 cm below the mineral soil surface, either an *n* value of 0.7 or less or less than 8 percent clay in the fine-earth fraction; *and*

(2) *One or both* of the following:

(a) A salic horizon or a histic, mollic, plaggen, or umbric epipedon; *or*

(b) In 50 percent or more of the layers between the mineral soil surface and a depth of 50 cm, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more), which decreases with increasing depth below 50 cm, and also ground water within 100 cm of the mineral soil surface at some time during the year when the soil is not frozen in any part.

Representative Pedon and Data

Following is a description of a representative Inceptisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Inceptisol."

Classification: Coarse-loamy, isotic, frigid Typic Dystrudept
Site identification number: 87P0581
Location: Windsor County, Vermont; town of West Windsor; 30 m south of the Hartland town line and 2,280 m east of the Reading town line
Latitude: 43 degrees 31 minutes 41 seconds N.
Longitude: 72 degrees 30 minutes 15 seconds W.
Landscape: Hills
Slope: 12 percent, complex, east facing
Elevation: 417 m above m.s.l.
Annual precipitation: 100 cm
Soil moisture regime: Udic
Average annual air temperature: 6 ^{o}C
Average annual soil temperature: 7 ^{o}C
Permeability class: Moderate
Drainage class: Well drained
Depth to water table: More than 150 cm
Land use: Pasture
Stoniness class: 1
Hazard of erosion: Slight
Runoff class: Medium
Particle-size control section: 25 to 73 cm
Parent material: Glacial till derived from schist and phyllite
Vegetation: Natural—mixed forest; cleared—native pasture
Diagnostic features: An ochric epipedon from a depth of 0 to 22 cm, a cambic horizon from a depth of 22 to 73 cm, and a lithic contact at a depth of 73 cm
Described by: Villars, McLeese, Gourley, and Wheeler

In the following pedon description, colors are for moist soil unless otherwise indicated.

Ap1—0 to 10 cm; very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; moderate medium granular structure; very friable, nonsticky and nonplastic; many very fine and many fine roots throughout; common very fine interstitial and tubular pores; neutral (pH 6.6); 1 percent metamorphic pebbles; abrupt smooth boundary.

Ap2—10 to 22 cm; very dark grayish brown (10YR 3/2) silt loam, light brownish gray (10YR 6/2) dry; weak fine subangular blocky structure parting to weak fine granular; friable, nonsticky and nonplastic; many very fine and common fine roots throughout; common very fine interstitial and tubular pores; common continuous faint iron stains on sand grains and pebbles; sand grains are coated with sesquioxides and have very few black micropellets when viewed with a 10X and 20X hand lens and a 100X microscope; slightly acid (pH 6.4); 1 percent metamorphic pebbles; abrupt wavy boundary.

Characterization Data for an Inceptisol

SITE IDENTIFICATION NO: 87P0581
CLASSIFICATION: COARSE-LOAMY, ISOTIC, FRIGID TYPIC DYSTRUDEPT
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	-1- TOTAL CLAY LT .002	-2- TOTAL SILT .002 -.05	-3- TOTAL SAND .05 -2	-4- CLAY FINE LT .0002	-5- CLAY CO_3 LT .002	-6- SILT FINE .002 -.02	-7- SILT COARSE .02 -.05	-8- SAND VF .05 -.10	-9- SAND F .10 -.25	-10- SAND M .25 -.50	-11- SAND C .5 -1	-12- SAND VC 1 -2	-13- WEIGHT 2 -5	-14- WEIGHT 5 -20	-15- WEIGHT 20 -75	-16- WEIGHT .1- 75	-17- WT PCT OF WHOLE SOIL
			<- Pct of <2mm (3A1)												<- Pct of <75mm(3B1)->				SOIL
87P3045	0- 10	Ap1	4.9	39.5	55.6	1.6		27.2	12.3	14.5	20.0	10.3	6.8	4.0	3	2	--	44	5
87P3046	10- 22	Ap2	3.4	38.3	58.3	0.6		24.3	14.0	13.1	18.6	10.3	8.0	8.3	9	7	2	55	18
87P3047	22- 40	Bw	1.6	44.5	53.9	0.7		28.9	15.6	13.2	16.8	9.4	7.1	7.4	7	4	1	48	12
87P3048	40- 55	Bt	1.7	45.4	52.9	0.2		29.1	16.3	13.4	17.3	9.3	7.1	5.8	5	7	--	47	15
87P3049	55- 73	BCt	1.0	39.6	59.4	--		24.2	15.4	14.5	18.4	10.0	8.3	8.2	8	8	1	54	20

The top rule above the first table numbers the columns -1- to -20-; the last three of these fall on the SAMPLE NO., DEPTH and HORIZON columns (printed without numbers) and are left out above.

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	DITH-CIT Al 6G7a	DITH-CIT Mn 6D2a	RATIO/CLAY CEC 8D1	RATIO/CLAY 15 BAR 8D1	ATTERBERG LIMITS LL 4F1	ATTERBERG PI 4F	BULK DENSITY FIELD MOIST 4A3a	BULK DENSITY 1/3 BAR 4A1d	BULK DENSITY OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	WATER CONTENT FIELD MOIST 4B4	WATER CONTENT 1/10 BAR 4B1c	WATER CONTENT 1/3 BAR 4B1c	WATER CONTENT 15 BAR 4B2a	WRD WHOLE SOIL 4C1
	Pct	<2mm	ppm	<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 10	5.16	0.457			1.7	0.4	0.1	4.51	8.00				0.91	1.04	0.045		27.1	25.9	11.5	
10- 22	2.17	0.186			1.7	0.5	0.1	3.09	2.18				1.38	1.38	--		26.1	24.6	6.4	0.21
22- 40	1.29	0.100			1.7	0.5	0.1	4.50	6.00				1.24	1.26	0.005		33.1	28.1	5.6	0.22
40- 55	1.02				1.5	0.5	0.1	3.29	4.00				1.25	1.25	--		29.8	25.1	4.6	0.22
55- 73	0.81				1.4	0.3	TR	4.90	3.70										3.7	

DEPTH (cm)	NH_4OAc EXTRACTABLE BASES Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACIDITY 6H5a	EXTR Al 6G9b	CEC SUM CATS 5A3a	CEC NH_4-OAc 5A8b	CEC BASES + Al 5A3b	Al SAT 5G1	BASE SAT SUM 5C3	BASE SAT NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	PH NaF 8C1d	PH $CaCl_2$ .01M 8C1f	PH H_2O 8C1f
	<- -meq / 100 g ->										<- - -Pct - - ->							1:2	1:1
0- 10	15.1	0.4	0.1	0.1	15.7	14.7	TR	30.4	22.1			52	71				9.7	5.3	5.6
10- 22	4.7	TR	TR	--	4.7	11.0		15.7	10.5			30	45				10.4	5.3	5.8
22- 40	0.9	TR	--	--	0.9	11.6	1.1	12.5	7.2	2.0	55	7	13				10.9	4.8	5.4
40- 55	0.9	--	0.1	--	1.0	8.8		9.8	5.6			10	18				10.8	5.0	5.7
55- 73	1.2	TR	TR	--	1.2	7.4		8.6	4.9			14	24				10.6	5.0	5.7

SAMPLE NO.	HZ NO	ACID OXALATE EXTRACTION OPT DEN 8J	Fe 6C9a	Si 6V2	Al 6G12	PHOSPHORUS RET 6S4	PHOSPHORUS CIT-ACID 6S5	KCl Mn 6D3	TOTAL C 6A2d	WATER CONTENT 0.06 BAR 4B1c	1- BAR 4B1a	2- BAR 4B1a	15 BAR 4B2b	PIPETTE CLAY 3A1c	PIPETTE SILT 3A1c	PIPETTE SAND 3A1c	HYDROMETER CLAY SML	HYDROMETER SILT SML	HYDROMETER SAND SML	MIN SOIL CONT 8F1	AGGRT STABL <5mm 4G1
			<- Pct of <2mm ->			<- ppm ->			<- Percent of <2mm											->	Pct>
87P3045	1	0.27	0.72	0.05	0.44	52			5.30				39.2								95
87P3046	2	0.21	0.71	0.05	0.47	47			2.42	26.1			7.4								86
87P3047	3	0.16	0.65	0.08	0.59	56			1.63	33.1			9.6								
87P3048	4	0.09	0.46	0.07	0.50	52			1.34	29.8			6.8								
87P3049	5	0.09	0.49	0.05	0.37	44			1.08												39

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i (Peak size)	X-RAY	X-RAY	X-RAY	THERMAL DTA 7A6 (Percent)	THERMAL TGA 7A4b (Percent)	ELEMENTAL 7C3 SiO_2 (Percent)	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 (mg/g)	INTERPRETATION
87P3045	TCLY	KK 1	VR 1	MI 1						7.1			0.8			
87P3047	TCLY	VR 1	KK 1	MI 1	GE 1					13.9			1.0			
87P3049	TCLY	MI 1	KK 1	VR 1						7.1			0.7			

Characterization Data for an Inceptisol--Continued

	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	SAND - SILT MINERALOGY (2.0-0.002mm)																			
	FRAC-	X-RAY				THERMAL				OPTICAL										>INTER-
SAMPLE	TION					DTA		TGA		TOT RE	GRAIN COUNT									>PRETA-
		7A2i				7A3c		7A4c			7B1a									> TION
NUMBER		Peak Size				Percent				Percent										
87P3047	FS									66	QZ66	MS16	BT13	AR 2	FK 2	FP 1				
87P3047	FS										FEtr	GNtr	OPtr	MZtr	PRtr					
87P3048	FS									72	QZ68	BT15	MS 7	FP 4	GN 3	AR 1				
87P3048	FS										OP 1	FK 1	PR 1	HNtr	SPtr					
87P3049	FS									64	QZ61	BT16	MS14	AR 3	FP 3	GN 2				
87P3049	FS										OP 1	FKtr	PRtr	HNtr	SPtr					

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm; FS, fine sand, 0.1-0.25 mm.
Mineral interpretation: KK, kaolinite; VR, vermiculite; MI, mica; GE, goethite; QZ, quartz; MS, muscovite; BT, biotite; AR, weathered aggregate; FK, potassium feldspar; FP, plagioclase feldspar; FE, iron oxides; GN, garnet; OP, opaques; MZ, monazite; PR, pyroxene; HN, hornblende; SP, sphene.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.

Bw—22 to 40 cm; dark brown (10YR 3/3) silt loam, pale brown (10YR 6/3) dry; weak fine subangular blocky structure; friable, weakly smeary, nonsticky and nonplastic; few fine roots throughout; few very fine interstitial and tubular pores; many continuous faint iron stains on sand grains and pebbles; slightly acid (pH 6.0); 1 percent metamorphic pebbles; sand grains are thinly coated with sesquioxides and have a few black micropellets; clear wavy boundary.

Bt—40 to 55 cm; dark grayish brown (2.5Y 4/2) silt loam; weak fine and medium subangular blocky structure; friable, nonsticky and nonplastic; few fine and few medium roots throughout; few very fine interstitial and tubular pores; few faint clay films on sand grains and pebbles; moderately acid (pH 5.8); 1 percent metamorphic pebbles and 2 percent metamorphic cobbles; coated sand grains; abrupt wavy boundary.

BCt—55 to 73 cm; dark grayish brown (2.5Y 4/2) silt loam; weak medium subangular blocky structure; friable, nonsticky and nonplastic; few fine roots throughout; few very fine interstitial and tubular pores; very few faint clay films on sand grains and pebbles; slightly acid (pH 6.0); 1 percent metamorphic pebbles and 2 percent metamorphic cobbles; coated sand grains; abrupt wavy boundary.

2R—73 cm; schist or phyllite.

Key to Suborders

KA. Inceptisols that have *one or more* of the following:

1. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. A histic epipedon; *or*

b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *or*

c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if there are redox concentrations; *or*

(2) 1 or less; *or*

d. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *or*

2. An exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, a decrease in ESP (or SAR) values with increasing depth below 50 cm, and ground water within 100 cm of the mineral soil surface for some time during the year.
Aquepts, p. 494

KB. Other Inceptisols that have a plaggen or anthropic epipedon.
Anthrepts, p. 494

KC. Other Inceptisols that have a cryic soil temperature regime.
Cryepts, p. 512

KD. Other Inceptisols that have an ustic soil moisture regime.

Ustepts, p. 530

KE. Other Inceptisols that have a xeric soil moisture regime.

Xerepts, p. 542

KF. Other Inceptisols that have a udic soil moisture regime.

Udepts, p. 516

Anthrepts

These are the more or less freely drained Inceptisols that have either an anthropic or plaggen epipedon. Most of these soils have been used as cropland or as sites for human occupation for many years. Anthrepts can have almost any temperature regime and almost any vegetation. Most have a cambic horizon.

Definition

Anthrepts are the Inceptisols that:

1. Have an anthropic or plaggen epipedon; *and*

2. Do not have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years and *one or more* of the following:

   a. A histic epipedon; *or*

   b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *or*

   c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

      (1) 2 or less if there are redox concentrations; *or*

      (2) 1 or less; *and*

3. Do not have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, an ESP (or SAR) below 50 cm that decreases with increasing depth, and ground water within 100 cm of the mineral soil surface during some time of the year; *and*

4. Do not have, within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

KBA. Anthrepts that have a plaggen epipedon.

Plagganthrepts, p. 494

KBB. Other Anthrepts.

Haplanthrepts, p. 494

Haplanthrepts

Haplanthrepts are the Anthrepts that have an anthropic epipedon. Because Haplanthrepts are not extensive, their classification has not been developed. Subgroups based on soil moisture regimes may be needed. Most of these soils are in Asia and North Africa. Haplanthrepts have gentle slopes and are either farmed or used as homesites.

Key to Subgroups

KBBA. All Haplanthrepts (provisionally).

Typic Haplanthrepts

Plagganthrepts

Plagganthrepts are the Anthrepts that have a plaggen epipedon. Because Plagganthrepts are not extensive, their classification has not been developed beyond their grouping into a single great group. These soils are known to occur only in Europe, including the British Isles. They have a udic moisture regime. They have gentle slopes and are used either as cropland or as homesites. The buried soils under the plaggen epipedon vary appreciably in morphology, but few of them had high natural fertility.

Key to Subgroups

KBAA. All Plagganthrepts (provisionally).

Typic Plagganthrepts

Aquepts

These are the wet Inceptisols. The natural drainage is poor or very poor and, if the soils have not been artificially drained, ground water is at or near the soil surface at some time during normal years but typically not at all seasons. These soils generally have a gray to black surface horizon and a gray subsurface horizon with redox concentrations that begins at a depth of less than 50 cm. A few of the soils have a brownish surface horizon that is less than 50 cm thick.

Most Aquepts formed in late-Pleistocene or younger deposits in depressions, on nearly level plains, or on flood plains. They occur from the Equator to latitudes with discontinuous permafrost. The common features of most of these soils are the grayish and reddish colors of redoximorphic features at a depth of 50 cm or less and, unless the soils have been artificially drained, shallow ground water. Aquepts may have almost any particle-size class except fragmental, any reaction class, any temperature regime, and almost any vegetation. Most of the soils have a cambic horizon, and some have a fragipan. It is possible that some have a plaggen epipedon.

Definition

Aquepts are the Inceptisols that have:

1. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

a. A histic epipedon; *or*

b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *or*

c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if there are redox concentrations; *or*

(2) 1 or less; *or*

2. An exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, an ESP (or SAR) below 50 cm that decreases with increasing depth, and ground water within 100 cm of the mineral soil surface during some time of the year; *or*

3. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

KAA. Aquepts that have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface.

Sulfaquepts, p. 510

KAB. Other Aquepts that have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume.

Petraquepts, p. 509

KAC. Other Aquepts that have *either*:

1. A salic horizon; *or*

2. In one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) and a decrease in ESP (or SAR) values with increasing depth below 50 cm.

Halaquepts, p. 505

KAD. Other Aquepts that have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Fragiaquepts, p. 504

KAE. Other Aquepts that have a cryic soil temperature regime.

Cryaquepts, p. 495

KAF. Other Aquepts that have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Vermaquepts, p. 511

KAG. Other Aquepts that have a histic, melanic, mollic, or umbric epipedon.

Humaquepts, p. 507

KAH. Other Aquepts that have episaturation.

Epiaquepts, p. 502

KAI. Other Aquepts.

Endoaquepts, p. 498

Cryaquepts

These are the cold Aquepts. They are of moderate extent in the high mountains and subarctic regions of North America and Eurasia. They typically have an ochric or histic epipedon over a cambic horizon. Cryaquepts are on flood plains, in depressional areas, and on plains. Most have grayish subsoils, and some are stratified. The major areas of the Cryaquepts in the United States are on the outwash plains and flood plains of Alaska. Cryaquepts formed mostly in late-Pleistocene or recent sediments south of the continuous permafrost zone. Most support mixed forest, shrub, or grassy vegetation. Many are nearly level, but some in areas of high precipitation have strong slopes. Because Cryaquepts are both cold and wet, they have low potential for cropping.

Definition

Cryaquepts are the Aquepts that:

1. Have a cryic soil temperature regime;

2. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface;

4. Do not have a cemented or indurated diagnostic horizon within 100 cm of the mineral soil surface in half or more of each pedon; *and*

5. Do not have *either*:

a. A salic horizon; *or*

b. In one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) and a decrease in ESP (or SAR) values with increasing depth below 50 cm.

Key to Subgroups

KAEA. Cryaquepts that have, within 150 cm of the mineral soil surface, *one or more* of the following:

1. A sulfuric horizon; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH between 3.5 and 4.0; *or*

3. Sulfidic materials.

Sulfic Cryaquepts

KAEB. Other Cryaquepts that have both a histic epipedon and a lithic contact within 50 cm of the mineral soil surface.

Histic Lithic Cryaquepts

KAEC. Other Cryaquepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryaquepts

KAED. Other Cryaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Cryaquepts

KAEE. Other Cryaquepts that have a histic epipedon.

Histic Cryaquepts

KAEF. Other Cryaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquepts

KAEG. Other Cryaquepts that have a slope of less than 25 percent; *and*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Cryaquepts

KAEH. Other Cryaquepts that have *both*:

1. Chroma of 3 or more in 40 percent or more of the matrix of one or more horizons at a depth between 15 and 50 cm from the mineral soil surface; *and*

2. A mollic or umbric epipedon.

Aeric Humic Cryaquepts

KAEI. Other Cryaquepts that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons at a depth between 15 and 50 cm from the mineral soil surface.

Aeric Cryaquepts

KAEJ. Other Cryaquepts that have a mollic or umbric epipedon.

Humic Cryaquepts

KAEK. Other Cryaquepts.

Typic Cryaquepts

Definition of Typic Cryaquepts

Typic Cryaquepts are the Cryaquepts that:

1. Do not have, within 150 cm of the mineral soil surface, *any* of the following:

a. A sulfuric horizon; *or*

b. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH between 3.5 and 4.0; *or*

c. Sulfidic materials;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Do not have a histic, umbric, or mollic epipedon;

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

5. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Do not have *both*:

a. Either 0.2 percent or more organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface or an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower; *and*

b. A slope of less than 25 percent; *and*

7. Have chroma of 2 or less in 60 percent or more of the mass of all horizons between depths of 15 and 50 cm.

Description of Subgroups

Typic Cryaquepts.—The central concept or Typic subgroup of Cryaquepts is fixed on soils that have a thick, gray regolith and an ochric epipedon and do not have a layer of materials with andic soil properties that is as thick as 18 cm and is near the surface.

Soils that have a lithic contact within a depth of 50 cm are assigned to the Lithic subgroup. Soils that have a histic epipedon are excluded from the Typic subgroup because they are considered intergrades to Histosols. Soils that have an umbric or mollic epipedon are excluded from the Typic subgroup because they are considered intergrades to Humaquepts and Aquolls, respectively. Soils that either have 0.2 percent or more organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface or have an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower, are considered intergrades to Fluvaquents.

Typic Cryaquepts are of moderate extent in the United States. They occur mostly in southern Alaska, but some are in the high mountains of the Western States. Most Typic Cryaquepts support native vegetation and have a thin O horizon.

Aeric Cryaquepts.—These soils have chroma of 3 or more in 40 percent or more of some subhorizon within 50 cm of the mineral soil surface. The high chroma is thought to reflect either deeper ground water or a shorter period of saturation than that in the Typic subgroup. The soils are otherwise like Typic Cryaquepts. Aeric Cryaquepts are of small extent in the United States and occur mostly in southern Alaska and in the high mountains of the Western and Northern States. Most of these soils support their native vegetation and have a thin O horizon. Most support forest vegetation, but some support water-tolerant grasses. Aeric Cryaquepts are used mainly as forest and wildlife habitat. Some are used as pasture and some as hayland.

Aeric Humic Cryaquepts.—These soils have a mollic or umbric epipedon and also have chroma of 3 or more in 40 percent or more of some subhorizon within 50 cm of the mineral soil surface. The high chroma is thought to reflect either deeper ground water or a shorter period of saturation than that in the Typic subgroup. The soils are otherwise like Typic Cryaquepts. Aeric Humic Cryaquepts are of very small extent in the United States and are known to occur only in southern Alaska. They support native vegetation and have a thin O horizon. The vegetation consists of water-tolerant trees, shrubs, and grasses. These soils are used mainly as wildlife habitat.

Aquandic Cryaquepts.—These soils have a layer in the upper 75 cm that has some andic soil properties. This layer is 18 cm or more thick. The clays in this layer normally do not disperse well and have a high pH-dependent charge. In the Aquandic Cryaquepts in the United States, this layer normally is at or very close to the soil surface. The epipedon commonly is umbric, but this is not required. These soils are of small extent in the United States and are known to occur in Alaska and Oregon. Most support native vegetation. Most support water-tolerant grasses, and some support forest vegetation. Aquandic Cryaquepts are used mainly as wildlife habitat. Some are used as pasture and some as hayland.

Fluvaquentic Cryaquepts.—These soils have either 0.2 percent or more organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface or an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower. They also have slopes of less than 25 percent. These soils are of small extent in the United States. They are on flood plains. Most support a native vegetation of water-tolerant trees and grasses. Fluvaquentic Cryaquepts are used mainly as wildlife habitat.

Histic Cryaquepts.—These soils have a histic epipedon but otherwise are like Typic Cryaquepts. They tend to have ground water at a higher level than in the soils of the Typic subgroup, and shallow water stands for some time above the soil surface. Histic Cryaquepts are considered intergrades to Histosols. They are of small extent in the United States and occur mostly in southern Alaska and in the high mountains of the Northwestern States. Most of the Histic Cryaquepts support native vegetation. They support forest vegetation or water-tolerant shrubs and grasses. Histic Cryaquepts are used mainly as forest and wildlife habitat.

Histic Lithic Cryaquepts.—These soils have a histic epipedon, and they have a lithic contact within 50 cm of the mineral soil surface. They tend to have ground water at a higher level than in the soils of the Typic subgroup, and very shallow water stands for some time above the mineral soil surface. Histic Lithic Cryaquepts are of very small extent in the United States and are known to occur only in southern Alaska. They support native vegetation, which consists of water-tolerant trees, shrubs, and grasses. These soils are used mainly as wildlife habitat.

Humic Cryaquepts.—These soils have an umbric or mollic epipedon but otherwise are like Typic Cryaquepts. They are considered intergrades to Humaquepts. Humic Cryaquepts are of small extent in the United States and occur mostly in southern Alaska and in Idaho. Most of these soils support native vegetation, which consists of trees or water-tolerant shrubs and grasses. The soils are used mainly as forest and wildlife habitat.

Lithic Cryaquepts.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. This subgroup is established for use in other parts of the world.

Sulfic Cryaquepts.—These soils have a sulfuric horizon or a horizon approaching a sulfuric horizon but otherwise are like Typic Cryaquepts. They are considered intergrades to Sulfaquepts. They are rare in the United States.

Vertic Cryaquepts.—These soils are like Typic Cryaquepts, but they are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are considered to be transitional to Vertisols. This subgroup is not known to occur in the United States. It is established for use in other parts of the world.

Endoaquepts

Endoaquepts are the Aquepts that have endosaturation. The ground water commonly fluctuates from a level near the soil surface to below a depth of 50 cm. These soils have a frigid or warmer soil temperature regime and do not have any sulfuric, placic, or salic horizon or a fragipan near the soil surface. They do not have high exchangeable sodium near the soil surface that becomes less with increasing depth below 50 cm. They have no horizon within 100 cm of the mineral soil surface in which plinthite or any other cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers that are 25 cm or more thick (cumulative) within 100 cm of the mineral soil surface. Before they were cultivated, most Endoaquepts supported forest vegetation. Generally, Endoaquepts are nearly level, and their parent materials are typically late-Pleistocene or younger sediments.

Definition

Endoaquepts are the Aquepts that:

1. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;

2. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon forms either a continuous phase or constitutes one-half or more of the volume;

3. Have an exchangeable sodium percentage (ESP) of less than 15 (or a sodium adsorption ratio [SAR] of less than 13) in half or more of the soil volume within 50 cm of the mineral soil surface or an ESP (or SAR) below 50 cm that remains constant or increases with increasing depth;

4. Have neither a salic horizon nor a fragipan with its upper boundary within 100 cm of the mineral soil surface;

5. Do not have a cryic soil temperature regime;

6. Do not have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

7. Do not have any histic, melanic, mollic, or umbric epipedon; *and*

8. Have endosaturation.

Key to Subgroups

KAIA. Endoaquepts that have, within 150 cm of the mineral soil surface, *one or more* of the following:

1. A sulfuric horizon; *or*

2. A horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH between 3.5 and 4.0; *or*

3. Sulfidic materials.

Sulfic Endoaquepts

KAIB. Other Endoaquepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquepts

KAIC. Other Endoaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaquepts

KAID. Other Endoaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaquepts

KAIE. Other Endoaquepts that have a slope of less than 25 percent; *and*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Endoaquepts

KAIF. Other Endoaquepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Endoaquepts

KAIG. Other Endoaquepts that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

1. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

a. If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

a. Both a color value, moist, and chroma of 3 or more; *or*

b. Chroma of 2 or more if there are no redox concentrations.

Aeric Endoaquepts

KAIH. Other Endoaquepts that have:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) in the Ap horizon or in the upper 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humic Endoaquepts

KAII. Other Endoaquepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) either in the Ap horizon or in the upper 15 cm after mixing.

Mollic Endoaquepts

KAIJ. Other Endoaquepts.

Typic Endoaquepts

Definition of Typic Endoaquepts

Typic Endoaquepts are the Endoaquepts that:

1. Do not have, within 150 cm of the mineral soil surface, any sulfuric horizon, a horizon 15 cm or more thick that has all of the characteristics of a sulfuric horizon, except that it has a pH between 3.5 and 4.0, or sulfidic materials;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Do not have *either*:

a. Both cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of less than 6.0 cm between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

5. *Either* have less than 0.2 percent organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower, *or* have a slope of 25 percent or more;

6. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

7. Do not have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

(1) Both a color value, moist, and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations; *and*

8. Have a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) in the Ap horizon or in the upper 15 cm after mixing.

Description of Subgroups

Typic Endoaquepts.—The central concept or Typic subgroup of Endoaquepts is fixed on dominantly gray soils with endosaturation. High chroma in some subhorizon is the basis for definition of the Aeric subgroup. Soils that have layers with some andic soil properties are excluded from the Typic subgroup because such layers indicate an intergrade to Aquands. Typic Endoaquepts have both less than 0.2 percent organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower, unless they have a slope of 25 percent or more. Soils that have fragic soil properties in a layer 15 cm or more thick are considered intergrades to Fragiaquepts. A lithic contact within a depth of 50 cm is the basis for definition of the Lithic subgroup. A high shrink-swell potential or deep, wide cracks in expanding clays indicate intergrades to Vertisols. Jarosite mottles, if associated with a low pH value, indicate intergrades to Sulfaquepts. A dark colored Ap horizon or a moderately thick, dark colored A horizon is the basis for defining intergrades to Humaquepts or to Aquolls, depending on the base status.

Typic Endoaquepts are extensive in the United States and occur in all parts of the country, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support their native vegetation.

Aeric Endoaquepts.—These soils have a horizon within the upper 75 cm that has a chroma too high for Typic Endoaquepts. The higher chroma is thought to indicate either a shorter period of saturation of the whole soil with water or somewhat deeper ground water than that in the soils of the Typic subgroup. The correlation of color with soil drainage classes is imperfect. A dark plow layer or a relatively thick, dark A horizon is permitted, but neither is required. These soils are extensive in the Eastern United States and occur in all parts of the United States, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support their native vegetation.

Aquandic Endoaquepts.—These soils have some andic soil properties in a layer in the upper 75 cm that is 18 cm or more thick. The clays in this layer normally do not disperse well and have a high pH-dependent charge. Typically, this layer is at or very close to the soil surface. These soils are of small extent in the United States and are known to occur in California and Idaho. Most supported water-tolerant grasses, and some support forest vegetation. Most of the soils are artificially drained and are used as cropland or hayland. Some are used as rangeland and some as wildlife habitat.

Fluvaquentic Endoaquepts.—These soils have either 0.2 percent or more organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface or an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower. They also have slopes of less than 25 percent. These soils are extensive in the United States. They are on flood plains in all parts of the country, except for the coldest and the driest parts. The native vegetation is mostly water-tolerant trees and grasses. Some of these soils are used as forest, and some have been cleared and artificially drained and are used as cropland or pasture.

Fragic Endoaquepts.—These soils have a significant volume of fragic soil properties, but they do not have a fragipan unless the upper boundary is at a depth of more than 100 cm below the mineral soil surface. The soils are rare in the United States.

Humic Endoaquepts.—These soils have a darker surface horizon than that in Typic Endoaquepts and have relatively low base saturation. They are considered to be intermediate between Typic Endoaquepts and Humaquepts. Humic Endoaquepts are of small extent in the United States. They occur mostly in the Eastern States. The native vegetation consists mostly of water-tolerant trees and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Lithic Endoaquepts.—These soils have a lithic contact within 50 cm of the soil surface but otherwise are like Typic Endoaquepts. Lithic Endoaquepts are of small extent in the United States. They occur mostly in Florida and New York. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Some of these soils are used as forest, and some have been cleared and artificially drained and are used as cropland or pasture.

Mollic Endoaquepts.—These soils have a darker surface horizon than that in Typic Endoaquepts and have relatively high base saturation. They are considered to be intermediate between Typic Endoaquepts and Endoaquolls. Mollic Endoaquepts are moderately extensive in the United States. They are mostly in the Eastern States. The native vegetation consists mostly of water-tolerant trees, grasses, and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support their native vegetation.

Sulfic Endoaquepts.—These soils are mainly in drained coastal marshes. Either they have jarosite mottles and a pH (1:1 water, air-dried slowly in shade) between 3.5 and 4.0 in some part within a depth of 50 cm, or they have jarosite mottles and a pH of less than 4.0 (1:1 water, air-dried slowly in shade) in some part at a depth between 50 and 150 cm from the surface. The soils are considered intergrades to Sulfaquepts. Sulfic Endoaquepts are mostly on tidal flats. Many of these soils have been cleared and artificially drained. Because of the acidity, however, they now support native vegetation. They support sparse vegetation of water- and acid-tolerant shrubs and grasses. They are used mainly as wildlife habitat.

Vertic Endoaquepts.—These soils are fine textured, and they shrink and swell appreciably when their moisture content changes. Most of the soils have a high content of smectite, and some have a dry season in which potential evapotranspiration exceeds precipitation. The soils are of moderate extent in the United States and occur in all parts of the country, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support their native vegetation.

Epiaquepts

Epiaquepts are the Aquepts that have episaturation. The ground water commonly fluctuates from a level near the soil surface to below a depth of 200 cm. These soils have a frigid or warmer soil temperature regime and do not have any sulfuric, placic, or salic horizon or a fragipan near the soil surface. They do not have high exchangeable sodium near the soil surface that becomes less with increasing depth below 50 cm. They have no horizon within 100 cm of the mineral soil surface in which plinthite or any other cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. Before cultivation, most Epiaquepts supported forest vegetation. Generally, Epiaquepts are nearly level or gently sloping, and their parent materials are typically late-Pleistocene or younger sediments.

Definition

Epiaquepts are the Aquepts that:

1. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;

2. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume;

3. Have an exchangeable sodium percentage (ESP) of less than 15 (or a sodium adsorption ratio [SAR] of less than 13) in half or more of the soil volume within 50 cm of the mineral soil surface or an ESP (or SAR) below 50 cm that remains constant or increases with increasing depth;

4. Have neither a salic horizon nor a fragipan with its upper boundary within 100 cm of the mineral soil surface;

5. Do not have a cryic soil temperature regime;

6. Do not have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

7. Do not have a histic, melanic, mollic, or umbric epipedon; *and*

8. Have episaturation.

Key to Subgroups

KAHA. Epiaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaquepts

KAHB. Other Epiaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

   a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

   b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaquepts

KAHC. Other Epiaquepts that have a slope of less than 25 percent; *and*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Epiaquepts

KAHD. Other Epiaquepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaquepts

KAHE. Other Epiaquepts that have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

1. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

a. If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

b. If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

2. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

a. Both a color value, moist, and chroma of 3 or more; *or*

b. Chroma of 2 or more if there are no redox concentrations.

Aeric Epiaquepts

KAHF. Other Epiaquepts that have *both*:

1. A color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) in the Ap horizon or in the upper 15 cm after mixing; *and*

2. A base saturation (by NH_4OAc) of less than 50 percent in some part within 100 cm of the mineral soil surface.

Humic Epiaquepts

KAHG. Other Epiaquepts that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed) either in the Ap horizon or in the upper 15 cm after mixing.

Mollic Epiaquepts

KAHH. Other Epiaquepts.

Typic Epiaquepts

Definition of Typic Epiaquepts

Typic Epiaquepts are the Epiaquepts that:

1. Do not have both cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface;

2. Have a linear extensibility of less than 6.0 cm between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. *Either* have less than 0.2 percent organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower, *or* have a slope of 25 percent or more;

5. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

6. Do not have, in one or more horizons between the A or Ap horizon and a depth of 75 cm below the mineral soil surface, *one* of the following colors:

a. Hue of 7.5YR or redder in 50 percent or more of the matrix; *and*

(1) If peds are present, either chroma of 2 or more on 50 percent or more of ped exteriors or no redox depletions with chroma of 2 or less in ped interiors; *or*

(2) If peds are absent, chroma of 2 or more in 50 percent or more of the matrix; *or*

b. In 50 percent or more of the matrix, hue of 10YR or yellower and *either*:

(1) Both a color value, moist, and chroma of 3 or more; *or*

(2) Chroma of 2 or more if there are no redox concentrations; *and*

7. Have a color value, moist, of 4 or more or a color value, dry, of 6 or more (crushed and smoothed) in the Ap horizon or in the upper 15 cm after mixing.

Description of Subgroups

Typic Epiaquepts.—The central concept or Typic subgroup of Epiaquepts is fixed on dominantly gray soils with episaturation. High chroma in some subhorizon is the basis for definition of the Aeric subgroup. Soils that have some andic soil properties in layers that are near the surface are excluded from the Typic subgroup because such layers indicate an intergrade to Aquands. Typic Epiaquepts have both less than 0.2 percent organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower, unless they have a slope of 25 percent or more. Soils that have fragic soil properties in a layer 15 cm or more thick are considered intergrades to Fragiaquepts. Deep, wide cracks in expanding clays indicate intergrades to Vertisols. A dark colored Ap horizon or a moderately thick, dark colored A horizon is the basis for defining intergrades to Humaquepts or to Aquolls, depending on the base status.

Typic Epiaquepts are of small extent in the United States. They are widely distributed and occur in all parts of the country, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Aeric Epiaquepts.—These soils have a horizon within the upper 75 cm that has a chroma too high for Typic Epiaquepts. The higher chroma is thought to indicate either a shorter period of saturation of the whole soil with water or somewhat deeper ground water than that in the soils of the Typic subgroup. The correlation of color with soil drainage classes is imperfect. A dark plow layer or a relatively thick, dark A horizon is permitted, but neither is required. Aeric Epiaquepts are extensive in the Eastern United States. They occur in all parts of the United States, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Aquandic Epiaquepts.—These soils have some andic soil properties in a layer in the upper 75 cm that is 18 cm or more thick. The clays in this layer normally do not disperse well and have a high pH-dependent charge. These soils are not known to occur in the United States. The subgroup is provided for use elsewhere.

Fluvaquentic Epiaquepts.—These soils have either 0.2 percent or more organic carbon (Holocene age) at a depth of 125 cm below the mineral soil surface or an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower. They also have slopes of less than 25 percent. They are moderately extensive in the United States. They are on flood plains in all parts of the country, except for the coldest and the driest parts. The native vegetation is mostly water-tolerant trees and grasses. Some of these soils are used as forest, and some have been cleared and artificially drained and are used as cropland or pasture.

Fragic Epiaquepts.—These soils have a significant volume of fragic soil properties, but they do not have a fragipan unless it has its upper boundary at a depth of more than 100 cm below the mineral soil surface. The soils are of small extent in the United States.

Humic Epiaquepts.—These soils have a darker surface horizon than that in Typic Epiaquepts and have relatively low base saturation. They are considered to be intermediate between Typic Epiaquepts and Humaquepts. Humic Epiaquepts are rare in the United States. The native vegetation consists mostly of water-tolerant trees and shrubs.

Mollic Epiaquepts.—These soils have a darker surface horizon than that in Typic Epiaquepts and have relatively high base saturation. They are considered to be intermediate between Typic Epiaquepts and Epiaquolls. Mollic Epiaquepts are of small extent in the United States. They occur mostly in the Northern and Eastern States. The native vegetation consists mostly of water-tolerant trees, grasses, and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Vertic Epiaquepts.—These soils are fine textured, and they shrink and swell appreciably when their moisture content changes. Most of them have a high content of smectite, and some have a dry season in which potential evapotranspiration exceeds precipitation. These soils are of moderate extent in the United States. They occur in all parts of the country, except for the coldest and the driest parts. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Fragiaquepts

These are the Aquepts that have a fragipan within 100 cm of the mineral soil surface, commonly at a depth of 30 to 50 cm. Typically, the soils have episaturation and the water table is perched on the fragipan. The horizons above the pan are grayish and are saturated with water during some periods in normal years. Most of these soils have a forest vegetation, but a few areas have been cleared. The trees have a shallow root system and are particularly subject to windthrow. A distinct microrelief of 50 to 60 cm or more is very common above the pan. The upper surface of the pan generally is smooth. In many areas of these soils, the horizons above the fragipan appear to have been mixed by the uplift of the roots of falling trees. In some areas the horizons above the pan consist of an O horizon, an ochric epipedon, and an intermittent cambic horizon below the mounds. In other areas the cambic horizon is continuous.

The Fragiaquepts in the United States have mostly a frigid or mesic soil temperature regime. They are moderately extensive in parts of the Northeastern States, and a few of the soils occur in Oregon and Washington. Fragiaquepts that have a temperature regime marginal to cryic have been reported in other countries, but no unique subgroups are provided for these soils. Most Fragiaquepts are nearly level or gently sloping and developed in Pleistocene-age sediments.

Definition

Fragiaquepts are the Aquepts that:

1. Have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;

3. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume;

4. Have an SAR of less than 13 (or less than 15 percent saturation with sodium) in half or more of the upper 50 cm or have an SAR (or saturation with sodium) that is constant or increases with increasing depth below 50 cm; *and*

5. Do not have a salic horizon.

Key to Subgroups

KADA. Fragiaquepts that have, in 50 percent or more of the matrix of one or more horizons either between the plow layer and a depth of 75 cm below the mineral soil surface or, if there is no plow layer, between depths of 15 and 75 cm, chroma of *either*:

1. 3 or more; *or*

2. 2 or more if there are no redox concentrations.

Aeric Fragiaquepts

KADB. Other Fragiaquepts that have a histic, mollic, or umbric epipedon.

Humic Fragiaquepts

KADC. Other Fragiaquepts.

Typic Fragiaquepts

Definition of Typic Fragiaquepts

Typic Fragiaquepts are the Fragiaquepts that:

1. Do not have a histic, mollic, or umbric epipedon; *and*

2. Have, in more than 50 percent of the matrix of one or more horizons either between the plow layer and 75 cm below the mineral soil surface or, if there is no plow layer, between depths of 15 and 75 cm, chroma of *either*:

a. 2 or less if redox concentrations are present; *or*

b. 1 or less.

Description of Subgroups

Typic Fragiaquepts.—The central concept or Typic subgroup of Fragiaquepts is fixed on soils that have an ochric epipedon. These soils have dominant chroma, in the matrix of all subhorizons between the Ap horizon or a depth of 15 cm and a depth of 75 cm below the mineral soil surface, of 2 or less if there are redox concentrations or of 1 or less if there are no redox concentrations. Chroma higher than these limits is considered evidence of somewhat better aeration and is the basis for defining the Aeric subgroup. An umbric or mollic epipedon is the basis for defining the Humic subgroup.

Typic Fragiaquepts are of small extent in the United States. They occur mostly in the Northern and Eastern States. The native vegetation consists mostly of water-tolerant trees and shrubs. Many of these soils support native vegetation, but some have been cleared and artificially drained and are used as cropland or pasture.

Aeric Fragiaquepts.—These soils have one or more horizons that have chroma too high for the Typic subgroup but are otherwise like Typic Fragiaquepts. Aeric Fragiaquepts are of moderate extent in the United States. They occur mostly in the Northern and Eastern States. The native vegetation consists mostly of water-tolerant trees and shrubs. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Humic Fragiaquepts.—These soils have an umbric epipedon or, rarely, a mollic epipedon that has been produced by liming an umbric epipedon. The soils are otherwise like Typic Fragiaquepts. Humic Fragiaquepts are rare in the United States.

Halaquepts

These are saline or sodic soils that have both a seasonal high water table and a season in which capillary rise and evapotranspiration bring sodium or other salts to or near the soil surface. Salt efflorescence on the soil surface is common in dry seasons.

Halaquepts typically have grayish colors, and some have redox concentrations from near the soil surface downward. Nearly all are level and formed in Holocene alluvium. The native vegetation is mostly sedges and salt-tolerant grasses and shrubs, but some of the soils have been artificially drained and are used as irrigated cropland. Halaquepts are not extensive in the United States.

Definition

Halaquepts are the Aquepts that:

1. Have:

a. An SAR of 13 or more (or sodium saturation that is 15 percent or more), in half or more of the upper 50 cm, that decreases with increasing depth below 50 cm and saturation with water at some period within a depth of 100 cm; *or*

b. A salic horizon;

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *and*

3. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume.

Key to Subgroups

KACA. Halaquepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Halaquepts

KACB. Other Halaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Halaquepts

KACC. Other Halaquepts that have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented or indurated soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Duric Halaquepts

KACD. Other Halaquepts that have chroma of 3 or more in 40 percent or more of the matrix of one or more horizons at a depth between 15 and 75 cm from the mineral soil surface.

Aeric Halaquepts

KACE. Other Halaquepts.

Typic Halaquepts

Definition of Typic Halaquepts

Typic Halaquepts are the Halaquepts that:

1. Have chroma of 2 or less in 60 percent or more of the matrix in all subhorizons between depths of 15 and 75 cm;

2. Do not have a horizon 15 cm or more thick that has 20 percent or more (by volume) cemented or indurated soil material and has its upper boundary within 100 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Halaquepts.—The central concept or Typic subgroup of Halaquepts is fixed on soils that have chroma of 2 or less in all subhorizons between depths of 15 and 75 cm. These soils have less than 20 percent cemented soil material in the upper 100 cm. Some of the soils have a salic horizon. Salinity commonly varies with seasons in these soils, even under irrigation. Most of the soils, however, have electrical conductivity in excess of 2 dS/m in some horizon at some time of the year. Commonly, the conductivity exceeds 15 dS/m. Chroma of more than 2 in more than 40 percent of the matrix of some subhorizon between depths of 15 and 75 cm is the basis for definition of the Aeric subgroup.

Typic Halaquepts are of moderate extent in the Western United States. The native vegetation consists mostly of water- and salt-tolerant shrubs and grasses. Most of these soils support native vegetation and are used as rangeland. Some have been cleared and artificially drained and are used as irrigated cropland or pasture.

Aeric Halaquepts.—These soils have chroma too high for the Typic subgroup in some subhorizon between depths of 15 and 75 cm below the soil surface. The higher chroma is thought to indicate a lower level of ground water and somewhat better aeration. These soils are of moderate extent in the Western United States. The native vegetation is mostly water- and salt-tolerant shrubs and grasses. Most of these soils are used as rangeland. Some have been cleared and artificially drained and are used as irrigated cropland or pasture.

Aquandic Halaquepts.—These soils have some andic soil properties in a layer in the upper 75 cm that is 18 cm or more thick. The clays in this layer normally do not disperse well and have a high pH-dependent charge. These soils are not known to occur in the United States. The subgroup is provided for use elsewhere.

Duric Halaquepts.—These soils have 20 percent or more cemented or indurated soil material in a horizon 15 cm or more thick that is in the upper 100 cm. The soils are of moderate extent in the Western United States. They occur in the semiarid, high valleys east of the Cascade Range in southern Oregon. The native vegetation consists mostly of water- and salt-tolerant shrubs and grasses. Most of these soils are used as rangeland. Some have been cleared and artificially drained and are used as irrigated cropland or pasture.

Vertic Halaquepts.—These soils are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils are considered to be transitional to Vertisols. Vertic Halaquepts are of small extent and occur in the Western United States and in Puerto Rico.

Humaquepts

Humaquepts are the Aquepts that have a histic, melanic, mollic, or umbric epipedon. The ground water commonly fluctuates from a level near the soil surface to below a depth of 50 cm. These soils have a frigid or warmer soil temperature regime and do not have any sulfuric, placic, or salic horizon or a fragipan near the soil surface. They do not have high exchangeable sodium near the soil surface that becomes less with increasing depth below 50 cm. They have no horizon within 100 cm of the mineral soil surface in which plinthite or any other cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume. Recognizable bioturbation, such as filled animal burrows, wormholes, or casts, is less than 50 percent (by volume) in all layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface. Before they were cultivated, most Humaquepts supported forest vegetation. Generally, Humaquepts are nearly level, and their parent materials are typically late-Pleistocene or younger sediments. These soils are of small extent in the United States.

Definition

Humaquepts are the Aquepts that:

1. Have an umbric, mollic, melanic, or histic epipedon;

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface;

3. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume;

4. Have an exchangeable sodium percentage (ESP) of less than 15 (or a sodium adsorption ratio [SAR] of less than 13) in half or more of the soil volume within 50 cm of the mineral soil surface or an ESP (or SAR) below 50 cm that remains constant or increases with increasing depth;

5. Have neither a salic horizon nor a fragipan with its upper boundary within 100 cm of the mineral soil surface;

6. Do not have a cryic soil temperature regime; *and*

7. Do not have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the mineral soil surface, 25 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts.

Key to Subgroups

KAGA. Humaquepts that have an *n* value of *either*:

1. More than 0.7 (and less than 8 percent clay) in one or

more layers at a depth between 20 and 50 cm from the mineral soil surface; *or*

2. More than 0.9 in one or more layers at a depth between 50 and 100 cm.

Hydraquentic Humaquepts

KAGB. Other Humaquepts that have a histic epipedon.

Histic Humaquepts

KAGC. Other Humaquepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Humaquepts

KAGD. Other Humaquepts that have a slope of less than 25 percent; *and*

1. An umbric or mollic epipedon 60 cm or more thick; *and either*

2. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

3. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Humaquepts

KAGE. Other Humaquepts that have a slope of less than 25 percent; *and*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Humaquepts

KAGF. Other Humaquepts that have hue of 5Y or redder and chroma of 3 or more in more than 40 percent of the matrix of one or more subhorizons at a depth between 15 and 75 cm from the mineral soil surface.

Aeric Humaquepts

KAGG. Other Humaquepts.

Typic Humaquepts

Definition of Typic Humaquepts

Typic Humaquepts are the Humaquepts that:

1. Have chroma of 2 or less, moist, or hue less red than 5Y in 60 percent or more of the matrix in all subhorizons between depths of 15 and 75 cm;

2. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Have a content of organic carbon (Holocene age) that decreases regularly with increasing depth and, unless a densic, lithic, or paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 125 cm of the soil surface;

4. Do not have a histic epipedon; *and*

5. Have an *n* value of less than 0.9 between depths of 50 and 100 cm and of 0.7 or less in all layers between depths of 20 and 50 cm.

Description of Subgroups

Typic Humaquepts.—The central concept or Typic subgroup of Humaquepts is fixed on very poorly drained soils that have an umbric epipedon that is between 25 and 60 cm thick, have a low *n* value, have a regular decrease in organic-carbon content (Holocene age) with increasing depth, and do not have a significant amount of materials that have some andic soil properties. A few of these soils have a mollic epipedon.

An overthickened epipedon indicates addition of materials at the surface and is the basis for definition of the Cumulic subgroup. A histic epipedon indicates a transition to Histosols. A high *n* value is characteristic of Hydraquents and causes soils to be excluded from the Typic subgroup. An irregular decrease in organic-carbon content (Holocene age) with increasing depth indicates buried horizons and is the basis for defining the Fluvaquentic subgroup.

Typic Humaquepts are of moderate extent in the United States. They are widely distributed and commonly occur in the most moist parts of the country. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Many of these soils have been cleared and artificially drained and are used as cropland or pasture. Some support native vegetation.

Aeric Humaquepts.—These soils have a horizon within the upper 75 cm that has a hue too red and a chroma too high for Typic Humaquepts. The higher chroma is thought to indicate either a shorter period of saturation of the whole soil with water or somewhat deeper ground water than that in the soils of the Typic subgroup. Aeric Humaquepts are not known to occur in the United States.

Aquandic Humaquepts.—These soils have some andic soil properties in a layer in the upper 75 cm that is 18 cm or more thick. The clays in this layer normally do not disperse well and have a high pH-dependent charge. Typically, this layer is at or very close to the soil surface. An umbric epipedon is common but is not required. These soils are of small extent in the United States and are known to occur in Washington, Oregon, and Idaho. Most of the soils supported water-tolerant forest vegetation, and some supported water-tolerant grasses and shrubs. Many of the soils are artificially drained and are used as cropland or hayland, and many are used as forest. Some are used as pasture and some as wildlife habitat.

Cumulic Humaquepts.—These soils have an irregular decrease in organic-carbon content (Holocene age) with increasing depth or have a relatively high amount of organic carbon (Holocene age) in the deep layers. In addition, they have a thick epipedon. These soils commonly are on flood plains or at the margins of closed depressions where there has been very slow deposition of new materials. The deposition has been slow enough for new materials to have become part of the epipedon. These soils are of moderate extent in the United States. They are widely distributed and occur mostly in the most moist parts of the country. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Most of these soils support native vegetation. Some have been cleared and artificially drained and are used as cropland or pasture.

Fluvaquentic Humaquepts.—These soils have an irregular decrease in organic-carbon content (Holocene age) with increasing depth or have a relatively high amount of organic carbon (Holocene age) in the deep layers. They are subject to flooding by muddy water and have some of the properties of Fluvents. Fluvaquentic Humaquepts are of small extent in the United States. They are widely distributed and occur mostly in the most moist parts of the country. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Most of these soils support their native vegetation. Some have been cleared and artificially drained and are used as cropland or pasture.

Histic Humaquepts.—These soils have a histic epipedon. They are the wettest of the Humaquepts and are intergrades to Histosols. The organic-carbon content (Holocene age) may be relatively high in the deep layers. Histic Humaquepts are of moderate extent in the United States and are widely distributed mostly in the northern and eastern parts of the country. The native vegetation consists mostly of water-tolerant trees, shrubs, and grasses. Most of these soils support native vegetation. A few of the soils have been cleared and artificially drained and are used as cropland or pasture.

Hydraquentic Humaquepts.—These soils have an *n* value of either more than 0.7 in one or more layers at a depth between 20 and 50 cm from the mineral soil surface or of more than 0.9 in one or more layers at a depth between 50 and 100 cm from the mineral soil surface. The soils are rare in the United States. They are on tidal flats. The native vegetation consists mostly of water-tolerant grasses, sedges, rushes, and shrubs.

Petraquepts

These are the Aquepts that have one or more horizons, within 100 cm of the mineral soil surface, in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume. A layer of plinthite and the placic horizon are the only horizons known to occur in the Petraquepts in the United States. A Typic subgroup is provided for Petraquepts with a duripan or petrocalcic horizon. Petraquepts are soils in which the ground water table fluctuates considerably during the year, between a level at or near the soil surface during the rainy season and a much lower level during less wet seasons. A histic or umbric epipedon and a cambic horizon may be present. In some of the soils, the placic horizon is so close to the soil surface that there is no cambic horizon above it.

Petraquepts are in areas of very high rainfall. The vegetation may be a rain forest, *Sphagnum*, or other water-loving plants. The temperature regime is frigid to isohyperthermic. Slopes generally are such that water does not pond on the surface, but high rainfall keeps some of the soils continuously wet. Petraquepts are rare in the world.

Definition

1. Petraquepts are the Aquepts that have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume; *and*

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface.

Key to Subgroups

KABA. Petraquepts that have *both*:

1. A histic epipedon; *and*

2. A placic horizon.

Histic Placic Petraquepts

KABB. Other Petraquepts that have a placic horizon.

Placic Petraquepts

KABC. Other Petraquepts that have one or more horizons within 125 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthic Petraquepts

KABD. Other Petraquepts.

Typic Petraquepts

Definition of Typic Petraquepts

Typic Petraquepts are the Petraquepts that:

1. Do not have a placic horizon; *and*

2. Do not have one or more horizons within 125 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Description of Subgroups

Typic Petraquepts.—The central concept or Typic subgroup of Petraquepts is fixed on soils that have a duripan or a petrocalcic horizon within 100 cm of the mineral soil surface. These soils do not have a horizon within 125 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume and do not have a placic horizon. They can have a histic epipedon if there is no placic horizon. Typic Petraquepts are not the most common Petraquepts and are not known to occur in the United States.

Histic Placic Petraquepts.—These soils have both a histic epipedon and a placic horizon. They are like Typic Petraquepts in other defined properties. Histic Placic Petraquepts are of very small extent and occur only in Hawaii in the United States. They are used as wildlife habitat and as water catchments.

Placic Petraquepts.—These soils have a placic horizon but do not have a histic epipedon. Normally, the placic horizon lies within 25 to 50 cm of the mineral soil surface. These soils are of very small extent and occur only in Hawaii in the United States. They are used as wildlife habitat and as water catchments.

Plinthic Petraquepts.—These soils have one or more horizons within 125 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. These soils are not known to occur in the United States. The subgroup has been established for use in other countries.

Sulfaquepts

These are the acid sulfate soils (cat clays) that have been drained and oxidized at some time. They are extremely acid and toxic to most plants. They are mostly dark gray and have straw-colored mottles of iron sulfate (jarosite) within 50 cm of the soil surface. These soils are mainly in drained coastal marshes near the mouths of rivers that carry sediments that are free of carbonates or have a low content of carbonates. They can have any texture, but most are loamy or clayey. The soils contain an appreciable amount of organic carbon (Holocene age). They are rare in the United States but occur elsewhere in a few areas that have been used mainly for the production of rice.

Definition

Sulfaquepts are the Aquepts that have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface.

Key to Subgroups

KAAA. Sulfaquepts that have a salic horizon within 75 cm of the mineral soil surface.

Salidic Sulfaquepts

KAAB. Other Sulfaquepts that have an *n* value of *either*:

1. More than 0.7 (and less than 8 percent clay) in one or more layers at a depth between 20 and 50 cm from the mineral soil surface; *or*

2. More than 0.9 in one or more layers at a depth between 50 and 100 cm from the mineral soil surface.

Hydraquentic Sulfaquepts

KAAC. Other Sulfaquepts.

Typic Sulfaquepts

Definition of Typic Sulfaquepts

Typic Sulfaquepts are the Sulfaquepts that:

1. Do not have a salic horizon within 75 cm of the mineral soil surface; *and*

2. Have an *n* value *both*:

a. Of 0.7 or less in all layers at a depth between 20 and 50 cm from the mineral soil surface; *and*

b. Of less than 0.9 in all layers at a depth between 50 and 100 cm from the mineral soil surface.

Description of Subgroups

Typic Sulfaquepts.—The central concept or Typic subgroup of Sulfaquepts is fixed on very poorly drained soils that do not have a salic horizon and have an *n* value of 0.7 or less in all layers at a depth between 20 and 50 cm from the mineral soil surface and of 0.9 or less in all layers at a depth between 50 and 100 cm from the mineral soil surface.

These soils are rare in the United States. They are on tidal flats. The native vegetation is sparse and consists mostly of water-tolerant grasses, sedges, rushes, and shrubs.

Hydraquentic Sulfaquepts.—These soils have an *n* value of either more than 0.7 in one or more layers at a depth between 20 and 50 cm from the mineral soil surface or of more than 0.9 in one or more layers at a depth between 50 and 100 cm from the mineral soil surface. The soils are rare in the United States. They are on tidal flats. The native vegetation is sparse and consists of water-tolerant grasses, sedges, rushes, and shrubs.

Salidic Sulfaquepts.—These soils have a salic horizon within 75 cm of the mineral soil surface. They are rare in the United States. They are on tidal flats. The native vegetation consists of very sparse water- and salt-tolerant grasses, sedges, rushes, and shrubs.

Vermaquepts

Vermaquepts are the Aquepts that have recognizable bioturbation, such as filled animal burrows, wormholes, or casts. It has been shown that because krotovinas are dense, massive, compact, and stratified, they restrict water movement. Significant amounts of krotovinas in a soil affect soil morphology, soil hydrology, and soil behavior. These soils are known to occur along the coastal plain of Texas as well as other Southeastern States.

Definition

Vermaquepts are the Aquepts that:

1. Have, in one or more layers at least 25 cm thick (cumulative) within 100 cm of the soil surface, 50 percent or more (by volume) recognizable bioturbation, such as filled animal burrows, wormholes, or casts;

2. Do not have a sulfuric horizon that has its upper boundary within 50 cm of the soil surface;

3. Do not have, within 100 cm of the mineral soil surface, one or more horizons in which plinthite or a cemented or indurated diagnostic horizon either forms a continuous phase or constitutes one-half or more of the volume;

4. Do not have, in one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) and a decrease in ESP (or SAR) values with increasing depth below 50 cm;

5. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

6. Have a soil temperature regime warmer than cryic; *and*

7. Do not have a salic horizon.

Key to Subgroups

KAFA. Vermaquepts that have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio [SAR] of 6 or more) in one or more subhorizons within 100 cm of the mineral soil surface.

Sodic Vermaquepts

KAFB. Other Vermaquepts.

Typic Vermaquepts

Definition of Typic Vermaquepts

Typic Vermaquepts are the Vermaquepts that do not have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio [SAR] of 6 or more) in one or more subhorizons within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Vermaquepts.—The central concept or Typic subgroup of Vermaquepts is fixed on poorly drained soils that have an exchangeable sodium percentage of less than 7 (or a sodium adsorption ratio [SAR] of less than 6) in all subhorizons within 100 cm of the mineral soil surface. The recognizable bioturbation in the soils is caused mainly by crayfish. These soils are of small extent in the United States. They occur mostly on the coastal plain in Texas. The native vegetation consists mostly of water-tolerant trees and shrubs. Most of these soils have been cleared and are used as cropland. Rice is among the commonly grown crops. Crayfish are sometimes raised on the crop residue.

Sodic Vermaquepts.—These soils have an exchangeable sodium percentage of 7 or more (or a sodium adsorption ratio [SAR] of 6 or more) in one or more subhorizons within 100 cm of the mineral soil surface. The recognizable bioturbation in the soils is caused mainly by crayfish. These soils are of small extent in the United States. They occur mostly on the coastal plain in Texas. The native vegetation consists mostly of water-tolerant trees and shrubs. Most of these soils have been cleared and are used as cropland. Rice is among the commonly grown crops. Crayfish are sometimes raised on the crop residue.

Cryepts

Cryepts are the cold Inceptisols of high mountains or high latitudes. They cannot have permafrost within 100 cm of the soil surface. The vegetation is mostly conifers or mixed conifers and hardwoods. Few of the soils are cultivated. Cryepts formed in loess, drift, or alluvium or in solifluction deposits, mostly late Pleistocene or Holocene in age. The soils commonly have a thin, dark brownish ochric epipedon and a brownish cambic horizon. Some have bedrock within 100 cm of the surface. Cryepts are moderately extensive in the United States. They occur in the high mountains of the West and in southern Alaska as well as in other mountainous areas of the world.

Definition

Cryepts are the Inceptisols that:

1. Have a cryic temperature regime;

2. Do not have *both* aquic conditions *and* a histic epipedon, the colors defined for Aquepts, or enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, an ESP (or SAR) below 50 cm that decreases with increasing depth, and ground water within 100 cm of the mineral soil surface during some time of the year; *and*

4. Have neither a plaggen nor an anthropic epipedon.

Key to Great Groups

KCA. Cryepts that have *one or both* of the following:

1. Free carbonates within the soils; *or*

2. A base saturation (by NH_4OAc) of 60 percent or more in one or more horizons at a depth between 25 and 75 cm from the mineral soil surface.

Eutrocryepts, p. 514

KCB. Other Cryepts.

Dystrocryepts, p. 512

Dystrocryepts

These are the Cryepts that do not have free carbonates and have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface. The vegetation is mostly conifers or mixed conifers and hardwoods. Few of the soils are cultivated. Dystrocryepts may have formed in loess, drift, or alluvium or in solifluction deposits, mostly late Pleistocene or Holocene in age. The soils commonly have a thin, dark brownish ochric epipedon and a brownish cambic horizon. Some have an umbric epipedon, and some have bedrock within 100 cm of the surface. In the United States, Dystrocryepts are moderately extensive in the high mountains of the West and in southern Alaska. They also occur in other mountainous areas of the world.

Definition

Dystrocryepts are the Cryepts that:

1. Do not have free carbonates within the soils; *and*

2. Have a base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface.

Key to Subgroups

KCBA. Dystrocryepts that have *both*:

1. An umbric or mollic epipedon; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Humic Lithic Dystrocryepts

KCBB. Other Dystrocryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrocryepts

KCBC. Other Dystrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrocryepts

KCBD. Other Dystrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrocryepts

KCBE. Other Dystrocryepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrocryepts

KCBF. Other Dystrocryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystrocryepts

KCBG. Other Dystrocryepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Dystrocryepts

KCBH. Other Dystrocryepts that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Dystrocryepts

KCBI. Other Dystrocryepts that have a xeric moisture regime.

Xeric Dystrocryepts

KCBJ. Other Dystrocryepts that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Dystrocryepts

KCBK. Other Dystrocryepts that have an umbric or mollic epipedon.

Humic Dystrocryepts

KCBL. Other Dystrocryepts.

Typic Dystrocryepts

Definition of Typic Dystrocryepts

Typic Dystrocryepts are the Dystrocryepts that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

   a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

   b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

   c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

5. Have neither an umbric nor a mollic epipedon;

6. Do not have lamellae (two or more) within 200 cm of the mineral soil surface;

7. Do not have a horizon 5 cm or more thick that has *one or more* of the following:

   a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

   b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

   c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon;

8. Do not have a xeric moisture regime; *and*

9. Are dry in some part of the moisture control section for less than 45 days (cumulative) in normal years.

Description of Subgroups

Typic Dystrocryepts.—The central concept or the Typic subgroup of Dystrocryepts is fixed on deep, more or less freely drained soils that have an ochric epipedon and that do not have lamellae.

Soils that have lamellae in which silicate clay has accumulated are excluded from the Typic subgroup because they are considered to be intergrades to Alfisols. Shallow hard rock is used to define the Lithic subgroup. Soils that have a thin mantle or layer of materials that have some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. A shallow water table and redox depletions with low chroma indicate intergrades to Aquepts. An umbric or mollic epipedon is not considered typical and is used to define Humic and combination Humic subgroups.

Typic Dystrocryepts are of large extent in the United States. They are mostly in the mountains of the Western States and in Alaska. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Andic and Vitrandic Dystrocryepts.—These soils have, in the upper 75 cm, a layer that is 18 cm or more thick and that has some andic soil properties or that consists of fine pyroclastic materials. This layer is most commonly at the mineral soil surface. Most of these soils have an ochric or umbric epipedon and a cambic horizon. Andic and Vitrandic Dystrocryepts are of large extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Aquic Dystrocryepts.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, some of the soils have an umbric or mollic epipedon. Aquic Dystrocryepts are of small extent in the United States. They are mostly in Alaska, but a few are in the mountains of other Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Humic Dystrocryepts.—These soils are like Typic Dystrocryepts, but they have an umbric or mollic epipedon. Many of the soils are in areas of higher precipitation than the soils of the Typic subgroup. Humic Dystrocryepts are of moderate extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Humic Lithic Dystrocryepts.—These soils have an umbric or mollic epipedon and a lithic contact within 50 cm of the soil surface. They are of moderate extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Lamellic Dystrocryepts.—These soils have two or more lamellae. The top of the uppermost lamella is within 75 cm of the soil surface, but others may be deeper. Most of these soils have a coarse-loamy, coarse-silty, or loamy-skeletal particle-size class. Lamellic Dystrocryepts are of small extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Lithic Dystrocryepts.—These soils have an ochric epipedon and a lithic contact within 50 cm of the soil surface. They are of moderate extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Oxyaquic Dystrocryepts.—These soils are saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 consecutive days or 30 cumulative days in normal years. The soils are of small extent in the United States. They are mostly in Alaska and in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Spodic Dystrocryepts.—These soils have a weak accumulation of amorphous materials. They are presumed to be developing toward Spodosols, mainly Cryods, but are too weakly developed to be classified as Spodosols. Spodic Dystrocryepts are of small extent in the United States. They are in the mountains of the Western States.

Ustic Dystrocryepts.—These soils are like Typic Dystrocryepts, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years. They are considered to be transitional to Ustepts. Ustic Dystrocryepts commonly support a sparse coniferous forest with widely spaced trees or are used as rangeland. They are not extensive in the United States.

Xeric Dystrocryepts.—These soils are like Typic Dystrocryepts, but they have a xeric moisture regime. They are considered to be transitional to Xerepts. Xeric Dystrocryepts commonly support coniferous forest vegetation. Some of the forests have widely spaced trees. Some of the soils are used as rangeland. Xeric Dystrocryepts are not extensive in the United States.

Eutrocryepts

These are the Cryepts that have free carbonates or have a base saturation (by NH_4OAc) of 60 percent or more in some horizon at a depth between 25 and 75 cm from the mineral soil surface. The vegetation is mostly mixed conifers and hardwoods or shrubs, grass, and widely spaced trees. Few of the soils are used as cropland. Eutrocryepts formed mostly in drift, alluvium, or colluvium or in solifluction deposits, mostly late Pleistocene or Holocene in age. The soils commonly have a thin, dark brownish ochric epipedon and a brownish cambic horizon. Some have an umbric epipedon, and some have bedrock within 100 cm of the surface. In the United States, these soils are of small extent in the high mountains of the West. They also occur in other parts of the world, mostly in mountainous areas.

Definition

Eutrocryepts are the Cryepts that:

1. Have free carbonates within the soils; *or*

2. Have a base saturation (by NH_4OAc) of 60 percent or more in one or more horizons at a depth between 25 and 75 cm from the mineral soil surface.

Key to Subgroups

KCAA. Eutrocryepts that have *both*:

1. An umbric or mollic epipedon; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Humic Lithic Eutrocryepts

KCAB. Other Eutrocryepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Eutrocryepts

KCAC. Other Eutrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Eutrocryepts

KCAD. Other Eutrocryepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Eutrocryepts

KCAE. Other Eutrocryepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrocryepts

KCAF. Other Eutrocryepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Eutrocryepts

KCAG. Other Eutrocryepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Eutrocryepts

KCAH. Other Eutrocryepts that have a xeric moisture regime.

Xeric Eutrocryepts

KCAI. Other Eutrocryepts that are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years.

Ustic Eutrocryepts

KCAJ. Other Eutrocryepts that have an umbric or mollic epipedon.

Humic Eutrocryepts

KCAK. Other Eutrocryepts.

Typic Eutrocryepts

Definition of Typic Eutrocryepts

Typic Eutrocryepts are the Eutrocryepts that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

5. Do not have lamellae (two or more) within 200 cm of the mineral soil surface;

6. Have neither an umbric nor a mollic epipedon;

7. Do not have a xeric moisture regime; *and*

8. Are dry in some part of the moisture control section for less than 45 days (cumulative) in normal years.

Description of Subgroups

Typic Eutrocryepts.—The central concept or Typic subgroup of Eutrocryepts is fixed on deep, more or less freely drained soils that have an ochric epipedon and that do not have lamellae.

Soils that have lamellae in which silicate clay has accumulated are excluded from the Typic subgroup because they are considered to be intergrades to Alfisols. Shallow hard rock is used to define the Lithic subgroup. Soils that have a thin mantle or layer of materials that have some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. A shallow water table and redox depletions with low chroma indicate intergrades to Aquepts. An umbric or mollic epipedon is not considered typical and is used to define Humic and combination Humic subgroups.

Typic Eutrocryepts are of large extent in the United States and occur mostly in the mountains of the Western States and in southern Alaska. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Andic and Vitrandic Eutrocryepts.—These soils have, in the upper 75 cm, a layer 18 cm or more thick that has some andic soil properties or consists of fine pyroclastic materials. This layer is most commonly at the mineral soil surface. Most of these soils have an ochric or umbric epipedon and a cambic horizon. Andic and Vitrandic Eutrocryepts are of very small extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Aquic Eutrocryepts.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, some of the soils have an umbric or mollic epipedon. Aquic Eutrocryepts are of small extent in the United States. They are mostly in Alaska, but a few are in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Humic Eutrocryepts.—These soils have an umbric or mollic epipedon. They are of very small extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Humic Lithic Eutrocryepts.—These soils have an umbric or mollic epipedon and a lithic contact within 50 cm of the soil surface. They are of very small extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Lamellic Eutrocryepts.—These soils have two or more lamellae. The upper boundary of the uppermost lamella is within 75 cm of the soil surface, but others may be deeper. Most of these soils have a coarse-loamy, coarse-silty, or loamy-skeletal particle-size class. Lamellic Eutrocryepts are of small extent in the mountains of the Western United States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Lithic Eutrocryepts.—These soils have an ochric epipedon and a lithic contact within 50 cm of the soil surface. They are of moderate extent in the United States. They are mostly in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Oxyaquic Eutrocryepts.—These soils are saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 consecutive days or 30 cumulative days in normal years. The soils are of small extent in the United States. They are mostly in Alaska and in the mountains of the Western States. The vegetation is mostly coniferous forest. The soils are used mainly for timber production and wildlife habitat.

Ustic Eutrocryepts.—These soils are like Typic Eutrocryepts, but they are dry in some part of the moisture control section for 45 or more days (cumulative) in normal years. They are considered to be transitional to Ustepts. Ustic Eutrocryepts commonly support a sparse coniferous forest with widely spaced trees or are used as pasture. They are not extensive in the United States.

Xeric Eutrocryepts.—These soils are like Typic Eutrocryepts, but they have a xeric moisture regime. They are considered to be transitional to Xerepts. Xeric Eutrocryepts commonly support coniferous forest. Some of the forests have widely spaced trees. Some of the soils are used as pasture. Xeric Eutrocryepts are not extensive in the United States.

Udepts

Udepts are mainly the more or less freely drained Inceptisols that have a udic or perudic moisture regime. They formed on nearly level to steep surfaces, mostly of late-Pleistocene or Holocene age. Some of the soils, in areas where the soil moisture regime is perudic, formed in older deposits. Most of the soils had or now have a forest vegetation, but some support shrubs or grasses. A few formed from Mollisols by truncation of the mollic epipedon, mostly under cultivation. Most of the soils have an ochric or umbric epipedon and a cambic horizon. Some also have a sulfuric horizon, a fragipan, or a duripan. The Udepts in the United States are most extensive in the Appalachian Mountains, on the Allegheny Plateau, and on the west coast.

Definition

Udepts are the Inceptisols that:

1. Have a udic moisture regime;

2. Do not have *both* aquic conditions *and* a histic epipedon, the colors defined for Aquepts, or enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, an ESP (or SAR) below 50 cm that decreases with increasing depth, and ground water within 100 cm of the mineral soil surface during some time of the year;

4. Have neither a plaggen nor an anthropic epipedon; *and*

5. Have a soil temperature regime warmer than cryic.

Key to Great Groups

KFA. Udepts that have a sulfuric horizon within 50 cm of the mineral soil surface.

Sulfudepts, p. 530

KFB. Other Udepts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durudepts, p. 517

KFC. Other Udepts that have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Fragiudepts, p. 529

KFD. Other Udepts that have *one or both* of the following:

1. Free carbonates within the soils; *or*

2. A base saturation (by NH_4OAc) of 60 percent or more in one or more horizons at a depth between 25 and 75 cm from the mineral soil surface.

Eutrudepts, p. 524

KFE. Other Udepts.

Dystrudepts, p. 518

Durudepts

These are the Udepts that have a duripan that has its upper boundary within 100 cm of the soil surface. Most of the Udepts in the United States occur in areas that have a Mediterranean climate but that have high precipitation. Commonly, the soils have a perched water table above the duripan for part of winter or early spring. The vegetation commonly is coniferous forest. These soils are of very small extent in the United States.

Definition

Durudepts are the Udepts that:

1. Have a duripan that has its upper boundary within 100 cm of the soil surface; *and*

2. Do not have a sulfuric horizon within 50 cm of the mineral soil surface.

Key to Subgroups

KFBA. Durudepts that have *both*:

1. In one or more horizons above the duripan and within 60 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Durudepts

KFBB. Other Durudepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Durudepts

KFBC. Other Durudepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durudepts

KFBD. Other Durudepts that have, in one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durudepts

KFBE. Other Durudepts.

Typic Durudepts

Definition of Typic Durudepts

Typic Durudepts are the Durudepts that:

1. Do not have, in any horizon above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions; *and*

2. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Durudepts.—These are the Durudepts that are free of redoximorphic features and that do not have a layer near the surface that has many of the properties of Andisols. Typic Durudepts are of very small extent in the United States. The native vegetation is mostly coniferous forest. The soils are used mainly as forest, cropland, or homesites.

Andic and Vitrandic Durudepts.—These soils have a layer near the surface that is 18 cm or more thick and that has many of the properties of Andisols. Andic and Vitrandic Durudepts are of very small extent in the United States and are mostly in western Washington. The native vegetation is mostly coniferous forest. These soils are used mainly as forest, cropland, pasture, or homesites.

Aquandic Durudepts.—These soils have a layer near the surface that is 18 cm or more thick and that has many of the properties of Andisols. Aquandic Durudepts also have redox concentrations and aquic conditions and are wetter than Typic Durudepts. They are rare in the United States.

Aquic Durudepts.—These soils have redox concentrations and aquic conditions and are wetter than Typic Durudepts. Commonly, they also have gentler slopes. Aquic Durudepts are rare in the United States.

Dystrudepts

These are the acid Udepts of humid and perhumid regions. They developed mostly in late-Pleistocene or Holocene deposits. Some developed on older, steeply sloping surfaces. The parent materials generally are acid, moderately or weakly consolidated sedimentary or metamorphic rocks or acid sediments. A few of the soils formed in saprolite derived from igneous rocks. The vegetation was mostly deciduous trees. Most of the Dystrudepts that formed in alluvium are now cultivated, and many of the other Dystrudepts are used as pasture.

The normal horizon sequence in Dystrudepts is an ochric epipedon over a cambic horizon. Some of the steeper Dystrudepts have a shallow densic, lithic, or paralithic contact. Dystrudepts are extensive in the United States. They are mostly in the Eastern and Southern States.

Definition

Dystrudepts are the Udepts that:

1. Do not have free carbonates within the soils;

2. Have a base saturation of less than 60 percent (by NH_4OAc) in all subhorizons between depths of 25 and 75 cm below the soil surface;

3. Do not have a fragipan or duripan that has an upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have a sulfuric horizon within 50 cm of the mineral soil surface.

Key to Subgroups

KFEA. Dystrudepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. An umbric or mollic epipedon.

Humic Lithic Dystrudepts

KFEB. Other Dystrudepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrudepts

KFEC. Other Dystrudepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Dystrudepts

KFED. Other Dystrudepts that have *both*:

1. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Dystrudepts

KFEE. Other Dystrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrudepts

KFEF. Other Dystrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrudepts

KFEG. Other Dystrudepts that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Dystrudepts

KFEH. Other Dystrudepts that have a slope of less than 25 percent; *and*

1. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content

(Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Dystrudepts

KFEI. Other Dystrudepts that have *both*:

1. An umbric or mollic epipedon; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humic Dystrudepts

KFEJ. Other Dystrudepts that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrudepts

KFEK. Other Dystrudepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystrudepts

KFEL. Other Dystrudepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Dystrudepts

KFEM. Other Dystrudepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Dystrudepts

KFEN. Other Dystrudepts that have *both*:

1. An umbric or mollic epipedon; *and*

2. A sandy particle-size class throughout the particle-size control section.

Humic Psammentic Dystrudepts

KFEO. Other Dystrudepts that have a slope of less than 25 percent; *and*

1. An umbric or mollic epipedon; *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humic Dystrudepts

KFEP. Other Dystrudepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrudepts

KEEQ. Other Dystrudepts that have a horizon 5 cm or more thick that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Dystrudepts

KFER. Other Dystrudepts that have in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Dystrudepts

KFES. Other Dystrudepts that have an umbric or mollic epipedon that is 50 cm or more thick.

Humic Pachic Dystrudepts

KFET. Other Dystrudepts that have an umbric or mollic epipedon.

Humic Dystrudepts

KFEU. Other Dystrudepts that have *both*:

1. In each pedon a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon; *and*

2. A base saturation (by sum of cations) of 35 percent or more either at a depth of 125 cm from the top of the cambic horizon or directly above a densic, lithic, or paralithic contact if shallower.

Ruptic-Alfic Dystrudepts

KFEV. Other Dystrudepts that have in each pedon a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon.

Ruptic-Ultic Dystrudepts

KFEW. Other Dystrudepts.

Typic Dystrudepts

Definition of Typic Dystrudepts

Typic Dystrudepts are the Dystrudepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

4. Have a slope of 25 percent or more; *or*

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of less than 0.2 percent or a densic, lithic, or paralithic contact within that depth; *or*

b. A regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower;

5. Do not have a lithic contact within 50 cm of the mineral soil surface;

6. Do not have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon;

7. Do not have an umbric or mollic epipedon;

8. Do not have lamellae (two or more) within 200 cm of the soil surface;

9. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

10. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

11. Do not have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower, *either*:

a. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

b. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Description of Subgroups

Typic Dystrudepts.—The central concept or Typic subgroup of Dystrudepts is fixed on soils that are moderately deep or deep to hard rock, are freely drained and acid, have an ochric epipedon, and do not have any intermittent argillic, natric, or kandic horizon. In addition, the percentage of organic carbon of Holocene age decreases regularly with increasing depth and is very low at a depth of 125 cm.

Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to the Vertic subgroup because these properties are shared with Vertisols. If the percentage of carbon is relatively high at a depth of 125 cm or if the percentage decreases irregularly with increasing depth and slopes are gentle, the parent material normally is recent Holocene alluvium. The soils that formed in this alluvium are considered intergrades to Fluvents or to Fluvaquents if the soils are also wet. A shallow water table and redox depletions with low chroma indicate intergrades to Aquepts. An intermittent argillic, natric, or kandic horizon is considered evidence that the soil is developing toward Alfisols or Ultisols, depending on the base saturation. A lithic contact within a depth of 50 cm is the basis for defining the Lithic subgroup. The presence of an umbric or mollic epipedon is used to define Humic and combination Humic subgroups. Soils that have a thin mantle or layer that has some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. Soils with a low CEC in the clay fraction are considered intergrades to Oxisols.

Typic Dystrudepts are extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Andic and Vitrandic Dystrudepts.—These soils have some andic soil properties in a layer in the upper part that is 18 cm or more thick. Some of the soils contain a significant amount of volcanic ash. Some have an umbric epipedon. Andic and Vitrandic Dystrudepts are moderately extensive in the Northwestern United States. The native vegetation consists mostly of coniferous forest. Most of these soils support their native vegetation and are used as forest. A few of the less sloping soils have been cleared and are used as cropland or pasture.

Aquandic Dystrudepts.—These soils have aquic conditions and redox depletions with low chroma in the upper part of the subsoil. They also have some andic soil properties in a layer in the upper part that is 18 cm or more thick. Some of these soils contain a significant amount of volcanic ash, and some have an umbric epipedon. Ground water commonly is present in the soils only during winter. These soils have gentle slopes. They are of small extent in the United States and are mostly in the State of Washington. The native vegetation consists mostly of coniferous forest. Most of these soils support native vegetation and are used as forest. Some have been cleared and are used as pasture or cropland.

Aquic Dystrudepts.—These soils have redox depletions with low chroma in a brownish or reddish matrix in the subsoil. Most of the soils also have redox concentrations with high chroma. Ground water commonly is present only during wet periods. Most of the Aquic Dystrudepts in the United States formed in late-Pleistocene sediments and have gentle slopes. Some of the soils have an umbric epipedon. Aquic Dystrudepts are moderately extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Many of these soils have been cleared and are used as cropland or pasture, and many are used as forest.

Aquic Humic Dystrudepts.—These soils have redox depletions with low chroma in a brownish or reddish matrix in the subsoil and have an umbric or mollic epipedon. Most also have redox concentrations with high chroma. Most of the Aquic Humic Dystrudepts in the United States formed in late-Pleistocene sediments and have gentle slopes. Ground water commonly is present only during wet periods unless the soils are artificially drained. The native vegetation consists mostly of mixed forest. Many of these soils are used as forest, and many have been cleared and are used as cropland or pasture.

Fluvaquentic Dystrudepts.—These soils have redox depletions with low chroma in a brownish matrix. They formed in Holocene or recent alluvium. They are on flood plains along rivers draining regions that have acid soils. During wet periods ground water is present in the redox-depleted zone unless the soils have been drained. Most of these soils are subject to occasional flooding, but they receive little fresh sediment. Some of the soils have an umbric epipedon. Fluvaquentic Dystrudepts are moderately extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Many of these soils have been cleared and are used as cropland or pasture, and some are used as forest.

Fluventic Dystrudepts.—These soils are on flood plains along rivers draining regions that have acid soils. They formed in Holocene or recent alluvium. They are subject to occasional flooding but receive little fresh alluvium. Fluventic Dystrudepts are moderately extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Most of these soils have been cleared and are used as cropland. Some are used as pasture and some as forest.

Fluventic Humic Dystrudepts.—These soils are on flood plains along rivers draining regions that have acid soils. They have an umbric or mollic epipedon and formed in Holocene or recent alluvium. These soils are subject to occasional flooding but receive little fresh alluvium. Fluventic Humic Dystrudepts are of small extent in the United States. They are in Oregon and the Nashville Basin and Appalachian valleys in the United States. The native vegetation consists mostly of mixed forest. Most of these soils have been cleared and are used as intensively cultivated cropland. Some are used as pasture and some as forest.

Fragiaquic Dystrudepts.—These soils are like Typic Dystrudepts, but they have, at a shallow depth, redox depletions with low chroma and also aquic conditions for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are permitted to have a mollic or umbric epipedon. They are considered intergrades to Fraqiaquepts. They are not extensive in the United States.

Fragic Dystrudepts.—These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fragiudepts. They are not extensive in the United States.

Humic Dystrudepts.—These soils have an umbric or mollic epipedon that is less than 50 cm thick. They are otherwise like the soils of the Typic subgroup. Humic Dystrudepts are moderately extensive in the United States. They are widely distributed but are concentrated in the mountains of the Eastern and Northwestern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Humic Lithic Dystrudepts.—These soils have a lithic contact at a shallow depth and have an umbric or mollic epipedon. They formed mostly in acid sedimentary or metamorphic rocks. Most of the soils have moderate to steep slopes. Humic Lithic Dystrudepts are moderately extensive in the United States. They are widely distributed. The largest concentration is in the Northwestern States. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest. Some of the less sloping soils have been cleared and are used as pasture.

Humic Pachic Dystrudepts.—These soils have an umbric or mollic epipedon 50 cm or more thick. They are otherwise like the soils of the Typic subgroup. Humic Pachic Dystrudepts are of small extent in the United States. They are widely distributed but are concentrated in the mountains of the Eastern and Northwestern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Humic Psammentic Dystrudepts.—These soils have an umbric or mollic epipedon and a sandy particle-size class throughout all layers at a depth between 25 and 100 cm below the mineral soil surface. The soils are of small extent in the United States. The native vegetation consists mostly of forest. Most of these soils are used as forest. Some of the less sloping soils have been cleared and are used as cropland or pasture.

Lamellic Dystrudepts.—These soils are like Typic Dystrudepts, but they have two or more lamellae. They are not extensive in the United States.

Lithic Dystrudepts.—These soils are like Typic Dystrudepts, but they have a lithic contact at a shallow depth. They formed mostly in acid sedimentary or metamorphic rocks. Most of the soils have moderate to steep slopes. Lithic Dystrudepts are extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. Some of the less sloping soils have been cleared and are used as pasture.

Oxic Dystrudepts.—These soils have clays with a low cation-exchange capacity dominant in the particle-size control section. They are considered intergrades to Oxisols. Oxic Dystrudepts are not extensive in the United States.

Oxyaquic Dystrudepts.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The soils are moderately extensive in the United States. They are considered intergrades to Aquepts. Slopes are gentle. Many Oxyaquic Dystrudepts have been cleared and are used as cropland or pasture. Some are used as forest.

Ruptic-Alfic Dystrudepts.—These soils have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, natric, or kandic horizon, and they have a base saturation of 35 percent or more at a depth of 125 cm below the top of the argillic horizon or directly above a densic, lithic, or paralithic contact if one is shallower than that depth. Most of these soils are strongly sloping to steeply sloping, and in most of them the depth to rock is less than 125 cm. The soils are of very small extent in the United States.

Ruptic-Ultic Dystrudepts.—These soils have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, natric, or kandic horizon. Most of the soils are shallow over weakly consolidated sedimentary rock. Generally, the illuvial part of the cambic horizon is where the rock is deepest. The base saturation is less than 35 percent. The native vegetation is mostly hardwood forest. These soils generally are steeply sloping, and they are used as forest or pasture. They are of small extent in the United States.

Spodic Dystrudepts.—These soils have a weak accumulation of amorphous materials. They are presumed to be developing toward Spodosols, mainly Orthods, but are too weakly developed to be classified as Spodosols. Spodic Dystrudepts are of moderate extent in the United States. They are mainly in the Northeastern States.

Vertic Dystrudepts.—These soils are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils are considered to be transitional to Vertisols. They are of very small extent in the United States.

Eutrudepts

These are the base-rich Udepts of humid regions. Many developed in Holocene or late-Pleistocene deposits. Some of the soils that have steep slopes formed in older deposits. The parent materials commonly are calcareous sediments or basic sedimentary rocks. The vegetation was mostly deciduous hardwoods, but the gently sloping soils are now cultivated and many of the steeply sloping soils are used as pasture. Eutrudepts are not extensive in the United States.

Definition

Eutrudepts are the Udepts that:

1. Have *one or both* of the following:

a. Free carbonates within the soils; *or*

b. A base saturation of 60 percent or more (by NH_4OAc) in some subhorizon that is between depths of 25 and 75 cm below the mineral soil surface;

2. Do not have a fragipan or duripan with its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a sulfuric horizon with its upper boundary within 50 cm of the mineral soil surface.

Key to Subgroups

KFDA. Eutrudepts that have *both*:

1. An umbric or mollic epipedon; *and*

2. A lithic contact within 50 cm of the mineral soil surface.

Humic Lithic Eutrudepts

KFDB. Other Eutrudepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Eutrudepts

KFDC. Other Eutrudepts that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquertic Eutrudepts

KFDD. Other Eutrudepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Eutrudepts

KFDE. Other Eutrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Eutrudepts

KFDF. Other Eutrudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Eutrudepts

KFDG. Other Eutrudepts that have anthraquic conditions.

Anthraquic Eutrudepts

KFDH. Other Eutrudepts that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Eutrudepts

KFDI. Other Eutrudepts that have a slope of less than 25 percent; *and*

1. In one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Eutrudepts

KFDJ. Other Eutrudepts that:

1. Have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface.

Aquic Dystric Eutrudepts

KFDK. Other Eutrudepts that have, in one or more horizons within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrudepts

KFDL. Other Eutrudepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Eutrudepts

KFDM. Other Eutrudepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Eutrudepts

KFDN. Other Eutrudepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Eutrudepts

KFDO. Other Eutrudepts that have a slope of less than 25 percent; *and*

1. Do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface; *and either*

2. Have, at a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

3. Have an irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Dystric Fluventic Eutrudepts

KFDP. Other Eutrudepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene Age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Eutrudepts

KFDQ. Other Eutrudepts that have a sandy or sandy-skeletal particle-size class in all horizons within 50 cm of the mineral soil surface.

Arenic Eutrudepts

KFDR. Other Eutrudepts that do not have free carbonates throughout any horizon within 100 cm of the mineral soil surface.

Dystric Eutrudepts

KFDS. Other Eutrudepts that have 40 percent or more free carbonates, including coarse fragments as much as 75 mm in diameter, in all horizons between the top of the cambic horizon and either a depth of 100 cm from the mineral soil surface or a densic, lithic, or paralithic contact if shallower.

Rendollic Eutrudepts

KFDT. Other Eutrudepts that have an umbric or mollic epipedon.

Humic Eutrudepts

KFDU. Other Eutrudepts that have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon.

Ruptic-Alfic Eutrudepts

KFDV. Other Eutrudepts.

Typic Eutrudepts

Definition of Typic Eutrudepts

Typic Eutrudepts are the Eutrudepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 60 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Do not have anthraquic conditions;

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

5. Have a texture of very fine sand or finer within 50 cm of the soil surface;

6. Have free carbonates within 100 cm of the mineral soil surface in some part of each pedon;

7. Have a slope of 25 percent or more or *one or both* of the following:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of less then 0.2 percent and no densic, lithic, or paralithic contact within that depth; *or*

b. A regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower;

8. Do not have a lithic contact within 50 cm of the soil surface;

9. Do not have a cambic horizon that includes 10 to 50 percent (by volume) illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon;

10. Have neither an umbric nor a mollic epipedon;

11. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

12. Have less than 40 percent free carbonates, including coarse fragments as much as 75 mm in diameter, in and below the cambic horizon but above a densic, lithic, or paralithic contact and above a depth of 100 cm from the mineral soil surface;

13. Do not have lamellae (two or more) within 200 cm of the soil surface; *and*

14. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Eutrudepts.—The central concept or Typic subgroup of Eutrudepts is fixed on deep, more or less freely drained, loamy or clayey soils that have an ochric epipedon and some free carbonates, but not a large amount, within 100 cm of the soil surface.

Soils that have a thin mantle or layer that has some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. Soils that have redox depletions with low chroma accompanied by ground water at some time of the year or by artificial drainage are excluded because they are intergrades to Aquepts. A surface mantle of sand or loamy sand more than 50 cm thick is the basis for defining the Arenic extragrade, a convention used in many other taxa. Typic Eutrudepts have free carbonates above a depth of 100 cm from the mineral soil surface. The absence of free carbonates is used to define intergrades to Dystrudepts, and the presence of 40 percent or more free carbonates indicates a transition to Haprendolls. An irregular decrease in content of organic carbon (Holocene age) with increasing depth or a relatively high percentage in the deep layers is the basis for defining intergrades to Fluvents or, if the soils are periodically saturated with water, to Fluvaquents. A lithic contact shallower than 50 cm defines the Lithic subgroup, a convention used throughout this taxonomy. A cambic horizon that includes 10 to 50 percent illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon indicates development toward Alfisols and defines the Ruptic-Alfic subgroup. A high content of swelling clays accompanied by deep cracks indicates intergrades to Vertisols. An umbric or mollic epipedon is not considered typical and is used to define Humic and combination Humic subgroups.

Typic Eutrudepts are of moderate extent in the United States. They are widely distributed. The native vegetation consists mostly of hardwood or mixed forest. Most of the strongly sloping soils are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Andic and Vitrandic Eutrudepts.—These soils have some andic soil properties in a layer 18 cm or more thick in the upper part. In some of the soils, this layer was derived at least in part from pyroclastic materials. Andic and Vitrandic Eutrudepts are of small extent in the United States. They are known to occur only in western Montana. The native vegetation consists of coniferous forest. Most of these soils are used as forest.

Anthraquic Eutrudepts.—These soils have been irrigated for the production of paddy rice for many years and have developed anthraquic conditions. They are permitted, but not required, to have redox depletions with chroma of 2 or less in layers that in normal years also have aquic conditions within 75 cm of the mineral soil surface. These soils have level or nearly level slopes. They are not extensive and are not known to occur in the United States.

Aquertic Eutrudepts.—These soils have redox depletions with low chroma within 60 cm of the soil surface and either are artificially drained or are saturated with water within the redox-depleted zone at some time of the year. They have a high COLE and do not have a densic, lithic, or paralithic contact within 50 cm of the soil surface. These soils are not known to occur in the United States.

Aquic Dystric Eutrudepts.—These soils have redox depletions with low chroma above a depth of 60 cm and either are artificially drained or are saturated with water in the redox-depleted zone at some time of the year, usually in winter or spring. In addition, they have no free carbonates to a depth of 100 cm below the mineral soil surface. These soils are of moderate extent in the United States. Most formed in late-Pleistocene or Holocene sediments and are in the north-central and northeastern parts of the United States. The native vegetation consisted of forest. Most of these soils are nearly level and have been cleared and are used as cropland or pasture.

Aquic Eutrudepts.—These soils have redox depletions with low chroma within 60 cm of the soil surface and either are artificially drained or are saturated with water within the redox-depleted zone at some time of the year, usually in winter or spring. The soils are of small extent in the United States. Most formed in late-Pleistocene sediments and are in the Northeastern United States. The native vegetation consisted of forest. Most of these soils are nearly level and have been cleared and are used as cropland or pasture.

Arenic Eutrudepts.—These soils have a surface mantle of sand or loamy sand that is more than 50 cm thick and is underlain by a cambic horizon. In the United States, they formed in late-Pleistocene sediments and have gentle or moderate slopes. These soils are of very small extent in the United States and are known to occur only in Michigan. The native vegetation consists of mixed forest. Most of these soils are used as forest.

Dystric Eutrudepts.—These soils have no free carbonates above a depth of 100 cm from the mineral soil surface. In the United States, they formed mostly in late-Pleistocene or Holocene sediments. Some of the soils that have steep slopes formed in older deposits. Dystric Eutrudepts are moderately extensive in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. Most of the less sloping soils have been cleared and are used as cropland or pasture.

Dystric Fluventic Eutrudepts.—These soils formed in alluvium on flood plains along streams and rivers. They do not have free carbonates above a depth of 100 cm from the mineral soil surface. They are subject to occasional overflow but receive little fresh sediment. These soils are of moderate extent in the

Eastern United States. The native vegetation consists mostly of forest. Most of these soils have been cleared and are used as cropland. Some are used as pasture and some as forest.

Fluvaquentic Eutrudepts.—These soils formed mostly in Holocene alluvium along streams. They have redox depletions with low chroma within the upper 60 cm, and they either are artificially drained or are saturated with water at some time of the year, mostly when the streams are at flood stage. The soils are subject to occasional overflow but receive little fresh sediment. They are of moderate extent in the Eastern United States. The native vegetation consisted mostly of forest. Nearly all of the Fluvaquentic Eutrudepts in the United States have been cleared and are used as cropland.

Fluventic Eutrudepts.—These soils formed in alluvium on flood plains along streams and rivers. The content of organic carbon (Holocene age) decreases irregularly with increasing depth or is relatively high at a depth of 125 cm. The soils have some free carbonates above a depth of 100 cm from the mineral soil surface. Most are nearly level. These soils are of small extent in the Eastern United States. The native vegetation consisted mostly of forest. Nearly all of the Fluventic Eutrudepts in the United States have been cleared and are used as cropland.

Fragiaquic Eutrudepts.—These soils have, at a shallow depth, redox depletions with low chroma and also aquic conditions for some time in normal years. In addition, they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fraqiaquepts. They are not extensive in the United States.

Fragic Eutrudepts.—These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. The soils are considered intergrades to Fraqiudepts. They are not extensive in the United States.

Humic Eutrudepts.—These soils have an umbric or mollic epipedon but are otherwise like Typic Eutrudepts. Humic Eutrudepts are of moderate extent in the United States. They are widely distributed. The largest concentration is in the Northwestern States. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest. A few of the less sloping soils have been cleared and are used as cropland or pasture.

Humic Lithic Eutrudepts.—These soils have an umbric or mollic epipedon and a lithic contact within 50 cm of the mineral soil surface. They are of small extent in the United States. They are widely distributed. The largest concentration is in the Eastern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. A few of the less sloping soils have been cleared and are used as pasture.

Lamellic Eutrudepts.—These soils have two or more lamellae within 200 cm of the mineral soil surface. They are not extensive in the United States.

Lithic Eutrudepts.—These soils have an ochric epipedon and a lithic contact within 50 cm of the mineral soil surface. They are of small extent in the United States. They are widely distributed. The largest concentration is in the Northeastern States. The native vegetation consists mostly of mixed forest. Most of these soils are used as forest. A few of the less sloping soils have been cleared and are used as pasture.

Oxyaquic Eutrudepts.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are of small extent in the United States. They are considered intergrades to Aquepts. Slopes are gentle. Many Oxyaquic Eutrudepts have been cleared and are used as cropland or pasture. Some are used as forest.

Rendollic Eutrudepts.—These soils formed in marl, chalk, shattered limestone, or shattered dolomite. They have more than 40 percent calcium carbonate equivalent in some part above 100 cm from the mineral soil surface. Fragments more than 75 mm in diameter and solid limestone are excluded when the content of carbonates is determined. These soils are considered to be intergrades to Rendolls, and some of them have developed from Haprendolls. Rendollic Eutrudepts are of small extent in the United States. The native vegetation consisted mostly of trees and grasses. Most the Rendollic Eutrudepts in the United States have been cleared and are used as hayland or pasture. Some of the soils, mostly the steeper ones, are used as forest.

Ruptic-Alfic Eutrudepts.—These soils have a cambic horizon that includes 10 to 50 percent illuvial parts that otherwise meet the requirements for an argillic, kandic, or natric horizon. The soils are moderately sloping or strongly sloping and are shallow over calcareous, weakly consolidated sedimentary rock or fractured limestone. The illuvial parts of the cambic horizon are generally in the parts of the pedon where the depth to rock is greatest. These soils are of small extent in the United States. The native vegetation consisted mostly of hardwood forest. Most of the Ruptic-Alfic Eutrudepts in the United States have been cleared and are used as hayland or pasture. Some of the soils, mostly the steeper ones, are used as forest.

Vertic Eutrudepts.—These soils have a high COLE and do not have a densic, lithic, or paralithic contact within 50 cm of the soil surface. Most of the soils have gentle or moderate slopes. Vertic Eutrudepts are of small extent in the United States. The native vegetation consisted mostly of forest. Most of the Vertic Eutrudepts in the United States have been cleared and are used as cropland or pasture. Some are used as forest.

Fragiudepts

These are the Udepts that have a fragipan within 100 cm of the mineral soil surface. They do not have a sulfuric horizon within 50 cm of the mineral soil surface. Commonly, they have a brownish cambic horizon that is underlain, at a depth of about 50 cm, by a fragipan. Most Fragiudepts have perched water above the pan at some time of the year, and few roots penetrate the pan. Consequently, plants tend to have shallow root systems. Many Fragiudepts formed in late-Pleistocene or Holocene deposits on gentle or moderate slopes. Some are strongly sloping. The parent materials of most Fragiudepts are loamy and either are acid or have only a small amount of free carbonates. A few of the materials are sandy and have an appreciable amount of fine sand and very fine sand. Most of the Fragiudepts in the United States are in the Northeastern States and the States bordering the Mississippi and Ohio Rivers. A few are in the northern Lake States, and some are in the humid parts of the Northwestern States. These soils are extensive.

Definition

Fragiudepts are the Udepts that:

1. Have a fragipan within 100 cm of the mineral soil surface;

2. Do not have a sulfuric horizon within 50 cm of the mineral soil surface; *and*

3. Do not have a duripan within 100 cm of the mineral soil surface.

Key to Subgroups

KFCA. Fragiudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragiudepts

KFCB. Other Fragiudepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragiudepts

KFCC. Other Fragiudepts that have, in one or more horizons within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiudepts

KFCD. Other Fragiudepts that have an umbric or mollic epipedon.

Humic Fragiudepts

KFCE. Other Fragiudepts.

Typic Fragiudepts

Definition of Typic Fragiudepts

Typic Fragiudepts are the Fragiudepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions; *and*

3. Do not have an umbric or mollic epipedon.

Description of Subgroups

Typic Fragiudepts.—The central concept or Typic subgroup of Fragiudepts is fixed on soils that are free of distinct or prominent redox concentrations in the upper 30 cm, that have an ochric epipedon, and that do not have some andic soil properties in a layer near the surface that is as thick as 18 cm.

A mantle of materials with andic soil properties between 18 and 35 cm thick indicates an intergrade to Andisols. Most Typic Fragiudepts have perched ground water above the pan at some time of the year. Shallow redox concentrations indicate intergrades to Fragiaquepts and is the basis for defining the Aquic subgroup.

Typic Fragiudepts are moderately extensive in the United States. They occur mostly in the Northeastern States. The native vegetation consists of mixed forest. Most of the less sloping soils have been cleared and are used as cropland or pasture. Some of the soils, mostly the steeper ones, are used as forest.

Andic and Vitrandic Fragiudepts.—These soils have some andic soil properties in a layer near the surface that is 18 cm or more thick. This layer has many of the properties of Andisols. Andic and Vitrandic Fragiudepts are not extensive and are not known to occur in the United States.

Aquic Fragiudepts.—These soils have, at a shallow depth, redox concentrations of medium or high contrast and are somewhat wetter than Typic Fragiudepts. Commonly, they also have gentler slopes. Aquic Fragiudepts are of small extent in the United States. Most formed in late-Pleistocene sediments and are in the Northeastern States. The native vegetation consisted of forest. Most of these soils are nearly level and have been cleared and are used as cropland or pasture.

Humic Fragiudepts.—These soils are like Typic Fragiudepts, but they have a mollic or umbric epipedon. They are not extensive and are rare in the United States.

Sulfudepts

These are extremely acid soils that formed in sulfidic materials that have been exposed to aerobic conditions, mainly as a result of surface mining, road construction, dredging, or other earth-moving operations. These soils are of small extent in the United States.

Definition

Sulfudepts are the Udepts that have a sulfuric horizon within 50 cm of the mineral soil surface.

Key to Subgroups

KFAA. All Sulfudepts (provisionally).

Typic Sulfudepts

Ustepts

Ustepts are mainly the more or less freely drained Inceptisols that have an ustic moisture regime. They receive dominantly summer precipitation, or they have an isomesic, hyperthermic, or warmer temperature regime. They formed mostly in Pleistocene or Holocene deposits. Some of the soils that have steep slopes formed in older deposits. Some Ustepts formed from Mollisols by truncation of the mollic epipedon, mostly under cultivation. Most Ustepts have an ochric epipedon and a cambic horizon. Many are calcareous at a shallow depth and have a Bk or calcic horizon. A few have a duripan or an umbric epipedon. The native vegetation commonly was grass, but some of the soils supported trees. Most of the soils are used as cropland or pasture. Ustepts are of moderate extent in the United States. They are most common on the Great Plains, mostly in Montana, Texas, and Oklahoma.

Definition

Ustepts are the Inceptisols that:

1. Have an ustic moisture regime;

2. Do not have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years and *one or more* of the following:

   a. A histic epipedon; *or*

   b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *or*

   c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

      (1) 2 or less if there are redox concentrations; *or*

      (2) 1 or less; *or*

   d. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, a decrease in ESP (or SAR) values with increasing depth below 50 cm, and ground water within 100 cm of the mineral soil surface for some time during the year;

4. Have neither a plaggen nor an anthropic epipedon; *and*

5. Have a soil temperature regime warmer than cryic.

Key to Great Groups

KDA. Ustepts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durustepts, p. 533

KDB. Other Ustepts that *both*:

   1. Have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic

horizon that has its upper boundary within 150 cm of the mineral soil surface; *and*

2. Are either calcareous or have a texture of loamy fine sand or coarser in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Calciustepts, p. 531

KDC. Other Ustepts that have *both* of the following:

1. No free carbonates within 200 cm of the mineral soil surface; *and*

2. A base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface.

Dystrustepts, p. 534

KDD. Other Ustepts.

Haplustepts, p. 536

Calciustepts

These are the Ustepts that have a calcic or petrocalcic horizon and that are calcareous or have a sandy particle-size class in all overlying horizons. The soils do not have a duripan. The precipitation has been insufficient to remove the carbonates from the upper horizons, or there is a continuing external source of carbonates in dust or water.

Calciustepts formed mostly in Pleistocene or older materials. On the Calciustepts in the United States, the vegetation was dominantly grass before the soils were cultivated. The soils are most extensive on the Great Plains in the United States, but some are in the intermountain valleys of the Western States.

Definition

Calciustepts are the Ustepts that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface and are calcareous in all parts of all horizons above the calcic or petrocalcic horizon, after the upper part of the soil to a depth of 18 cm has been mixed, unless the texture is coarser than loamy very fine sand or very fine sand; *and*

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

KDBA. Calciustepts that have a petrocalcic horizon and a lithic contact within 50 cm of the mineral soil surface.

Lithic Petrocalcic Calciustepts

KDBB. Other Calciustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciustepts

KDBC. Other Calciustepts that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Torrertic Calciustepts

KDBD. Other Calciustepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciustepts

KDBE. Other Calciustepts that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Calciustepts

KDBF. Other Calciustepts that have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Gypsic Calciustepts

KDBG. Other Calciustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciustepts

KDBH. Other Calciustepts that have, when neither irrigated nor fallowed to store moisture, *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Calciustepts

KDBI. Other Calciustepts that have, when neither irrigated nor fallowed to store moisture, *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for four-tenths or less of the consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Calciustepts

KDBJ. Other Calciustepts.

Typic Calciustepts

Definition of Typic Calciustepts

Typic Calciustepts are the Calciustepts that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface;

4. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

5. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C and is dry for more than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

6. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Calciustepts.—The central concept or Typic subgroup of Calciustepts is fixed on more or less freely drained soils that have a calcic rather than a petrocalcic horizon and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years.

Redox concentrations and a ground water table that fluctuates within 75 cm of the mineral soil surface are properties shared with Aquolls and define the Aquic subgroup. A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy. A petrocalcic horizon indicates development more intensive than normal and defines the Petrocalcic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are used to define the Vertic subgroup.

Typic Calciustepts are of small extent in the United States. They are mostly on the northern Great Plains, in Montana and South Dakota. Many of these soils supported grasses and shrubs. Most of the soils on plains are now used as cropland.

Aquic Calciustepts.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. Color value and chroma of these soils commonly are lower than those of Typic Calciustepts. Aquic Calciustepts developed mostly in nearly level upland areas that commonly are concave. They are of very small extent in the United States.

Aridic Calciustepts.—These soils are drier than Typic Calciustepts. They generally receive less precipitation than the soils of the Typic subgroup, or they lose more water through runoff. Aridic Calciustepts are of moderately large extent and are widely distributed in the Western United States. The largest extent is in the western part of the Great Plains. Slopes range from nearly level to steep. In the United States, many of the soils that have suitable slopes are used as cropland. If the temperature regime is frigid or mesic, many are fallowed in alternate years to store moisture. Some are irrigated, and most of the more sloping soils are used as pasture.

Gypsic Calciustepts.—These soils have a gypsic horizon in addition to the calcic horizon. In most of these soils, the gypsic horizon is in the lower part of or below the calcic horizon. These soils are of very small extent in the United States. They are mostly on the southern Great Plains.

Lithic Calciustepts.—These soils have a shallow lithic contact. They are of small extent in the United States. They are mostly in the Western States. They have moderate to very steep slopes. The vegetation is mostly grass and shrubs, but a few of the soils support forest vegetation. Lithic Calciustepts are used mainly as pasture or forest.

Lithic Petrocalcic Calciustepts.—These soils have a petrocalcic horizon overlying hard bedrock within a depth of 50 cm. Typically, the fractures in the underlying bedrock are filled with cemented secondary carbonates. Most of these soils are drier than Typic Calciustepts. Slopes are gentle. Lithic Petrocalcic Calciustepts formed on surfaces older than the Pleistocene. They occur locally in Texas. They are used mainly as pasture.

Petrocalcic Calciustepts.—These soils have a petrocalcic horizon. In some of the soils, depth to the petrocalcic horizon is less than 50 cm. Some of the soils that have a petrocalcic horizon below a depth of 50 cm are underlain by hard bedrock. Petrocalcic Calciustepts are of small extent on the southern Great Plains of the United States. The largest extent is in Texas. Most of the soils are used as pasture.

Torrertic Calciustepts.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. Also, the soils are drier than Vertic Calciustepts. Torrertic Calciustepts are of very small extent in the United States.

Udic Calciustepts.—These soils are more moist than Typic Calciustepts and in most areas receive more precipitation. Udic Calciustepts are of small extent and are known to occur only in Texas. The native vegetation is mostly grasses and shrubs. Slopes generally are gentle. Most of these soils are used as cropland.

Vertic Calciustepts.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They formed mostly in material weathered from smectite-rich shale or from limestone. They are of small extent. The native vegetation was mostly grasses.

Durustepts

These are the Ustepts that have a duripan with its upper boundary within 100 cm of the soil surface. Commonly, these soils formed in the vicinity of volcanic cinders and ash falls. The parent materials are mainly volcanic tuffs, ash, cinders, and volcanic rocks. In the United States, the native vegetation is mostly grasses, shrubs, and trees. These soils are of small extent. They formed mainly in areas of Pleistocene deposits. They may be also on the leeward sides of some volcanic islands.

Definition

Durustepts are the Ustepts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

KDAA. All Durustepts (provisionally).

Typic Durustepts

Dystrustepts

These are the acid Ustepts. They developed mostly in Pleistocene or Holocene deposits. Some of the soils that have steep slopes formed in older deposits. The parent materials generally are acid, moderately or weakly consolidated sedimentary or metamorphic rocks or acid sediments. The vegetation was mostly forest. Most of these soils have a thermic or warmer temperature regime.

A common horizon sequence in Dystrustepts is an ochric or umbric epipedon over a cambic horizon. Some of the steeper soils have a shallow densic, lithic, or paralithic contact. Dystrustepts are of very small extent in the United States.

Definition

Dystrustepts are the Ustepts that:

1. Do not have free carbonates within the soils;

2. Have a base saturation of less than 60 percent (by NH_4OAc) in all subhorizons between depths of 25 and 75 cm below the soil surface;

3. Do not have a duripan that has an upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not meet *both* of the following:

a. Have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

b. *Either* have a texture of loamy fine sand or coarser in all parts above the calcic or petrocalcic horizon *or* are calcareous after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Key to Subgroups

KDCA. Dystrustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrustepts

KDCB. Other Dystrustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystrustepts

KDCC. Other Dystrustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystrustepts

KDCD. Other Dystrustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystrustepts

KDCE. Other Dystrustepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystrustepts

KDCF. Other Dystrustepts that have in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Dystrustepts

KDCG. Other Dystrustepts that have an umbric or mollic epipedon.

Humic Dystrustepts

KDCH. Other Dystrustepts.

Typic Dystrustepts

Definition of Typic Dystrustepts

Typic Dystrustepts are the Dystrustepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Have a slope of 25 percent or more; *or*

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of less than 0.2 percent or a densic, lithic, or paralithic contact within that depth; *or*

b. A regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have a lithic contact within 50 cm of the mineral soil surface;

5. Do not have an umbric or mollic epipedon; *and*

6. Do not have, in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower, *either*:

a. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

b. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Description of Subgroups

Typic Dystrustepts.—The central concept or Typic subgroup of Dystrustepts is fixed on soils that are moderately deep or deep to hard rock, are freely drained, are acid, and have an ochric epipedon. In addition, the percentage of organic carbon of Holocene age decreases regularly with increasing depth and is very low at a depth of 125 cm.

If the percentage of organic carbon is relatively high at a depth of 125 cm or if the percentage decreases irregularly with increasing depth and slopes are gentle, the parent material normally is recent Holocene alluvium. The soils that formed in this alluvium are considered intergrades to Fluvents. A shallow water table and redox depletions with low chroma indicate intergrades to Aquepts. A lithic contact within a depth of 50 cm is the basis for defining the Lithic subgroup. The presence of an umbric or mollic epipedon is used to define the Humic subgroup. Soils that have a thin mantle or layer that has some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. Soils with a low CEC in the clay fraction are considered intergrades to Oxisols.

Typic Dystrustepts are of very small extent in the United States and are known to occur only on tropical islands.

Andic and Vitrandic Dystrustepts.—These soils have some andic soil properties in a layer 18 cm or more thick in the upper part. Some of the soils contain a significant amount of volcanic ash, and some have an umbric epipedon. Andic and Vitrandic Dystrustepts are not known to occur in the United States.

Aquic Dystrustepts.—These soils have redox depletions with low chroma in a brownish or reddish matrix in the subsoil. Most of the soils also have concentrations with high chroma. Ground water is present during wet periods unless the soils are artificially drained. Some of these soils have an umbric epipedon. Aquic Dystrustepts are not known to occur in the United States.

Fluventic Dystrustepts.—These soils are on flood plains along rivers draining regions that have acid soils. They formed in Holocene or recent alluvium. They are subject to occasional flooding but receive little fresh alluvium. These soils are rare in the United States.

Humic Dystrustepts.—These soils have an umbric or mollic epipedon but are otherwise like the soils of the Typic subgroup. Humic Dystrustepts are known to occur only on tropical islands in the United States.

Lithic Dystrustepts.—These soils have a lithic contact at a shallow depth. They formed mostly in material weathered from acid rocks. Most of the soils have moderate to steep slopes. Lithic Dystrustepts are not known to occur in the United States.

Oxic Dystrustepts.—These soils have clays with a low cation-exchange capacity dominant in the particle-size control section. They are considered intergrades to Oxisols. Oxic Dystrustepts are not extensive in the United States.

Haplustepts

These are the more or less freely drained Ustepts that are calcareous at some depth or have a high base status. Some of the soils have a Bk or calcic horizon, but they do not have both a calcic or petrocalcic horizon and a sandy particle-size class or carbonates in all horizons above the calcic or petrocalcic horizon. The native vegetation commonly was grass, but some of the soils supported trees. Haplustepts are not extensive in the United States, except locally on the Great Plains.

Definition

Haplustepts are the Ustepts that:

1. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have *both*:

a. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

b. Either free carbonates or a texture of loamy fine sand or coarser in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed; *and*

3. Have:

a. Free carbonates within 200 cm of the mineral soil surface; *or*

b. A base saturation (by NH_4OAc) of 60 percent or more in some horizon at a depth between 25 and 75 cm from the mineral soil surface.

Key to Subgroups

KDDA. Haplustepts that have:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Lithic Haplustepts

KDDB. Other Haplustepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustepts

KDDC. Other Haplustepts that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Udertic Haplustepts

KDDD. Other Haplustepts that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haplustepts

KDDE. Other Haplustepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustepts

KDDF. Other Haplustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplustepts

KDDG. Other Haplustepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustepts

KDDH. Other Haplustepts that have anthraquic conditions.

Anthraquic Haplustepts

KDDI. Other Haplustepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustepts

KDDJ. Other Haplustepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustepts

KDDK. Other Haplustepts that have in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

1. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

2. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24.

Oxic Haplustepts

KDDL. Other Haplustepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haplustepts

KDDM. Other Haplustepts that have a slope of less than 25 percent; *and*

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Torrifluventic Haplustepts

KDDN. Other Haplustepts that have a slope of less than 25 percent; *and*

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Udifluventic Haplustepts

KDDO. Other Haplustepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haplustepts

KDDP. Other Haplustepts that have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Gypsic Haplustepts

KDDQ. Other Haplustepts that have *both*:

1. A calcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Haplocalcidic Haplustepts

KDDR. Other Haplustepts that have *both*:

1. A calcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Calcic Udic Haplustepts

KDDS. Other Haplustepts that have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Calcic Haplustepts

KDDT. Other Haplustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Haplustepts

KDDU. Other Haplustepts that have a base saturation (by sum of cations) of less than 60 percent in some horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Dystric Haplustepts

KDDV. Other Haplustepts that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 105 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for

less than four-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Haplustepts

KDDW. Other Haplustepts.

Typic Haplustepts

Definition of Typic Haplustepts

Typic Haplustepts are the Haplustepts that:

1. *Either* have a content of organic carbon (Holocene age) that decreases regularly with increasing depth and, unless a densic, lithic, or paralithic contact occurs at a shallower depth, reaches a level of 0.2 percent or less within 125 cm of the soil surface *or* have a slope of more than 25 percent;

2. Do not have a lithic contact within 50 cm of the surface;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have anthraquic conditions;

5. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

6. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid soil temperature regime and a moisture control section that in normal years is dry in some or all parts for 105 or more cumulative days per year but is not dry in all parts for four-tenths or more of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths to six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for 90 or more consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some part for a period between 120 cumulative days and six-tenths of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C;

7. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

8. Have a base saturation (by sum of cations) of more than 60 percent in all horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower;

9. Do not have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

10. Do not have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface;

11. Do not have lamellae (two or more) within 200 cm of the soil surface;

12. Have in less than 50 percent of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower:

a. A CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+) per kg clay; *or*

b. Both a ratio of measured clay in the fine-earth fraction to percent water retained at 1500 kPa tension of 0.6 or more and the following: the CEC (by 1N NH_4OAc pH 7) divided by the product of three times [percent water retained at 1500 kPa tension minus percent organic carbon (but no more than 1.00)] is less than 24; *and*

13. Are not saturated with water in one or more layers within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years.

Description of Subgroups

Typic Haplustepts.—The central concept or Typic subgroup of Haplustepts is fixed on thick soils that have a high base saturation throughout layers below the surface layer but do not have a calcic horizon. The soils are dry for moderate periods in normal years.

Gently sloping and nearly level Haplustepts are excluded from the Typic subgroup if the content of organic carbon (Holocene age) decreases irregularly with increasing depth or remains relatively high in the deep layers. These soils have some of the properties of Fluvents. Soils that have a lithic contact shallower than 50 cm are excluded from the Typic subgroup, a convention used throughout this taxonomy. Clayey soils that have expanding clays and deep cracks are excluded because they have some properties of Vertisols.

Typic Haplustepts are of large extent on the plains of the Western United States. They are widely distributed from Montana to Texas. Most of the soils are gently sloping to strongly sloping. The native vegetation consists mostly of grass, shrubs, and trees. Most of the strongly sloping soils are used as rangeland or forest. Most of the less sloping soils have been cleared and are used as cropland or pasture.

Andic and Vitrandic Haplustepts.—These soils have some andic soil properties in a layer 18 cm or more thick in the upper part and have many of the properties of Andisols. In some of these soils, this layer was derived at least in part from pyroclastic materials. Andic and Vitrandic Haplustepts are of small extent in the United States. They are known to occur only in western Montana. The native vegetation consists of coniferous forest. Most of these soils are used as forest.

Anthraquic Haplustepts.—These soils have been irrigated for the production of paddy rice for many years and have developed redoximorphic features in the upper part. They are permitted, but not required, to have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years within 75 cm of the mineral soil surface. These soils are not extensive and are not known to occur in the United States. They have level or nearly level slopes.

Aquic Haplustepts.—These soils have redox depletions with low chroma commonly in a brownish or reddish matrix in the subsoil. Redox concentrations with high chroma also are common. Most of the Aquic Haplustepts in the United States have nearly level or gentle slopes. Ground water is present during wet periods unless the soils are artificially drained. These soils are of small extent in the United States and are widely distributed on the Great Plains from Montana to Texas. The native vegetation consists mostly of trees or widely spaced trees and grass. Most of these soils have been cleared and are used as pasture.

Aridic Haplustepts.—These soils receive less moisture than the soils of the Typic subgroup but otherwise are like them in defined properties. In general, the depth to carbonates is less than that in the soils of the Typic subgroup. Aridic Haplustepts are extensive in the western part of the Great Plains in the United States. Slopes range from gentle to steep. Most of these soils are used as rangeland. Where slopes are suitable, many of the soils are used as cropland.

Aridic Lithic Haplustepts.—These soils have a lithic contact within 50 cm of the soil surface and receive less moisture than the soils of the Typic subgroup. The vegetation is mostly grass and shrubs. Slopes are gentle to steep. Aridic Lithic Haplustepts are used as rangeland or wildlife habitat.

Calcic Haplustepts.—These soils have a calcic horizon but otherwise are like Typic Haplustepts in defined properties. Calcic Haplustepts are of small extent on the Great Plains of the United States. The native vegetation consists mostly of grass and shrubs but in some areas is coniferous forest. Most of these soils are used as rangeland or forest. Where slopes are suitable, some of the soils are used as cropland or pasture.

Calcic Udic Haplustepts.—These soils receive more moisture than the soils of the Typic subgroup and have a calcic horizon. Calcic Udic Haplustepts are of small extent in the southern part of the Great Plains in the United States. The native vegetation consists mostly of grass, shrubs, and widely spaced trees. Slopes generally are gentle. Most of these soils are used as rangeland or pasture.

Dystric Haplustepts.—These soils have a base saturation of less than 60 percent in some horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower. Some of the soils have free carbonates at some depth within 200 cm of the soil surface. Dystric Haplustepts are known to occur only on tropical islands in the United States. They are of very small extent.

Fluventic Haplustepts.—These soils formed in alluvium. Slopes are gentle, and coarse stratification is common. These soils are of small extent in the southern part of the Great Plains in the United States. The native vegetation consisted mostly of grass and widely spaced trees. Most of these soils are used as cropland, rangeland, or pasture.

Gypsic Haplustepts.—These soils have a gypsic horizon within 100 cm of the mineral soil surface. They are of very small extent in the United States.

Haplocalcidic Haplustepts.—These soils receive less moisture than the soils of the Typic subgroup and have a calcic horizon. They are extensive in the western part of the Great

Plains and on foothills of the Rocky Mountains in the United States. The native vegetation consists mostly of grass and shrubs, but it includes pinyon pine and juniper trees in Arizona. Slopes range from gentle to steep. Most of these soils are used as rangeland or grazed forest. Where slopes are suitable, some of the soils are used as cropland.

Lamellic Haplustepts.—These soils are like Typic Haplustepts, but they have two or more lamellae. They are not extensive in the United States.

Lithic Haplustepts.—These soils have a lithic contact within 50 cm of the soil surface. Slopes are gentle to very steep. These soils are of moderate extent on the plains and foothills of the Western United States. They are widely distributed from Montana to Texas. The native vegetation consists mostly of grass, shrubs, and trees. Most of these soils are used as rangeland or grazed forest. A few of the less sloping soils have been cleared and are used as cropland or pasture.

Oxic Haplustepts.—These soils have a cambic horizon that approaches the properties of an oxic horizon but are otherwise like Typic Haplustepts in defined properties. Oxic Haplustepts are of very small extent in the United States. They occur mostly on tropical or semitropical islands. The native vegetation consists mostly of trees and shrubs. Most of these soils are used as forest. Where slopes are suitable, some of the soils have been cleared and are used as cropland or pasture.

Oxyaquic Haplustepts.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The soils are of very small extent in the United States. They are considered intergrades to Aquepts.

Torrertic Haplustepts.—These soils receive less moisture than the soils of the Typic subgroup. They are clayey and have deep cracks at some season in most years, a property that is shared with Torrerts. Torrertic Haplustepts generally are nearly level or gently sloping. They are of small extent in the United States and occur on the Great Plains from Montana to Oklahoma. The native vegetation consists of grass and shrubs. Most of these soils are used as rangeland, but some are used as cropland, some of which is irrigated.

Torrifluventic Haplustepts.—These soils formed in alluvium and receive less moisture than the soils of the Fluventic and Typic subgroups. In general, the depth to free carbonates is less than that in the soils in these subgroups. Torrifluventic Haplustepts are of very small extent in the United States. They are mostly in the western part of the Great Plains.

Udertic Haplustepts.—These soils receive more moisture than the soils of the Typic subgroup. They are clayey and have deep cracks at some season in most years, a property that is shared with Usterts. Udertic Haplustepts generally are nearly level to sloping. They are of small extent and are known to occur only in Texas in the United States. The native vegetation consists of hardwood forest or grass and widely spaced trees. Most of these soils are used as rangeland or hayland.

Udic Haplustepts.—These soils receive more moisture than the soils of the Typic subgroup. They are otherwise like Typic Haplustepts. Udic Haplustepts are of small extent in the United States. They occur mostly on the southern Great Plains. Where slopes are suitable, the soils are used mainly as cropland.

Udifluventic Haplustepts.—These soils formed in alluvium and receive more moisture than the soils of the Typic subgroup. Udifluventic Haplustepts are of small extent in the southern part of the Great Plains in the United States. The native vegetation consists of hardwood forest or grass and widely spaced trees. Most of these soils are used as cropland or rangeland or for pecan orchards.

Vertic Haplustepts.—These soils are clayey and have deep cracks at some season in normal years, a property that is shared with Usterts. Vertic Haplustepts generally are nearly level to sloping. They are of moderate extent and occur on the Great Plains from South Dakota to Texas in the United States. The native vegetation consists mostly of grass and some shrubs and widely spaced trees. Most of these soils are used as rangeland or cropland.

Xerepts

Xerepts are mainly the more or less freely drained Inceptisols that have a xeric moisture regime. They have a frigid, mesic, or thermic temperature regime. They formed mostly in Pleistocene or Holocene deposits. Some of the soils, mostly the ones that have steep slopes, formed in older deposits. Most of the soils have an ochric epipedon and a cambic horizon. Some have an umbric epipedon or a duripan, and a few have a fragipan. Some are calcareous at a shallow depth and have a Bk or calcic horizon. The native vegetation commonly is coniferous forest on the soils that have a frigid or mesic temperature regime and shrubs, grass, and widely spaced trees on the soils that have a thermic temperature regime.

Xerepts are of moderate extent in the United States. They are most common in the States of California, Oregon, Washington, Idaho, and Utah.

Definition

Xerepts are the Inceptisols that:

1. Have a xeric moisture regime;

2. Do not have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years and *one or more* of the following:

a. A histic epipedon; *or*

b. A sulfuric horizon that has its upper boundary within 50 cm of the mineral soil surface; *or*

c. A layer directly under the epipedon, or within 50 cm of the mineral soil surface, that has, on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if there are redox concentrations; *or*

(2) 1 or less; *or*

d. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in half or more of the soil volume within 50 cm of the mineral soil surface, a decrease in ESP (or SAR) values with increasing depth below 50 cm, and ground water within 100 cm of the mineral soil surface for some time during the year;

4. Have neither a plaggen nor an anthropic epipedon; *and*

5. Have a mesic, frigid, or thermic soil temperature regime.

Key to Great Groups

KEA. Xerepts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durixerepts, p. 545

KEB. Other Xerepts that *both*:

1. Have a calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

2. Are calcareous in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Calcixerepts, p. 543

KEC. Other Xerepts that have a fragipan that has its upper boundary within 100 cm of the mineral soil surface.

Fragixerepts, p. 549

KED. Other Xerepts that have *both* of the following:

1. No free carbonates within 200 cm of the mineral soil surface; *and*

2. A base saturation (by NH_4OAc) of less than 60 percent in all horizons at a depth between 25 and 75 cm from the mineral soil surface.

Dystroxerepts, p. 546

KEE. Other Xerepts.

Haploxerepts, p. 551

Calcixerepts

These are the Xerepts that do not have a duripan or a fragipan but have a calcic or petrocalcic horizon and that are calcareous in all overlying horizons. Either the parent materials had more carbonates than the rainfall could remove from the upper horizons, or there is a continuing external source of carbonates in dust or water.

Calcixerepts formed mostly in Pleistocene sediments or younger materials on surfaces of comparable age. In the United States, the vegetation was dominantly grass and shrubs before the soils were cultivated. These soils are most extensive in California, Idaho, and Utah.

Definition

Calcixerepts are the Xerepts that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface and are calcareous in all parts of all horizons above the calcic or petrocalcic horizon; *and*

2. Do not have a duripan or fragipan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

KEBA. Calcixerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixerepts

KEBB. Other Calcixerepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calcixerepts

KEBC. Other Calcixerepts that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Calcixerepts

KEBD. Other Calcixerepts that have an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in one or more subhorizons within 100 cm of the mineral soil surface.

Sodic Calcixerepts

KEBE. Other Calcixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Calcixerepts

KEBF. Other Calcixerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calcixerepts

KEBG. Other Calcixerepts.

Typic Calcixerepts

Definition of Typic Calcixerepts

Typic Calcixerepts are the Calcixerepts that:

1. Do not have a lithic contact within 50 cm of the soil surface;

2. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

6. Have an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio [SAR] of less than 13) in all subhorizons within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Calcixerepts.—The central concept or Typic subgroup of Calcixerepts is fixed on more or less freely drained soils that have a calcic rather than a petrocalcic horizon. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years.

Soils that have a thin mantle or layer of materials that have some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols. Redox concentrations and a ground water table that fluctuates within 75 cm of the mineral soil surface are properties shared with Aquolls and define the Aquic subgroup. A shallow lithic contact defines the Lithic subgroup, a convention used throughout this taxonomy. A petrocalcic horizon indicates development more intensive than normal and is used to define the Petrocalcic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are used to define the Vertic subgroup.

Typic Calcixerepts are of small extent in the United States. They are mostly in California, Utah, and Idaho. Many of these soils supported grasses and shrubs and widely spaced trees. Most are used as rangeland or irrigated cropland.

Aquic Calcixerepts.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. The soils are not known to occur in the United States.

Lithic Calcixerepts.—These soils have a shallow lithic contact. They are of very small extent in the Western United States.

Petrocalcic Calcixerepts.—These soils have a petrocalcic horizon. They are not known to occur in the United States.

Sodic Calcixerepts.—These soils have a high content of sodium in the upper part. They are of very small extent in the United States.

Vertic Calcixerepts.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of very small extent in the United States.

Vitrandic Calcixerepts.—These soils have some andic soil properties in a layer 18 cm or more thick in the upper part and have many of the properties of Andisols. In some areas this layer was derived at least in part from pyroclastic materials. Vitrandic Calcixerepts are of very small extent in the United States.

Durixerepts

These are the Xerepts that have a duripan that has its upper boundary within 100 cm of the soil surface. These soils have a Mediterranean climate and receive a large part of their annual precipitation in winter. Commonly, water is perched above the duripan for part of winter or early spring. The vegetation was commonly a coniferous forest or a mixture of grasses and scattered trees. Durixerepts are not extensive in the United States as a whole but are extensive locally.

Definition

Durixerepts are the Xerepts that have a duripan that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

KEAA. Durixerepts that have *both*:

1. In one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Durixerepts

KEAB. Other Durixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Durixerepts

KEAC. Other Durixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more, above the duripan and within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durixerepts

KEAD. Other Durixerepts that have, in one or more horizons above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixerepts

KEAE. Other Durixerepts that have a duripan that is strongly cemented or less cemented in all subhorizons.

Entic Durixerepts

KEAF. Other Durixerepts.

Typic Durixerepts

Definition of Typic Durixerepts

Typic Durixerepts are the Durixerepts that:

1. Have a duripan that is very strongly cemented or is indurated;

2. Do not have, in any horizon above the duripan and within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions; *and*

3. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Durixerepts.—The central concept or Typic subgroup of Durixerepts is fixed on soils that are free of redoximorphic features and have a very strongly cemented or indurated duripan. These soils do not have a layer near the surface that has many of the properties of Andisols. The pan generally has very coarse polyhedrons that are 100 cm or more across. It commonly is within 50 cm of the mineral soil surface. Soils that have a less strongly cemented duripan are considered to be intergrades to Entisols.

Typic Durixerepts are of small extent in the United States. The native vegetation is mostly shrubs and grass. These soils are used mainly as rangeland or irrigated cropland. Some are used as homesites.

Andic and Vitrandic Durixerepts.—These soils have many of the properties of Andisols in a layer near the surface that is 18 cm or more thick. Andic and Vitrandic Durixerepts are of small extent in the United States. They occur mostly in the western part of Washington State. The native vegetation is mostly coniferous forest, but in some areas it is shrubs and grass. These soils are used mainly as forest. Some have been cleared and are used as cropland, pasture, or homesites.

Aquandic Durixerepts.—These soils have many of the properties of Andisols in a layer near the surface that is 18 cm or more thick. Aquandic Durixerepts also have redox concentrations and aquic conditions and are wetter than Typic Durixerepts. They are rare in the United States.

Aquic Durixerepts.—These soils have redox concentrations and aquic conditions and are wetter than Typic Durixerepts. Commonly, they also have gentler slopes. Aquic Durixerepts are rare in the United States.

Entic Durixerepts.—These soils have a duripan that is cemented but is not very strongly cemented or indurated. Because the pan is not very strongly cemented or indurated, these soils are considered intergrades to Entisols. Entic Durixerepts are of small extent in the United States. The vegetation is mostly annual grasses and scattered trees on the thermic soils and forest on the cooler soils.

Dystroxerepts

These are the acid Xerepts. They developed mostly in Pleistocene or Holocene deposits. Some of the soils that have steep slopes formed in older deposits. The normal horizon sequence in Dystroxerepts is an ochric epipedon over a cambic horizon. Some of the steep Dystroxerepts have a shallow densic, lithic, or paralithic contact. The parent materials generally are acid, moderately or weakly consolidated sedimentary or metamorphic rocks or acid sediments, commonly with additions of volcanic ash near the surface. A few of the soils formed in saprolite derived from igneous rocks. The vegetation was mostly coniferous trees. Most Dystroxerepts are used as forest or pasture. Some of the soils, mostly the least sloping ones, are used as cropland.

Dystroxerepts are extensive soils in the States of California, Washington, and Oregon.

Definition

Dystroxerepts are the Xerepts that:

1. Do not have free carbonates within the soils;

2. Have a base saturation of less than 60 percent (by NH_4OAc) in all subhorizons between depths of 25 and 75 cm below the soil surface; *and*

3. Do not have a fragipan or duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

KEDA. Dystroxerepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. An umbric or mollic epipedon.

Humic Lithic Dystroxerepts

KEDB. Other Dystroxerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystroxerepts

KEDC. Other Dystroxerepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Dystroxerepts

KEDD. Other Dystroxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Dystroxerepts

KEDE. Other Dystroxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Dystroxerepts

KEDF. Other Dystroxerepts that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions in normal years (or artificial drainage).

Fragiaquic Dystroxerepts

KEDG. Other Dystroxerepts that have a slope of less than 25 percent; *and*

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluvaquentic Dystroxerepts

KEDH. Other Dystroxerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Dystroxerepts

KEDI. Other Dystroxerepts that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystroxerepts

KEDJ. Other Dystroxerepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Dystroxerepts

KEDK. Other Dystroxerepts that have a slope of less than 25 percent; *and*

1. An umbric or mollic epipedon; *and*

2. *Either*:

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

b. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Humic Dystroxerepts

KEDL. Other Dystroxerepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Dystroxerepts

KEDM. Other Dystroxerepts that have an umbric or mollic epipedon.

Humic Dystroxerepts

KEDN. Other Dystroxerepts.

Typic Dystroxerepts

Definition of Typic Dystroxerepts

Typic Dystroxerepts are the Dystroxerepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years;

4. Have a slope of 25 percent or more; *or*

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of less than 0.2 percent or a densic, lithic, or paralithic contact within that depth; *or*

b. A regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower;

5. Do not have a lithic contact within 50 cm of the mineral soil surface;

6. Do not have an umbric or mollic epipedon; *and*

7. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Dystroxerepts.—The central concept or Typic subgroup of Dystroxerepts is fixed on soils that are moderately deep or deeper to hard rock, are freely drained, are acid, and have an ochric epipedon. In addition, the content of organic carbon of Holocene age decreases regularly with increasing depth and is very low at a depth of 125 cm.

If content of organic carbon is relatively high at a depth of 125 cm or if it decreases irregularly with increasing depth and slopes are gentle, the parent material normally is recent Holocene alluvium. The soils that formed in this alluvium are considered intergrades to Fluvents or, if the soils have aquic conditions near the surface, to Fluvaquents. A shallow water table and redox depletions with low chroma indicate intergrades to Aquepts. A lithic contact within a depth of 50 cm is the basis for defining the Lithic subgroup. The presence of an umbric or mollic epipedon is used to define Humic and combination Humic subgroups. Soils that have a thin mantle or layer that has some andic soil properties are excluded from the Typic subgroup because they are considered to be an intergrade to Andisols.

Typic Dystroxerepts are of moderate extent in the United States. They are mostly in the Northwestern States. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest. Some of the less sloping soils have been cleared and are used as cropland or pasture.

Andic and Vitrandic Dystroxerepts.—These soils have some andic soil properties in a layer in the upper part that is 18 cm or more thick. Some of the soils contain a significant amount of volcanic ash. Some have an umbric epipedon. Andic and Vitrandic Dystroxerepts are moderately extensive in the Northwestern United States. The native vegetation consists mostly of coniferous forest. Most of these soils support native vegetation and are used as forest. A few of the less sloping soils have been cleared and are used as cropland or pasture.

Aquandic Dystroxerepts.—These soils have aquic conditions in the upper part of the subsoil and have some andic soil properties in a layer in the upper part that is 18 cm or more thick. Some of the soils contain a significant amount of volcanic ash, and some have an umbric epipedon. Ground water commonly is present only during winter unless the soils are artificially drained. These soils have gentle slopes. They are of small extent in the United States. They occur mostly in Washington State. The native vegetation consists mostly of coniferous forest. Most of these soils support native vegetation and are used as forest. Some have been cleared and are used as pasture or cropland.

Aquic Dystroxerepts.—These soils have redox depletions with low chroma in a brownish or reddish matrix in the subsoil. Many of the soils also have redox concentrations with high chroma. Most of the Aquic Dystroxerepts in the United States formed in late-Pleistocene sediments and have gentle slopes. Ground water commonly is present only during wet periods unless the soils are artificially drained. Some of these soils have an umbric epipedon. Aquic Dystroxerepts are of small extent in the United States. They occur mostly in Washington State. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Fluvaquentic Dystroxerepts.—These soils have redox depletions with low chroma in a brownish matrix and formed in Holocene or recent alluvium. They are on flood plains. During wet periods ground water is present in the redox-depleted zone unless the soils have been drained. Most of these soils are subject to occasional flooding, but they receive little fresh sediment. Some of the soils have an umbric epipedon. Fluvaquentic Dystroxerepts are of very small extent in the United States.

Fluventic Dystroxerepts.—These soils are on flood plains along rivers and streams. They formed in Holocene or recent alluvium. They are subject to occasional flooding but receive little fresh alluvium. These soils are of very small extent in the United States.

Fluventic Humic Dystroxerepts.—These soils are on flood plains along rivers and streams. They have an umbric or mollic epipedon. They formed in Holocene or recent alluvium. They are subject to occasional flooding but receive little fresh alluvium. These soils are of very small extent in the United States.

Fragiaquic Dystroxerepts.—These soils have fragic soil properties in 30 percent or more of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of a layer 15 cm or more thick anywhere in the soils. In addition, they have redox depletions with low chroma in a brownish or reddish matrix in the subsoil. Commonly, there are also redox concentrations with high chroma. Ground water commonly is present in these soils during winter. The soils are considered intergrades to Fragiaquepts. They are not extensive in the United States.

Fragic Dystroxerepts.—These soils have fragic soil properties in 30 percent or more of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fragixerepts. They are not extensive in the United States.

Humic Dystroxerepts.—These soils have an umbric or mollic epipedon but are otherwise like the soils of the Typic subgroup. Humic Dystroxerepts are moderately extensive in the United States. They are mostly in California and in the Northwestern States. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Humic Lithic Dystroxerepts.—These soils have a lithic contact within 50 cm of the mineral soil surface and have a mollic or umbric epipedon. An umbric epipedon is more common than a mollic epipedon. These soils are of small extent in the Northwestern United States.

Lithic Dystroxerepts.—These soils have a lithic contact at a shallow depth. They formed mostly in acid sedimentary or metamorphic rocks. Most of the soils have moderate to steep slopes. Lithic Dystroxerepts are of small extent in the United States. They are mostly in California and Oregon. The native vegetation consists mostly of coniferous forest. Most of these soils are used as forest.

Oxyaquic Dystroxerepts.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The soils are of small extent in the United States. They are considered intergrades to Aquepts. Most Oxyaquic Dystroxerepts are used as forest. Some have been cleared and are used as cropland or pasture.

Fragixerepts

These are the Xerepts that have a fragipan within 100 cm of the mineral soil surface. Commonly, these soils have a brownish cambic horizon that is underlain by a fragipan at a depth of about 70 cm. Most Fragixerepts have perched water above the pan in winter, and few roots penetrate the pan. Consequently, plants tend to have shallow root systems. Many Fragixerepts formed in late-Pleistocene deposits. They have mostly gentle or moderate slopes, but some are steep. Most of these soils are loamy and have been leached of any free carbonates. The Fragixerepts in the United States are mostly in the States of Idaho and Oregon. They are of small extent.

Definition

Fragixerepts are the Xerepts that:

1. Have a fragipan within 100 cm of the mineral soil surface;

2. Do not have a duripan within 100 cm of the mineral soil surface; *and*

3. Do not have *both*:

a. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

b. Calcareous materials in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Key to Subgroups

KECA. Fragixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Fragixerepts

KECB. Other Fragixerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Fragixerepts

KECC. Other Fragixerepts that have, in one or more horizons within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragixerepts

KECD. Other Fragixerepts that have an umbric or mollic epipedon.

Humic Fragixerepts

KECE. Other Fragixerepts.

Typic Fragixerepts

Definition of Typic Fragixerepts

Typic Fragixerepts are the Fragixerepts that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have, in any horizon within 30 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions; *and*

3. Do not have an umbric or mollic epipedon.

Description of Subgroups

Typic Fragixerepts.—The central concept or Typic subgroup of Fragixerepts is fixed on soils that are free of distinct or prominent redox concentrations in the upper 30 cm, have an ochric epipedon, and do not have some andic soil properties in a layer near the surface that is as thick as 18 cm. A mantle of materials with andic soil properties between 18 and 35 cm thick indicates an intergrade to Andisols. Most Typic Fragixerepts have a perched water table above the pan at times during the winter. Shallow redox concentrations indicate intergrades to Fragiaquepts and are the basis for defining the Aquic subgroup.

Typic Fragixerepts are of small extent in the United States. They occur mostly in the Northwestern States. The native vegetation consists of mixed forest. Many of the less sloping soils have been cleared and are used as cropland or pasture. Some of the soils, mostly the steeper ones, are used as forest.

Andic and Vitrandic Fragixerepts.—These soils have a layer near the surface that is 18 cm or more thick and that contains volcanic glass or has some andic soil properties. In some soils this layer has many of the properties of Andisols. Andic and Vitrandic Fragixerepts are not extensive and are not known to occur in the United States.

Aquic Fragixerepts.—These soils have, at a shallow depth, redox concentrations of medium or high contrast and are somewhat wetter than Typic Fragixerepts. Commonly, they also have gentler slopes. Aquic Fragixerepts are of very small extent in the Northwestern United States. The native vegetation consisted of forest. Most of these soils are nearly level or gently sloping and have been cleared and are used as cropland or pasture.

Humic Fragixerepts.—These soils are like Typic Fragixerepts, but they have an umbric or mollic epipedon. They are rare in the United States.

Haploxerepts

These are the more or less freely drained Xerepts that are calcareous at some depth or have a high base status. Some of the soils have a Bk or calcic horizon, but they do not have both a calcic or petrocalcic horizon and free carbonates in all horizons above the calcic or petrocalcic horizon. Haploxerepts are moist in winter and into the spring but are thoroughly dry for much of the summer. They have a frigid, mesic, or thermic temperature regime. Slopes are gentle to very steep, and the soils are shallow to very deep. The most common vegetation on the Haploxerepts in the United States was coniferous forest on the frigid and mesic soils and grass and widely spaced trees on the thermic soils. Haploxerepts are in the Western United States. They are moderately extensive.

Definition

Haploxerepts are the Xerepts that:

1. Have:

a. Free carbonates in some part within 200 cm of the mineral soil surface; *or*

b. A base saturation (by NH_4OAc) of 60 percent or more in some horizon at a depth between 25 and 75 cm from the mineral soil surface;

2. Have neither a duripan nor a fragipan that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have *both*:

a. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

b. Free carbonates in all parts above the calcic or petrocalcic horizon, after the soil between the mineral soil surface and a depth of 18 cm has been mixed.

Key to Subgroups

KEEA. Haploxerepts that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. An umbric or mollic epipedon.

Humic Lithic Haploxerepts

KEEB. Other Haploxerepts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerepts

KEEC. Other Haploxerepts that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxerepts

KEED. Other Haploxerepts that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium

oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Haploxerepts

KEEE. Other Haploxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxerepts

KEEF. Other Haploxerepts that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxerepts

KEEG. Other Haploxerepts that have a gypsic horizon within 100 cm of the mineral soil surface.

Gypsic Haploxerepts

KEEH. Other Haploxerepts that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerepts

KEEI. Other Haploxerepts that have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haploxerepts

KEEJ. Other Haploxerepts that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haploxerepts

KEEK. Other Haploxerepts that have a slope of less than 25 percent; *and either*

1. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of 0.2 percent or more and no densic, lithic, or paralithic contact within that depth; *or*

2. An irregular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower.

Fluventic Haploxerepts

KEEL. Other Haploxerepts that have a calcic horizon or identifiable secondary carbonates within *one* of the following particle-size class and depth combinations:

1. A sandy or sandy-skeletal particle-size class and within 150 cm of the mineral soil surface; *or*

2. A clayey, clayey-skeletal, fine, or very-fine particle-size class and within 90 cm of the mineral soil surface; *or*

3. Any other particle-size class and within 110 cm of the mineral soil surface.

Calcic Haploxerepts

KEEM. Other Haploxerepts that have an umbric or mollic epipedon.

Humic Haploxerepts

KEEN. Other Haploxerepts.

Typic Haploxerepts

Definition of Typic Haploxerepts

Typic Haploxerepts are the Haploxerepts that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Do not have an umbric or mollic epipedon;

3. Have a slope of 25 percent or more; *or*

a. At a depth of 125 cm below the mineral soil surface, an organic-carbon content (Holocene age) of less than 0.2 percent or a densic, lithic, or paralithic contact within that depth; *or*

b. A regular decrease in organic-carbon content (Holocene age) between a depth of 25 cm and either a depth of 125 cm below the mineral soil surface or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have a lithic contact within 50 cm of the soil surface in 10 percent or more of each pedon;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or

more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

6. Do not have a calcic horizon or identifiable secondary carbonates within the following particle-size class and depth combinations:

a. A sandy or sandy-skeletal particle-size class and within 150 cm of the mineral soil surface; *or*

b. A clayey, clayey-skeletal, fine, or very-fine particle-size class and within 90 cm of the mineral soil surface; *or*

c. Any other particle-size class and within 110 cm of the mineral soil surface;

7. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

8. Do not have a gypsic horizon within 100 cm of the soil surface;

9. Do not have lamellae (two or more) within 200 cm of the soil surface; *and*

10. Do not have fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick.

Description of Subgroups

Typic Haploxerepts.—The central concept or Typic subgroup of Haploxerepts is fixed on moderately deep or deeper, relatively well drained soils that have an ochric epipedon. These soils do not have a Bk or calcic horizon, unless it is deep, and do not have a surface mantle that has some andic soil properties or a high content of volcanic glass.

Soils that have shallow redox depletions with low chroma and ground water in the depleted zone or artificial drainage are excluded from the Typic subgroup because these properties indicate intergrades to Aquepts and are the basis for recognition of the Aquic subgroup. A layer or a surface mantle, 18 cm or more thick, that has some andic properties or a high content of volcanic glass is excluded from the Typic subgroup because it indicates a transition to Andisols and is used to define Andic and Vitrandic subgroups. A shallow lithic contact is the basis for recognition of the Lithic subgroup. Soils that have a clayey texture accompanied by deep cracks are excluded from the Typic subgroup because these characteristics indicate intergrades to Vertisols and define the Vertic subgroup. Soils that have an umbric or mollic epipedon are not considered typical and are assigned to Humic and combination Humic subgroups. Soils that have an organic-carbon content (Holocene age) that decreases irregularly with increasing depth or that remains relatively high in the deep layers are excluded from the Typic subgroup and are considered intergrades to Fluvents and Fluvaquents. Soils that have a shallow Bk or calcic horizon are also excluded and are considered intergrades to Calcixerepts.

Typic Haploxerepts are of moderate extent. They are in the Western United States. Slopes are gentle to steep. The native vegetation consists mostly of grass and shrubs. Most of the less sloping soils are used as cropland. Some of the soils, commonly the most sloping ones, support their native vegetation and are used as rangeland.

Andic and Vitrandic Haploxerepts.—These soils have a layer or a surface mantle, 18 cm or more thick, that has some andic soil properties and that has many of the properties of Andisols. In addition, some Andic and Vitrandic Haploxerepts have an umbric epipedon. Andic and Vitrandic Haploxerepts are of small extent. Slopes are gentle to very steep. The native vegetation consists mostly of coniferous forest. Many of these soils support their native vegetation and are used as forest. Many of the less sloping soils have been cleared and are used as cropland or pasture.

Aquandic Haploxerepts.—These soils have redox depletions with low chroma (less than 2) within 75 cm of the soil surface and either are artificially drained or are saturated with water in the redox-depleted horizons at some time of the year, usually in winter or early spring. The soils also have a layer or a surface mantle, 18 cm or more thick, that has many of the properties of Andisols. In addition, Aquandic Haploxerepts commonly have an umbric epipedon. These soils are of very small extent in the United States. They occur mostly in the State of Washington. Slopes are gentle. The native vegetation consists mostly of coniferous forest. Some of these soils have been cleared and are used as cropland or pasture. Some support their native vegetation and are used as forest.

Aquic Haploxerepts.—These soils have redox depletions with low chroma (less than 2) within 75 cm of the soil surface and either are artificially drained or are saturated with water in the redox-depleted horizons at some time of the year, usually in winter or spring. These soils are of small extent in the Western United States. Slopes are gentle. The native vegetation consists mostly of coniferous forest. Many of these soils have been cleared and are used as cropland or pasture. Some support their native vegetation and are used as forest.

Calcic Haploxerepts.—These soils have, in the upper part, a calcic or Bk horizon that contains identifiable secondary carbonates. These soils are of small extent in the United States. They occur in the Western States. Slopes are gentle to very steep. The native vegetation consists mostly of grass and shrubs, but some of the soils support widely spaced trees. Most Calcic Haploxerepts support their native vegetation and are used as rangeland. Some of the less sloping soils are used as cropland.

Fluventic Haploxerepts.—These soils formed in stratified alluvium on gentle slopes. The soils are of small extent in the Western United States. The native vegetation consists mostly of grass and shrubs, but in some areas it is coniferous forest. Most of these soils have been cleared and are used as cropland or pasture. Some support their native vegetation and are used as rangeland or forest.

Fragic Haploxerepts.—These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are considered intergrades to Fragixerepts. They are not extensive in the United States.

Gypsic Haploxerepts.—These soils have a gypsic horizon within 100 cm of the mineral soil surface. They are of very small extent and are known to occur only in California in the United States.

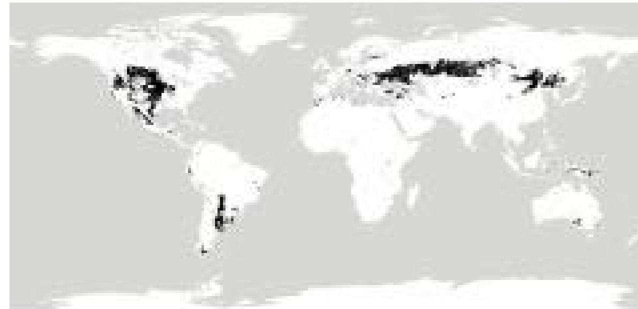
Humic Haploxerepts.—These soils have an umbric or mollic epipedon. They are otherwise like the soils of the Typic subgroup. The Humic Haploxerepts in the United States formed mostly in materials weathered from rocks or in other materials that have few or no free carbonates. Many of the soils receive a relatively high amount of precipitation. Humic Haploxerepts are of moderate extent in the Western United States. Slopes are gentle to very steep. The native vegetation consists mostly of coniferous forest. Many of these soils support their native vegetation and are used as forest. Some are cleared and are used as cropland or pasture.

Humic Lithic Haploxerepts.—These soils have an umbric or mollic epipedon and have a shallow lithic contact. In the United States, they formed mostly in materials that weathered from rocks and have few or no free carbonates. Many of the soils receive a relatively high amount of precipitation. Humic Lithic Haploxerepts are of small extent in the Western United States. Slopes are gentle to very steep. The native vegetation consists mostly of coniferous forest. Many of these soils support their native vegetation and are used as forest.

Lamellic Haploxerepts.—These soils are like Typic Haploxerepts, but they have two or more lamellae in the subsoil. They are not extensive in the United States.

Lithic Haploxerepts.—These soils have a shallow lithic contact. They are of moderate extent in the Western United States. Slopes are gentle to very steep. The native vegetation consists mostly of sparse coniferous forest. Many of these soils support their native vegetation and are used as forest or rangeland.

Vertic Haploxerepts.—These soils have a clayey texture and have deep cracks in summer if they are not irrigated. Vertic Haploxerepts are of small extent in the Western United States. Slopes are gentle to moderately steep. The native vegetation consists mostly of grass and shrubs. Most of the less sloping soils are used as cropland. Some of the soils, commonly the most sloping ones, support their native vegetation and are used as rangeland.



CHAPTER 16
Mollisols

Mollisols commonly are the very dark colored, base-rich, mineral soils of the steppes. Nearly all of these soils have a mollic epipedon. Many also have an argillic, natric, or calcic horizon. A few have an albic horizon. Some also have a duripan or a petrocalcic horizon.

Mollisols are extensive in subhumid to semiarid areas on the plains of North America, Europe, Asia, and South America. They lie generally between the Aridisols of arid climates and the Spodosols or Alfisols of humid climates. They are most extensive at mid latitudes, but they also occur at high latitudes and high altitudes and in tropical regions.

Many of these soils developed under grass at some time, although many apparently were forested at an earlier time. Some of the soils that are in the mountains or that were derived from highly calcareous parent material apparently formed under forest vegetation. Mollisols may have any of the defined temperature regimes but do not have permafrost. Soils with mollic epipedons and permafrost are Gelisols. Mollisols can have any moisture regime, but enough available moisture to support perennial grasses seems to be essential.

Most Mollisols at high latitudes formed in late-Pleistocene or Holocene deposits. Beyond the limits of glaciation, Mollisols may be in areas of older deposits or on older surfaces dating back perhaps to the mid Pleistocene or earlier, and these commonly have an argillic horizon with a reddish hue.

In frigid or warmer areas where slopes are not too steep, Mollisols are used mainly for small grain in the drier regions and maize (corn) or soybeans in the warmer, humid regions.

Definition of Mollisols and Limits Between Mollisols and Soils of Other Orders

Mollisols are mineral soils that either have a mollic epipedon or have a surface horizon that, after mixing to a depth of 18 cm, meets all of the requirements for a mollic epipedon except thickness. They also have an upper subhorizon that is more than 7.5 cm thick in an argillic or natric horizon that meets the color, organic-carbon content, base saturation, and structure requirements for a mollic epipedon but is separated from the surface horizon by an albic horizon (the combined thickness must meet the thickness requirements for a mollic epipedon), and they meet *all* of the following:

1. Unlike Gelisols, Mollisols do not have *either* of the following:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

2. Unlike Histosols, Mollisols do not have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact and have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 6 months or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more;

3. Unlike Spodosols, Mollisols do not have a spodic horizon or an Ap horizon containing 85 percent or more spodic materials and do not have *one or more* of the following:

a. An albic horizon in 50 percent or more of each pedon and a cryic soil temperature regime; *or*

b. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature soil regime; *or*

(e) A cryic temperature soil regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy particle-size class between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) Either at a depth of 25 cm or more below the mineral soil surface, at the top of a duripan or fragipan, or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth if the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime or if the soil has a cryic temperature regime;

4. Unlike Andisols, Mollisols must not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower than 60 cm;

5. Unlike Oxisols, Mollisols must not have:

a. An oxic horizon within 150 cm of the soil surface; *or*

b. *Both*:

(1) 40 percent or more clay in the surface 18 cm of the mineral soil after mixing; *and*

(2) A kandic horizon with less than 10 percent weatherable minerals within 150 cm of the soil surface;

6. Unlike Vertisols, Mollisols must not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, duripan, or petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically;

7. Unlike Aridisols, Mollisols must:

a. Have a mollic epipedon; *and*

b. Not have a salic horizon if they also have *all* of the following:

(1) Saturation with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

(2) A moisture control section that is, in at least some part, dry in normal years; *and*

(3) No sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface;

8. Unlike Alfisols and Ultisols, Mollisols must have:

a. *Either*:

(1) A mollic epipedon; *or*

(2) Both a surface horizon that meets all of the requirements for a mollic epipedon except thickness after the soil has been mixed to a depth of 18 cm and a subhorizon more than 7.5 cm thick, within the upper part of an argillic, kandic, or natric horizon, that meets the color, organic-carbon content, base saturation, and structure requirements for a mollic epipedon but is separated from the surface horizon by an albic horizon; *and*

b. An argillic, kandic, or natric horizon that has a base saturation of 50 percent or more (by NH_4OAc) in the upper 125 cm or in all subhorizons if the argillic horizon is less than 125 cm thick; *and*

9. Unlike Inceptisols and Entisols, Mollisols have both a mollic epipedon and a base saturation of 50 percent or more (by NH_4OAc) in all subhorizons to a depth of 180 cm below the mineral soil surface.

Representative Pedon and Data

Following is a description of a representative Mollisol. Data for the pedon identified in this description are given in the table "Characterization Data for a Mollisol."

Classification: Fine-silty, mixed, superactive, mesic Pachic Argiustoll
Site identification number: 79P0146
Location: Gosper County, Nebraska; 135 m east and 750 m north of the southwest corner of sec. 7, T. 7 N., R. 22 W.

Landscape: Plains
Soil moisture regime: Ustic
Depth to water table: More than 150 cm
Permeability class: Moderate
Land use: Cropland
Parent material: Loess
Diagnostic horizons: A mollic epipedon from a depth of 0 to 71 cm and an argillic horizon from a depth of 30 to 91 cm
Described by: M. Dixon and S. Scheinost

In the following pedon description, colors are for dry soil unless otherwise indicated.

Ap—0 to 18 cm; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, very friable, nonsticky; common fine roots; abrupt smooth boundary.
A—18 to 30 cm; dark grayish brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine and medium subangular blocky structure; slightly hard, very friable, slightly sticky; common fine roots; clear smooth boundary.
Bt1—30 to 49 cm; dark gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; hard, friable, slightly sticky; common fine roots; common faint clay films on faces of peds; clear smooth boundary.
Bt2—49 to 71 cm; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; slightly hard, friable, slightly sticky; few fine roots; few fine tubular pores; common faint clay films on faces of peds; clear wavy boundary.
Bt3—71 to 91 cm; dark grayish brown (10YR 4/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak coarse prismatic structure parting to moderate medium subangular blocky; few clay films on faces of prisms; few fine roots; gradual wavy boundary.
BC—91 to 117 cm; light brownish gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist; weak medium prismatic structure parting to weak fine subangular blocky; slightly hard, very friable, nonsticky; few fine tubular pores; few old root channels; gradual wavy boundary.
BCk1—117 to 142 cm; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, nonsticky; few very fine tubular pores; common fine and medium concretions of lime; common old root channels; slightly effervescent; diffuse wavy boundary.
BCk2—142 to 165 cm; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak coarse prismatic structure; slightly hard, very friable, nonsticky; coatings of lime or carbonate on faces of peds and in pores; common fine and medium soft masses of lime; slightly effervescent.

Key to Suborders

IA. Mollisols that have:

1. An argillic or natric horizon; *and*

2. An albic horizon that has chroma of 2 or less and is 2.5 cm or more thick, has its lower boundary 18 cm or more below the mineral soil surface, and either lies directly below the mollic epipedon or separates horizons that together meet all of the requirements for a mollic epipedon; *and*

3. In one or more subhorizons of the albic horizon and/or of the argillic or natric horizon and within 100 cm of the mineral soil surface, redox concentrations in the form of masses or concretions, or both, and also aquic conditions for some time in normal years (or artificial drainage).

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IB. Other Mollisols that have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and *one or more* of the following:

1. A histic epipedon overlying the mollic epipedon; *or*

2. An exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in the upper part of the mollic epipedon and a decrease in ESP (or SAR) values with increasing depth below 50 cm from the mineral soil surface; *or*

3. A calcic or petrocalcic horizon that has its upper boundary within 40 cm of the mineral soil surface; *or*

4. A mollic epipedon, with chroma of 1 or less, that extends to a lithic contact within 30 cm of the mineral soil surface; *or*

5. *One* of the following colors:

a. Chroma of 1 or less in the lower part of the mollic epipedon;[1] *and either*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Either directly below the mollic epipedon or within 75 cm of the mineral soil surface if a calcic horizon intervenes, a color value, moist, of 4 or more and *one* of the following:

(a) 50 percent or more chroma of 1 on faces of peds or in the matrix, hue of 10YR or redder, and redox concentrations; *or*

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[1] If the mollic epipedon extends to a lithic contact within 30 cm of the mineral soil surface, the requirement for redoximorphic features is waived.

Characterization Data for a Mollisol

SITE IDENTIFICATION NO.: 79P0146
CLASSIFICATION: FINE-SILTY, MIXED, SUPERACTIVE, MESIC PACHIC ARGIUSTOLL
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	(- - -TOTAL - - -) CLAY LT .002	SILT .002 -.05	SAND .05 -2	(- -CLAY- -) FINE LT .0002	CO_3 LT .002	(- -SILT- -) FINE .002 -.02	COARSE .02 -.05	(- - - - -SAND- - - - - -) VF .05 -.10	F .10 -.25	M .25 -.50	C .5 -1	VC 1 -2	(-COARSE FRACTIONS(mm)-) - - - WEIGHT - - - 2 -5	5 -20	20 -75	.1- 75	(>2mm) WT PCT OF WHOLE SOIL
			<- - - Pct of <2mm (3A1)											- - ->	<- Pct of <75mm(3B1)->				SOIL
79P 720	0- 18	Ap	21.1	61.0	17.9	14.8		21.6	39.4	16.9	0.4	0.3	0.1	0.2	--	--	--	1	--
79P 721	18- 30	A	21.4	61.0	17.6	16.4		21.0	40.0	16.6	0.6	0.2	0.1	0.1	--	--	--	1	--
79P 722	30- 49	Bt1	27.5	58.5	14.0	21.2		20.8	37.7	12.7	0.6	0.4	0.2	0.1	--	--	--	1	--
79P 723	49- 71	Bt2	28.5	53.9	17.6	22.3		20.6	33.3	16.7	0.4	0.3	0.1	0.1	--	--	--	1	--
79P 724	71- 91	Bt3	25.9	55.5	18.6	18.8		20.9	34.6	18.0	0.3	0.2	0.1	TR	--	--	--	1	--
79P 725	91-117	BC	21.7	56.5	21.8	13.0		20.9	35.6	20.9	0.6	0.2	0.1	TR	--	--	--	1	--
79P 726	117-142	BCk1	19.6	59.4	21.0	8.5	0.3	23.0	36.4	20.3	0.4	0.2	0.1	TR	--	--	--	1	--
79P 727	142-165	BCk2	18.4	56.3	25.3	7.3		22.2	34.1	24.6	0.4	0.2	0.1	TR	--	--	--	1	--

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B1b <2mm	EXTR P 6S1a ppm	TOTAL S 6R3a	(- - DITH-CIT - -) EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG) - LIMITS - LL 4F1	PI 4F	(- BULK DENSITY -) FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	(- - -WATER CONTENT - -) FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2	WRD WHOLE SOIL 4C1
				<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 18	1.52	0.149			0.4	0.1	TR	0.96	0.53	33	10		1.31	1.43	0.030		34.6	27.2	11.1	0.21
18- 30	1.14	0.122			0.4	0.1	TR	0.93	0.52	34	12		1.34	1.45	0.027		32.3	25.7	11.2	0.19
30- 49	0.99	0.097			0.5	0.1	TR	0.90	0.52	42	22		1.32	1.48	0.039		30.5	27.2	14.3	0.17
49- 71	0.61	0.067			0.5	0.1	TR	0.88	0.54	44	23		1.46	1.62	0.035		27.5	25.1	15.4	0.14
71- 91	0.40	0.049			0.5	0.1	TR	0.90	0.53	42	21		1.47	1.58	0.024		26.6	23.4	13.6	0.14
91-117	0.26	0.039			0.4	0.1	TR	1.00	0.53	34	13		1.41	1.49	0.019		28.4	22.7	11.6	0.16
117-142	0.18	0.027			0.4	0.1	TR	1.09	0.57	32	11		1.36	1.43	0.017		33.0	25.2	11.2	0.19
142-165	0.15	0.022			0.4	0.1	TR	1.13	0.57	32	9		1.32	1.38	0.015		37.1	23.8	10.4	0.18

DEPTH (cm)	(- NH_4OAc EXTRACTABLE BASES -) Ca 5B4a 6N2e	Mg 5B4a 6O2d	Na 5B4a 6P2b	K 5B4a 6Q2b	SUM BASES	ACID-ITY 6H2b	(- -CEC- -) SUM CATS 5A3a	NH_4-OAc 5A6a	EXCH Na 5D2 Pct	SAR 5E	BASE SATURATION SUM 5C3	NH_4OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1b Pct	RES. ohms /cm 8E1	$CaSO_4$ AS GYPSUM <2mm 6F1c	<20mm 6F1c	(- - - -PH - - -) SAT PASTE 8C1b	$CaCl_2$ .01M 8C1e 1:2	H_2O 8C1a 1:1
	<- - - - - - - - - -meq / 100 g							- - - ->			<- -Pct- >				<- -Pct ->				
0- 18	12.0	3.0	TR	2.6	17.6	6.0	23.6	20.3	TR		75	87						5.7	6.3
18- 30	14.6	3.7	0.1	1.4	19.8	7.6	27.4	19.8	TR		72	100	TR					5.6	6.1
30- 49	18.1	5.7	0.1	1.0	24.9	4.1	29.0	24.7	TR		86	100	TR					6.4	7.0
49- 71	17.3	6.2	0.2	1.4	25.1	3.8	28.9	25.0	1		87	100	TR					6.5	7.1
71- 91	16.2	5.6	0.2	1.5	23.5	2.7	26.2	23.3	1		90	100	TR					6.9	7.4
91-117	18.3	5.6	0.2	1.8	25.9	1.7	27.6	21.8	1	TR	94	100	TR	2200			7.4	7.4	8.0
117-142		6.9	0.2	2.2				21.4	1		100	100	2					7.8	8.5
142-165		7.6	0.3	2.4				20.8	1		100	100	3					7.9	8.6

DEPTH (cm)	(- - -WATER EXTRACTED FROM SATURATED PASTE- - -) Ca 6N1b	Mg 6O1b	Na 6P1b	K 6Q1b	CO_3 6I1b	HCO_3 6J1b	F 6U1a	Cl 6K1c	SO_4 6L1c	NO_2 6W1a	NO_3 6M1c	H_2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A1a mmhos /cm	PRED. ELEC. COND. 8I mmhos /cm
	< - - - - - - - - - - -meq / liter										- - - ->	<- -Pct- ->			
91-117	2.0	1.0	0.4	0.7	--	3.4	--	0.1	0.2	--	--	74.0	TR	0.42	

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i Peak size				THERMAL DTA 7A6 Percent	TGA 7A4b Percent	ELEMENTAL 7C3 SiO_2 Percent	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 mg/g	INTERPRETATION
79P 720	TCLY	MI 3	KK 2	MT 2	QZ 1					6.0			2.5			
79P 721	TCLY	MI 3	KK 2	MT 2	QZ 1					6.3			2.4			
79P 722	TCLY	MT 4	MI 3	KK 2	QZ 1	KK15				6.7			2.2			
79P 723	TCLY	MT 3	MI 2	KK 2	QZ 1					6.1			2.0			
79P 724	TCLY	MT 3	MI 3	KK 2	QZ 1					6.9			2.2			
79P 725	TCLY	MT 3	MI 2	KK 2	QZ 1					6.3			2.3			
79P 726	TCLY	MT 3	MI 2	KK 2	QZ 1					6.1			2.2			
79P 727	TCLY	MT 2	MI 1	KK 1	QZ 1					6.3			2.2			

Characterization Data for a Mollisol--Continued

SAMPLE NUMBER	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
	SAND - SILT MINERALOGY (2.0-0.002mm)																			
	FRAC-	X-RAY				THERMAL				OPTICAL									INTER-	
SAMPLE	TION					DTA		TGA		TOT RE	GRAIN COUNT								PRETA-	
		7A2i				7A3c		7A4c		7B1a									TION	
NUMBER		Peak Size				Percent				Percent										
79P 722	CSi									61	QZ52	FK19	FP 7	GS 6	CD 4	PO 3				
79P 722	CSi										GA 2	HN 1	AR 1	FE 1	OP 1	MS 1				
79P 722	CSi										PR 1	BTtr	BYtr	STtr	ZRtr	RUtr				
79P 722	CSi										EPtr	GNtr	TMtr	TEtr	APtr					
79P 723	CSi									60	QZ51	FK25	FP 7	CD 4	PO 3	GS 2				
79P 723	CSi										HN 2	AR 2	OP 1	MS 1	GA 1	TM 1				
79P 723	CSi										FEtr	BTtr	PRtr	STtr	ZEtr	GNtr				
79P 723	CSi										CTtr	APtr	ZRtr	BYtr	TEtr					
79P 724	CSi									61	QZ54	FK22	FP 7	CD 4	GS 3	AR 3				
79P 724	CSi										HN 2	MS 2	OP 2	PR 1	FE 1	POtr				
79P 724	CSi										BTtr	ZRtr	ZEtr	FZtr	CTtr	GNtr				
79P 724	CSi										APtr	BYtr	RUtr	TMtr						

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm; CSi, coarse silt, 0.02-0.05 mm.
Mineral interpretation: MI, mica; KK, kaolinite; MT, montmorillonite; QZ, quartz; FK, potassium feldspar; FP, plagioclase feldspar; GS, glass; CD, chalcedony; PO, plant opal; GA, glass aggregate; HN, hornblende; AR, weathered aggregate; FE, iron oxides; OP, opaques; MS, muscovite; PR, pyroxene; BT, biotite; BY, beryl; ST, stilbite; ZR, zircon; RU, rutile; EP, epidote; GN, garnet; TM, tourmaline; TE, tremolite; AP, apatite; ZE, zeolite; CT, cassiterite; FZ, feldspathoid.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.

(b) 50 percent or more chroma of 2 or less on faces of peds or in the matrix, hue of 2.5Y, and redox concentrations; *or*

(c) 50 percent or more chroma of 1 on faces of peds or in the matrix and hue of 2.5Y or yellower; *or*

(d) 50 percent or more chroma of 3 or less on faces of peds or in the matrix, hue of 5Y, and redox concentrations; *or*

(e) 50 percent or more chroma of 0 on faces of peds or in the matrix; *or*

(f) Hue of 5GY, 5G, 5BG, or 5B; *or*

(g) Any color if it results from uncoated sand grains; *or*

b. Chroma of 2 in the lower part of the mollic epipedon; *and either*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Directly below the mollic epipedon, *one* of the following matrix colors:

(a) A color value, moist, of 4, chroma of 2, and some redox depletions with a color value, moist, of 4 or more and chroma of 1 or less; *or*

(b) A color value, moist, of 5 or more, chroma of 2 or less, and redox concentrations; *or*

(c) A color value, moist, of 4 and chroma of 1 or less; *or*

6. At a depth between 40 and 50 cm from the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquolls, p. 563

IC. Other Mollisols that:

1. Have a mollic epipedon less than 50 cm thick; *and*

2. Do not have an argillic or calcic horizon; *and*

3. Have, either within or directly below the mollic epipedon, mineral soil materials less than 7.5 cm in diameter that have a $CaCO_3$ equivalent of 40 percent or more; *and*

4. Have either or both a udic moisture regime or a cryic soil temperature regime.

Rendolls, p. 584

ID. Other Mollisols that have a cryic soil temperature regime.

Cryolls, p. 575

IE. Other Mollisols that have either a xeric moisture regime or an aridic moisture regime that borders on xeric.

Xerolls, p. 630

IF. Other Mollisols that have either an ustic moisture regime or an aridic moisture regime that borders on ustic.

Ustolls, p. 601

IG. Other Mollisols.

Udolls, p. 586

Albolls

Albolls are the Mollisols that have an albic horizon and fluctuating ground water. Most of these soils are saturated with water to or near the soil surface at some time during winter or spring in normal years. In summer ground water commonly is not within a depth of 200 cm. Below the albic horizon, there is either an argillic or, less commonly, a natric horizon. These soils developed mostly on broad, nearly level to sloping ridges, on back slopes, or in closed depressions. Most have episaturation. In the United States, most Albolls are in areas of late-Pleistocene deposits. Most Albolls developed under grass or grass and shrub vegetation. In early stages of development, some are thought to have had forest vegetation that was replaced by grass. Because slopes are gentle, most of the Albolls in the United States are now cultivated.

Definition

Albolls are the Mollisols that have *all* of the following:

1. An argillic or natric horizon; *and*

2. An albic horizon that has chroma of 2 or less and that is 2.5 cm or more thick, has its lower boundary 18 cm or more below the mineral soil surface, and either lies directly below the mollic epipedon or separates horizons that together meet all of the requirements for a mollic epipedon; *and*

3. In one or more subhorizons of the albic horizon and/or of the argillic or natric horizon and within 100 cm of the mineral soil surface, redox concentrations in the form of masses or concretions, or both, and also aquic conditions for some time in normal years (or artificial drainage).

Key to Great Groups

IAA. Albolls that have a natric horizon.

Natralbolls, p. 562

IAB. Other Albolls.

Argialbolls, p. 560

Argialbolls

These are the Albolls that have an argillic horizon but do not have a natric horizon. Most of the soils have very dark gray to black coatings of humus and clay on the peds in the upper part of the argillic horizon. In the United States, these soils are most extensive in the loess-covered areas of the Midwestern States where temperature regimes are mesic. A very few of the soils have a frigid or thermic temperature regime. A distinct moisture deficit in summer and a moisture surplus in winter and spring seem to be essential to the genesis of these soils. Argialbolls are associated on the landscape with soils of all other suborders of Mollisols, except possibly for Rendolls. Because they have gentle slopes, most of the Argialbolls in the United States are cultivated.

Definition

Argialbolls are the Albolls that have an argillic horizon but do not have a natric horizon.

Key to Subgroups

IABA. Argialbolls that have *both*:

1. *One or both* of the following:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. If not irrigated, a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Xerertic Argialbolls

IABB. Other Argialbolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm

or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argialbolls

IABC. Other Argialbolls that:

1. Do not have an abrupt textural change from the albic to the argillic horizon; *and*

2. If not irrigated, have a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Argiaquic Xeric Argialbolls

IABD. Other Argialbolls that do not have an abrupt textural change from the albic to the argillic horizon.

Argiaquic Argialbolls

IABE. Other Argialbolls that, if not irrigated, have a moisture control section that in normal years is dry in all parts for 45 or more consecutive days during the 120 days following the summer solstice.

Xeric Argialbolls

IABF. Other Argialbolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Argialbolls

IABG. Other Argialbolls.

Typic Argialbolls

Definition of Typic Argialbolls

Typic Argialbolls are the Argialbolls that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Have an abrupt textural change from the albic to the argillic horizon;

3. When not irrigated, have a moisture control section that in normal years is not dry in all parts for as long as 45 consecutive days during the 120 days following the summer solstice; *and*

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Argialbolls.—The central concept or Typic subgroup of Argialbolls is fixed on soils that are saturated with water at some season long enough to have a low chroma dominant in the albic horizon and that receive enough summer rainfall for the moisture control section to be moistened, at least in some part, at frequent intervals in normal years. In addition, the argillic horizon has an abrupt upper boundary, has a markedly greater percentage of clay than the albic horizon, and has the accessory property of low or very low hydraulic conductivity when the water content is at or above field capacity.

Prolonged dryness of the moisture control section occurs in Mediterranean climates. It is a property of the Xeric suborder of Mollisols and is the basis for defining the Xeric subgroups of Argialbolls. A gradual upper boundary of the argillic horizon or a small difference in the percentage of clay between the albic and argillic horizons indicates an intergrade to Argiaquolls. A surface mantle that shows the influence of pyroclastic materials has many of the properties of Andisols and is the basis for defining the Aquandic subgroup.

Typic Argialbolls are of moderate extent in the United States and are mostly on the Great Plains. Most of these soils supported water-tolerant grasses, sedges, and shrubs. Most are used as cropland or hayland, and many are artificially drained. Some are used as grazing land and some as wildlife habitat.

Aquandic Argialbolls.—These soils are like Typic Argialbolls, but they have a layer in the upper 75 cm that is 18 cm or more thick and has some andic soil properties. The clays in this layer normally do not disperse well and have a high pH-dependent charge. Typically, this layer is at or very close to the soil surface. Aquandic Argialbolls are of very small extent in the United States and are known to occur only in California and Oregon.

Argiaquic Argialbolls.—These soils are like Typic Argialbolls, but they do not have the abrupt textural change required of Typic Argialbolls. They are considered to be intergrades to Argiaquolls. The hydraulic conductivity in the argillic horizon of soils in the Argiaquic subgroup normally is greater than that of Typic Argialbolls. Most Argiaquic Argialbolls supported water-tolerant grasses. Many have been artificially drained and are used as cropland or hayland. Some are used as grazing land and some as wildlife habitat.

Argiaquic Xeric Argialbolls.—These soils consistently have long periods in summer when the moisture control section is dry, and they do not have the abrupt textural change that marks the Typic subgroup. In these properties they resemble Xerolls and Argiaquolls. Argiaquic Xeric Argialbolls are of small extent in the United States and are known to occur only in Oregon, Idaho, and Montana. Some of these soils supported trees, and some supported mostly water-tolerant grasses and shrubs. Most of the soils are used as cropland, hayland, or pasture. Some are used as rangeland.

Vertic Argialbolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of small extent in the United States. They occur throughout the Great Plains. These soils supported mostly water-tolerant grasses. Most are used as cropland or hayland. Some have been artificially drained. Some are used as grazing land and some as wildlife habitat.

Xerertic Argialbolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They consistently have long periods in summer when the moisture control section is dry. These soils are of small extent in the United States and are known to occur only in Oregon and Idaho. Some of the soils supported coniferous forest vegetation, and some supported mostly water-tolerant grasses. Most of the soils are used as cropland or hayland. Some are used as forest and some as grazing land.

Xeric Argialbolls.—These soils consistently have long periods in summer when the moisture control section is dry. They are of moderate extent in the United States and occur mostly in the Northwestern States. Most of these soils supported water-tolerant grasses, and some supported coniferous forest vegetation. Most are used as cropland or hayland. Some are used as grazing land and some as forest.

Natralbolls

These are the Albolls that have a natric horizon. The natric horizon normally lies very close to the surface. These soils commonly have a thin epipedon overlying an albic horizon. The color of the upper part of the soils, after mixing to a depth of 18 cm, however, is dark enough for a mollic epipedon because the epipedon and the natric horizon are dark colored. Ground water is shallow during part of the year, and capillary rise in many Natralbolls has concentrated salts, including sodium salts, in the upper 50 cm of the soils.

Natralbolls are known to occur only in subhumid and humid regions. They are in areas of late-Pleistocene till plains and lacustrine deposits or Holocene deposits. The vegetation consists of grasses and sedges. The soils are used as cropland or rangeland, or the grasses are cut for hay.

Definition

Natralbolls are the Albolls that have a natric horizon.

Key to Subgroups

IAAA. Natralbolls that have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Leptic Natralbolls

IAAB. Other Natralbolls.

Typic Natralbolls

Definition of Typic Natralbolls

Typic Natralbolls are the Natralbolls that do not have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Description of Subgroups

Typic Natralbolls.—The central concept or Typic subgroup of Natralbolls is fixed on soils that do not have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface. The salts adversely affect the use of these soils and are the basis for defining the Leptic subgroup. These soils are of very small extent in the United States. They are mostly on the northern Great Plains. They supported mostly salt-tolerant grasses and sedges. Slopes generally are gentle, and many of these soils are cultivated. Some of the soils are used as rangeland or hayland.

Leptic Natralbolls.—These soils have visible evidence of salts at least as soluble as gypsum within 40 cm of the soil surface. They have thinner sola than those of the Typic subgroup, and the close proximity of the soluble salts to the surface restricts plant growth. Leptic Natralbolls are moderately extensive on the northern Great Plains of the United States. They are on gentle slopes and are used primarily as rangeland.

Aquolls

Aquolls are the Mollisols that are wet and that have dominant low chroma, commonly in olive hues, and have high-contrast redox depletions in or below the epipedon. These soils commonly develop in low areas where water collects and stands, but some are on broad flats or on seepy hillsides. Most of the soils have had a vegetation of grasses, sedges, and forbs, but a few also have had forest vegetation. In the United States, Aquolls are most extensive in glaciated areas of the Midwestern States where the drift or loess was calcareous. In a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, Aquolls have aquic conditions or are artificially drained. They can have any temperature regime from cryic to isohyperthermic.

Definition

Aquolls are the Mollisols that have, in a layer above a densic, lithic, or paralithic contact or in a layer at a depth between 40 and 50 cm from the mineral soil surface, whichever is shallower, aquic conditions for some time in normal years (or artificial drainage) and meet *one or more* of the following:

1. Have a histic epipedon overlying the mollic epipedon; *or*

2. Have an exchangeable sodium percentage (ESP) of 15 or more (or a sodium adsorption ratio [SAR] of 13 or more) in the upper part of the mollic epipedon and a decrease in ESP (or SAR) values with increasing depth below 50 cm from the mineral soil surface; *or*

3. Have a calcic or petrocalcic horizon that has its upper boundary within 40 cm of the mineral soil surface; *or*

4. Have a mollic epipedon, with chroma of 1 or less, that extends to a lithic contact within 30 cm of the mineral soil surface; *or*

5. Have *one* of the following colors:

a. Chroma of 1 or less in the lower part of the mollic epipedon; *and either*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Either directly below the mollic epipedon or within 75 cm of the mineral soil surface if a calcic horizon intervenes, a color value, moist, of 4 or more and *one* of the following:

(a) 50 percent or more chroma of 1 on faces of peds or in the matrix, hue of 10YR or redder, and redox concentrations; *or*

(b) 50 percent or more chroma of 2 or less on faces of peds or in the matrix, hue of 2.5Y, and redox concentrations; *or*

(c) 50 percent or more chroma of 1 on faces of peds or in the matrix and hue of 2.5Y or yellower; *or*

(d) 50 percent or more chroma of 3 or less on faces of peds or in the matrix, hue of 5Y, and redox concentrations; *or*

(e) 50 percent or more chroma of 0 on faces of peds or in the matrix; *or*

(f) Hue of 5GY, 5G, 5BG, or 5B; *or*

(g) Any color if it results from uncoated sand grains; *or*

b. Chroma of 2 in the lower part of the mollic epipedon; *and either*

(1) Distinct or prominent redox concentrations in the lower part of the mollic epipedon; *or*

(2) Matrix colors directly below the mollic epipedon as follows: *either*

(a) A color value, moist, of 4, chroma of 2, and some redox depletions with a color value, moist, of 4 or more and chroma of 1 or less; *or*

(b) A color value, moist, of 5 or more, chroma of 2 or less, and redox concentrations; *or*

(c) A color value, moist, of 4 and chroma of 1 or less; *or*

6. At a depth between 40 and 50 cm from the mineral soil surface, have enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *and*

7. Do not have both an albic horizon and, within 100 cm of the mineral soil surface, any subhorizon of the albic horizon and/or of the argillic or natric horizon that has redox concentrations in the form of masses or concretions, or both, and also aquic conditions.

Key to Great Groups

IBA. Aquolls that have a cryic soil temperature regime.
Cryaquolls, p. 566

IBB. Other Aquolls that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.
Duraquolls, p. 568

IBC. Other Aquolls that have a natric horizon.
Natraquolls, p. 574

IBD. Other Aquolls that have a calcic or gypsic horizon that has its upper boundary within 40 cm of the mineral soil surface but do not have an argillic horizon unless it is a buried horizon.
Calciaquolls, p. 565

IBE. Other Aquolls that have an argillic horizon.
Argiaquolls, p. 564

IBF. Other Aquolls that have episaturation.
Epiaquolls, p. 571

IBG. Other Aquolls.
Endoaquolls, p. 569

Argiaquolls

These are the Aquolls that have both an argillic horizon and a temperature regime warmer than cryic. In these soils the depth to ground water fluctuates appreciably and commonly is shallow in winter and spring but deep in summer. Most of the Argiaquolls in the United States have been drained and are used as cropland. They are extensive and are widely distributed throughout the Midwest and the western parts of the country.

Definition

Argiaquolls are the Aquolls that:

1. Have an argillic horizon but do not have a natric horizon; *and*

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Have a soil temperature regime that is warmer than cryic.

Key to Subgroups

IBEA. Argiaquolls that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Argiaquolls

IBEB. Other Argiaquolls that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Argiaquolls

IBEC. Other Argiaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiaquolls

IBED. Other Argiaquolls that have an argillic horizon that, with increasing depth, has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within its upper 7.5 cm.

Abruptic Argiaquolls

IBEE. Other Argiaquolls.

Typic Argiaquolls

Definition of Typic Argiaquolls

Typic Argiaquolls are the Argiaquolls that:

1. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below the upper boundary;

2. Have a texture finer than loamy fine sand in some subhorizon within 50 cm of the mineral soil surface; *and*

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Argiaquolls.—The central concept or Typic subgroup of Argiaquolls is fixed on soils that have a gradual textural change at the top of the argillic horizon, have a loamy or clayey particle-size class close to the surface, but do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. An abrupt textural change is the basis for defining Abruptic extragrades of Argiaquolls. A sandy surface layer more than 50 cm thick is the basis for defining Arenic and Grossarenic extragrades. Deep cracks, slickensides, wedge-shaped aggregates, and a high linear extensibility are characteristics shared with Vertisols and are the basis for defining the Vertic subgroup.

Typic Argiaquolls are extensive in the United States. They are widely distributed, but the largest extent is in the Midwest and on the Great Plains. These soils supported mostly water-tolerant grasses, sedges, and shrubs. Most have been artificially drained and are used as cropland. Some are used as grazing land or hayland and some as wildlife habitat.

Abruptic Argiaquolls.—These soils have an abrupt textural change at the top of the argillic horizon. They become dry in the moisture control section in normal years. They may be intergrades to Argialbolls, but they show no clear evidence of the development of an albic horizon. These soils are of small extent in the United States and occur mostly on the Great Plains. They supported mostly water-tolerant grasses, sedges, and shrubs. Slopes are gentle, and most of the soils have been artificially drained and are used as cropland or hayland. Some of the soils are used as grazing land and some as wildlife habitat.

Arenic Argiaquolls.—These soils have a sandy or sandy-skeletal particle-size class to a depth between 50 and 100 cm. These soils are of very small extent in the United States and are known to occur only in Florida.

Grossarenic Argiaquolls.—These soils have a sandy or sandy-skeletal particle-size class to a depth of more than 100 cm. They are of very small extent in the United States and are known to occur only in Florida.

Vertic Argiaquolls.—These soils are like Typic Argiaquolls, but they are high in content of expanding clays and have cracks, slickensides, wedge-shaped aggregates, or a high linear extensibility. Most of the soils in this subgroup have a clayey particle-size class in a significant part. These soils are of moderate extent in the United States and occur mostly on the Great Plains. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils have been artificially drained and are used as cropland or hayland. Some are used as grazing land and some as wildlife habitat.

Calciaquolls

These are the Aquolls that have a shallow calcic or gypsic horizon. They have a temperature regime warmer than cryic, do not have a natric or argillic horizon, and do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface. Capillary rise of calcium-rich water and then evapotranspiration have been important processes in the genesis of these soils. In the humid parts of the United States, the soils commonly formed around the margins of shallow, intermittent ponds in closed depressions left by glaciers. In semiarid and arid areas, the soils are mainly on flood plains, low terraces, and the margins of Pleistocene lakes where ground water is shallow. A calcic horizon normally is at or very close to the surface of the soils. Carbonates in high concentrations act as a white pigment, and not all Calciaquolls have a surface horizon that is dark colored when dry. Aquolls with a gypsic horizon are included with Calciaquolls, but no Calciaquolls with a gypsic horizon have been recognized in the United States.

Calciaquolls are moderately extensive in the United States. Most are calcareous from the surface downward, and problems with plant chlorosis are common. In humid regions potassium deficiency in plants can be severe. In arid regions salinity may be a problem.

Definition

Calciaquolls are the Aquolls that:

1. Have a calcic or gypsic horizon that has its upper boundary within 40 cm of the mineral soil surface;

2. Have a soil temperature regime warmer than cryic;

3. Do not have a natric or argillic horizon; *and*

4. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IBDA. Calciaquolls that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Petrocalcic Calciaquolls

IBDB. Other Calciaquolls that have 50 percent or more chroma of 3 or more on faces of peds or in the matrix of one or more horizons within 75 cm of the mineral soil surface or that have the following colors directly below the mollic epipedon:

1. Hue of 2.5Y or yellower and chroma of 3 or more; *or*

2. Hue of 10YR or redder and chroma of 2 or more; *or*

3. Hue of 2.5Y or yellower and chroma of 2 or more if there are no distinct or prominent redox concentrations.
Aeric Calciaquolls

IBDC. Other Calciaquolls.
Typic Calciaquolls

Definition of Typic Calciaquolls

Typic Calciaquolls are the Calciaquolls that:

1. Have more than 50 percent chroma of 2 or less on faces of peds or in the matrix in all horizons within 75 cm of the mineral soil surface or have the following colors directly below the mollic epipedon:

a. Hue of 2.5Y or yellower, chroma of 2 or less, and distinct or prominent redox concentrations; *or*

b. Hue of 2.5Y or yellower and chroma of 1; *or*

c. Hue of 10YR or redder and chroma of 1; *or*

d. Chroma of 0; *and*

2. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Calciaquolls.—The central concept or Typic subgroup of Calciaquolls is fixed on soils that have redox concentrations with high chroma or have low chroma at a shallow depth and that do not have a petrocalcic horizon above a depth of 100 cm.

The absence of redox concentrations that have high chroma and chroma in the matrix higher than that of the Typic subgroup are evidence of somewhat better natural drainage than that of the Typic subgroup, and these properties are the basis for defining the Aeric subgroup. A shallow petrocalcic horizon is known to occur only in arid climates and is not considered normal. It is the basis for defining the Petrocalcic subgroup. Calciaquolls that have a gypsic horizon are included in the Typic subgroup, but none are known to occur in the United States.

Typic Calciaquolls are moderately extensive in the United States. They are widely distributed, but the largest extent is in the Midwest and on the Great Plains. These soils supported mostly water-tolerant grasses, sedges, and shrubs. Most are used as grazing land or hayland. Some are used as cropland and some as wildlife habitat.

Aeric Calciaquolls.—These soils have chroma higher than that of Typic Calciaquolls and are deeper to redox concentrations. Ground water is normally deeper than in soils of the Typic subgroup. Aeric Calciaquolls are of moderate extent in the United States, mostly on the Great Plains. They supported mostly water-tolerant grasses and shrubs. Most of the soils are used as cropland, grazing land, or hayland, but some are used as wildlife habitat.

Petrocalcic Calciaquolls.—These soils have a petrocalcic horizon within 100 cm of the mineral soil surface and commonly within 50 cm. They are mostly on the margins of Pleistocene lakes in arid regions. The processes that produced the petrocalcic horizon are not understood. These soils are of very small extent in the United States and are known to occur only in Utah.

Cryaquolls

Cryaquolls are the cold Aquolls of high elevations or high latitudes. Because they are both wet and cold, most of these soils are not cultivated. The presence or absence of horizons used to define the great groups of warmer soils has less significance to the use of these soils, although the processes that produced the horizons appear to be similar. Cryaquolls may have an argillic or cambic horizon or a shallow calcic horizon. In the United States, these soils are mostly in high mountain valleys in the West, but they are not extensive. They are used mostly for grazing, or the grasses are cut for hay.

Definition

Cryaquolls are the Aquolls that have a cryic temperature regime.

Key to Subgroups

IBAA. Cryaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Cryaquolls

IBAB. Other Cryaquolls that have a histic epipedon.

Histic Cryaquolls

IBAC. Other Cryaquolls that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Cryaquolls

IBAD. Other Cryaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Cryaquolls

IBAE. Other Cryaquolls that have an argillic horizon.

Argic Cryaquolls

IBAF. Other Cryaquolls that have a calcic horizon either within or directly below the mollic epipedon.

Calcic Cryaquolls

IBAG. Other Cryaquolls that have a mollic epipedon 50 cm or more thick.

Cumulic Cryaquolls

IBAH. Other Cryaquolls.

Typic Cryaquolls

Definition of Typic Cryaquolls

Typic Cryaquolls are the Cryaquolls that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

   a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

   b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

   c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

      (1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

      (2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

2. Do not have an argillic horizon;

3. Do not have a calcic horizon within or directly below the mollic epipedon;

4. Have a mollic epipedon that is less than 50 cm thick;

5. Do not have a histic epipedon;

6. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within a depth of 100 cm; *and*

7. Do not have *either*:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Cryaquolls.—The central concept or Typic subgroup of Cryaquolls is fixed on soils that have a mollic epipedon less than 50 cm thick and that do not have a histic epipedon or an argillic or calcic horizon. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. They do not have a buried Histosol or a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols.

An argillic horizon in or below the mollic epipedon is rare and is the basis for defining intergrades to Argiaquolls. A calcic horizon in or directly below the epipedon is rare and is the basis for defining intergrades to Calciaquolls. The thickness of the mollic epipedon is normally less than 50 cm, but in some Cryaquolls the thickness is quite variable within distances of a few centimeters because of frost action. Tongues of the mollic epipedon a few centimeters across may penetrate the cambic horizon for a distance of more than 25 cm. If such tongues are present, the average penetration is used to determine the thickness of the epipedon. An overthickened epipedon is the basis for defining the Cumulic extragrade.

The wettest Cryaquolls may have a histic epipedon, and they are regarded as a transition to Histosols. A buried Histosol at a depth of less than 100 cm is the basis for defining the Thapto-Histic subgroup.

Typic Cryaquolls are of moderate extent in the United States. They are mostly in mountain valleys in the Western States. These soils supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as grazing land or wildlife habitat.

Aquandic Cryaquolls.—These soils are like Typic Cryaquolls, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of small extent in the United States. They are in mountain valleys in the Northwestern States. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as grazing land or wildlife habitat.

Argic Cryaquolls.—These soils have an argillic horizon and are considered intergrades to Argiaquolls. They are of small extent in the United States. They are mostly in mountain valleys in the Western States. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as grazing land or wildlife habitat.

Calcic Cryaquolls.—These soils have a calcic horizon in or directly below the mollic epipedon and are considered intergrades to Calciaquolls. The water table usually is high during the short summer, and the water results in enrichment of the surface layer with carbonates by capillary rise and evapotranspiration. These soils are of small extent in the United States. They are mostly in mountain valleys in the Western States. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as grazing land or wildlife habitat.

Cumulic Cryaquolls.—These soils have an overthickened mollic epipedon as a result of slow accumulation of material washed from higher areas. They are subject to occasional flooding when streams are high. These soils are of small extent in the United States. They are mostly in narrow mountain valleys in the Western States. They supported mostly water-tolerant grasses, sedges, shrubs, and trees. Most of the soils are used as grazing land or wildlife habitat.

Histic Cryaquolls.—These soils have a histic epipedon and are considered intergrades to Histosols. They are the wettest of the Cryaquolls, and the level of ground water in them fluctuates the least. Histic Cryaquolls are rare in the United States. They are known to occur only in Colorado.

Thapto-Histic Cryaquolls.—These soils formed in mineral deposits over a Histosol. The epipedon may extend to the buried Histosol, which has its upper boundary within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Vertic Cryaquolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are dry periodically in at least the upper part during normal years. They are not known to occur in the United States.

Duraquolls

These are the Aquolls that have a duripan and a soil temperature regime warmer than cryic. In the United States, these soils are restricted to areas that have a Mediterranean climate or to arid regions. All Duraquolls are near enough to volcanoes to have received ash falls. They are wet in winter, but most are quite dry in summer. The upper boundary of the duripan most commonly lies about 50 to 75 cm below the soil surface. These soils range from slightly acid to strongly alkaline. They are of small extent.

Definition

Duraquolls are the Aquolls that:

1. Have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Have a soil temperature regime that is warmer than cryic.

Key to Subgroups

IBBA. Duraquolls that have a natric horizon.
Natric Duraquolls

IBBB. Other Duraquolls that have, above the duripan, *one or both* of the following:

1. Cracks that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick; *or*

2. A linear extensibility of 6.0 cm or more.
Vertic Duraquolls

IBBC. Other Duraquolls that have an argillic horizon.
Argic Duraquolls

IBBD. Other Duraquolls.
Typic Duraquolls

Definition of Typic Duraquolls

Typic Duraquolls are the Duraquolls that:

1. Do not have an argillic or natric horizon; *and*

2. Do not have *either*:

a. Cracks that for some time in normal years are 5 mm or more wide throughout a layer 30 cm or more thick either within 125 cm of the mineral soil surface or above a duripan if shallower, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface or above a duripan if shallower; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact or a duripan, whichever is shallower.

Description of Subgroups

Typic Duraquolls.—The central concept or Typic subgroup of Duraquolls is fixed on soils that do not have an argillic horizon and do not have a natric horizon. These soils do not have deep cracks, slickensides, wedge-shaped aggregates, or a high linear extensibility. The presence of an argillic or natric horizon is the basis for defining intergrades to Argiaquolls and Natraquolls, respectively. Typic Duraquolls are of small extent in the United States. They are only in the Western States. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as irrigated cropland, hayland, or rangeland.

Argic Duraquolls.—These soils are like Typic Duraquolls, but they have an argillic horizon. They are of very small extent in the United States. They are known to occur only in California and Oregon, where they are used mostly as rangeland.

Natric Duraquolls.—These soils are like Typic Duraquolls, but they have a natric horizon above the duripan. They are of small extent in the United States. They are only in the Western States. They supported mostly water-tolerant grasses, sedges, and shrubs. Most of the soils are used as irrigated cropland, hayland, or rangeland.

Vertic Duraquolls.—These soils are like Typic Duraquolls, but they have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of very small extent in the United States. They supported mostly water-tolerant grasses.

Endoaquolls

These are the Aquolls that have both endosaturation and a temperature regime warmer than cryic. They do not have an argillic, natric, calcic, or gypsic horizon. The depth to ground water fluctuates appreciably in these soils. Commonly, the ground water is at or near the soil surface in winter and spring but is deep in summer. Most of the Endoaquolls in the United States have been artificially drained and are used as cropland. They are extensive and are widely distributed throughout the Midwest and the western parts of the country.

Definition

Endoaquolls are the Aquolls that:

1. Have endosaturation;

2. Have a soil temperature regime that is warmer than cryic;

3. Do not have an argillic or natric horizon;

4. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have a calcic or gypsic horizon that has its upper boundary within 40 cm of the mineral soil surface.

Key to Subgroups

IBGA. Endoaquolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquolls

IBGB. Other Endoaquolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A mollic epipedon 60 cm or more thick.

Cumulic Vertic Endoaquolls

IBGC. Other Endoaquolls that have *both* of the following:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Vertic Endoaquolls

IBGD. Other Endoaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Endoaquolls

IBGE. Other Endoaquolls that have a histic epipedon.

Histic Endoaquolls

IBGF. Other Endoaquolls that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Endoaquolls

IBGG. Other Endoaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Endoaquolls

IBGH. Other Endoaquolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Endoaquolls

IBGI. Other Endoaquolls that have a mollic epipedon 60 cm or more thick.

Cumulic Endoaquolls

IBGJ. Other Endoaquolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Endoaquolls

IBGK. Other Endoaquolls.

Typic Endoaquolls

Definition of Typic Endoaquolls

Typic Endoaquolls are the Endoaquolls that:

1. Do not have a histic epipedon;

2. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist;

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^{3} or less, measured at 33 kPa water retention, and Al plus $^{1}/_{2}$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

6. Do not have a lithic contact within 50 cm of the mineral soil surface;

7. Have a mollic epipedon that is less than 60 cm thick; *and*

8. Either have less than 0.3 percent organic carbon at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower or have a slope of 25 percent or more.

Description of Subgroups

Typic Endoaquolls.—The Typic subgroup of Endoaquolls is fixed on deep soils that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. These soils have a mollic epipedon less than 60 cm thick and have both a regular decrease in organic-carbon content with increasing depth and an organic-carbon content of less than 0.3 percent in some horizon within 125 cm of the mineral soil surface. They do not have a horizon within 100 cm of the mineral soil surface that has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist. These soils do not have a lithic contact, a histic epipedon, or a buried organic layer.

Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic or combination Vertic subgroups because these properties are shared with Vertisols. Typic Endoaquolls do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols.

Typic Endoaquolls are extensive and occur throughout a large part of the United States. They are most extensive in the Midwestern States. They are nearly level. Most of the soils have been artificially drained and are used as cropland, but some are used as pasture or forest.

Aquandic Endoaquolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of small extent in the United States and occur only in the Western States. They are used mostly as pasture or have been artificially drained and are used as cropland.

Cumulic Endoaquolls.—These soils have a mollic epipedon 60 cm or more thick. They commonly have an irregular decrease in organic-carbon content with increasing depth. They formed mostly in recent alluvium on flood plains or in closed depressions. These soils are extensive and occur throughout a large part of the United States. They are most extensive in the Midwestern and Western States. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland or wildlife habitat.

Cumulic Vertic Endoaquolls.—These soils are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. They also have a mollic epipedon 60 cm or more thick. They formed mostly in recent alluvium on flood plains or in closed depressions. These soils are of small extent and occur mostly in the Midwestern States of the United States. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland or wildlife habitat.

Duric Endoaquolls.—These soils have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. These soils are rare in the United States.

Fluvaquentic Endoaquolls.—These soils are like Typic Endoaquolls, but they have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface. The soils formed mostly in recent alluvium on flood plains. They are extensive and occur throughout a large part of the United States. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland or wildlife habitat.

Fluvaquentic Vertic Endoaquolls.—These soils are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. They also have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface. These soils formed mostly in recent alluvium on flood plains. They are of small extent in the United States. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland or wildlife habitat.

Histic Endoaquolls.—These soils are like Typic Endoaquolls, but they have a histic epipedon. They are more poorly drained than Typic Endoaquolls. Histic Endoaquolls are rare in the United States.

Lithic Endoaquolls.—These soils are like Typic Endoaquolls, but they have a lithic contact within 50 cm of the mineral soil surface. They are rare in the United States.

Thapto-Histic Endoaquolls.—These soils are like Typic Endoaquolls, but they have a buried Histosol with its upper boundary within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Vertic Endoaquolls.—These soils are like Typic Endoaquolls, but they are high in content of expanding clays and have cracks, slickensides, wedge-shaped aggregates, or a high linear extensibility. They formed mostly in late-Pleistocene or Holocene deposits. Vertic Endoaquolls are of moderate extent in the United States, mostly in the Midwest and on the Great Plains. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland, rangeland, or wildlife habitat.

Epiaquolls

These are the Aquolls that have both episaturation and a temperature regime warmer than cryic. They do not have an argillic or natric horizon. The depth to ground water fluctuates appreciably in these soils. A perched water table is at or near the soil surface during wet periods, mostly in winter and early spring, but commonly does not occur during dry periods in summer. Most of the Epiaquolls in the United States have some artificial drainage, mostly surface drainage, and are used as cropland. The soils are extensive and are widely distributed throughout the Midwest and the western parts of the country.

Definition

Epiaquolls are the Aquolls that:

1. Have episaturation;

2. Have a soil temperature regime that is warmer than cryic;

3. Do not have an argillic or natric horizon;

4. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have a calcic horizon that has its upper boundary within 40 cm of the mineral soil surface.

Key to Subgroups

IBFA. Epiaquolls that have *both* of the following:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A mollic epipedon 60 cm or more thick.

Cumulic Vertic Epiaquolls

IBFB. Other Epiaquolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Vertic Epiaquolls

IBFC. Other Epiaquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaquolls

IBFD. Other Epiaquolls that have a histic epipedon.

Histic Epiaquolls

IBFE. Other Epiaquolls that have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface.

Thapto-Histic Epiaquolls

IBFF. Other Epiaquolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Epiaquolls

IBFG. Other Epiaquolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Epiaquolls

IBFH. Other Epiaquolls that have a mollic epipedon 60 cm or more thick.

Cumulic Epiaquolls

IBFI. Other Epiaquolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Epiaquolls

IBFJ. Other Epiaquolls.

Typic Epiaquolls

Definition of Typic Epiaquolls

Typic Epiaquolls are the Epiaquolls that:

1. Do not have a histic epipedon;

2. Do not have a buried layer of organic soil materials, 20 cm or more thick, that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist;

4. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

6. Have a mollic epipedon less than 60 cm thick; *and*

7. Either have less than 0.3 percent organic carbon at a depth of 125 cm below the mineral soil surface and a regular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower or have a slope of 25 percent or more.

Description of Subgroups

Typic Epiaquolls.—The Typic subgroup of Epiaquolls is centered on deep soils that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. These soils have a mollic epipedon that is less than 60 cm thick and have both a regular decrease in organic-carbon content with increasing depth and an organic-carbon content of less than 0.3 percent in some horizon within 125 cm of the mineral soil surface. They do not have a horizon within 100 cm of the mineral soil surface that has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist.

Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to Vertic and combination Vertic subgroups because these properties are shared with Vertisols. Typic Epiaquolls do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials because these properties are shared with Andisols.

Typic Epiaquolls are moderately extensive in the United States and are mostly in the Midwestern States. These soils are nearly level. Most have been artificially drained and are used as cropland. Some are used as pasture and some as forest.

Aquandic Epiaquolls.—These soils are like Typic Epiaquolls, but they have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. Aquandic Epiaquolls are not known to occur in the United States.

Cumulic Epiaquolls.—These soils are like Typic Epiaquolls, but they have a mollic epipedon 60 cm or more thick. They commonly have an irregular decrease in organic-carbon content with increasing depth. They formed mostly in recent alluvium on flood plains or in closed depressions. Cumulic Epiaquolls are of very small extent.

Cumulic Vertic Epiaquolls.—These soils are like Typic Epiaquolls, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. They also have a mollic epipedon 60 cm or more thick. These soils formed mostly in recent alluvium on flood plains or in closed depressions. They are of small extent in the United States. They are nearly level. Most of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as forest.

Duric Epiaquolls.—These soils have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. They are otherwise like Typic Epiaquolls in their defined properties and in most other properties. Duric Epiaquolls are not known to occur in the United States.

Fluvaquentic Epiaquolls.—These soils are like Typic Epiaquolls, but they have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within

125 cm of the mineral soil surface. These soils formed mostly in recent alluvium on flood plains. They are not known to occur in the United States.

Fluvaquentic Vertic Epiaquolls.—These soils are like Typic Epiaquolls, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. They also have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface. These soils formed mostly in recent alluvium on flood plains. They are not known to occur in the United States.

Histic Epiaquolls.—These soils are like Typic Epiaquolls, but they have a histic epipedon. They are more poorly drained than Typic Epiaquolls. Histic Epiaquolls are rare in the United States.

Thapto-Histic Epiaquolls.—These soils are like Typic Epiaquolls, but they have a buried Histosol with its upper boundary within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Vertic Epiaquolls.—These soils are like Typic Epiaquolls, but they are high in content of expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a high linear extensibility. These soils formed mostly in late-Pleistocene or Holocene deposits. They are of moderate extent in the United States, mostly in the Midwest and on the Great Plains. Many of the soils have been artificially drained and are used as cropland. Some are used as pasture and some as woodland, rangeland, or wildlife habitat.

Natraquolls

These are the Aquolls that have a temperature regime warmer than cryic and have a natric horizon. They do not have a duripan within 100 cm of the mineral soil surface. The natric horizon normally lies very close to the surface. The thin overlying horizon commonly has a dry color that is too light for a mollic epipedon. The color of the upper part of the soils, after mixing to a depth of 18 cm, however, is dark enough for a mollic epipedon because the natric horizon is nearly black. Ground water is shallow during most of the year, and capillary rise in many Natraquolls has concentrated salts, including sodium salts, in the upper 50 cm of the soils.

Natraquolls are known to occur only in subhumid to arid regions. They are on flood plains and on the margins of lakes. They formed in late-Pleistocene or Holocene deposits. The vegetation consists of grasses, sedges, and shrubs. The soils are used as rangeland, or the grasses are cut for hay. The soils are rarely cultivated. They are rare in the United States.

Definition

Natraquolls are the Aquolls that:

1. Have a natric horizon;

2. Have a soil temperature regime that is warmer than cryic; *and*

3. Do not have a duripan that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

IBCA. Natraquolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natraquolls

IBCB. Other Natraquolls.

Typic Natraquolls

Definition of Typic Natraquolls

Typic Natraquolls are the Natraquolls that do not have *either*:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Natraquolls.—The central concept or Typic subgroup of Natraquolls is fixed on soils that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. Deep cracks, slickensides, wedge-shaped aggregates, and a high linear extensibility are characteristics shared with Vertisols and are the basis for defining the Vertic subgroup. Typic Natraquolls are of small extent in the United States. They are widely distributed throughout the Western United States. These soils supported mostly salt-tolerant grasses, sedges, and shrubs. Some of the soils have been artificially drained and are used as cropland. Some are used as grazing land or hayland and some as wildlife habitat.

Vertic Natraquolls.—These soils are like Typic Natraquolls, but they have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of small extent in the United States. They are recognized only in South Dakota. These soils supported mostly salt-tolerant grasses, sedges, and shrubs. Most are used as hayland or grazing land.

Cryolls

Cryolls are the cool or cold, more or less freely drained Mollisols. They are moderately extensive in the high mountains of the Western United States. They also are extensive on the plains and mountains of Eastern Europe and in Asia. On the plains they are mainly in areas of late-Pleistocene or Holocene deposits. In the mountains of the Western States, some of the soils may be on older surfaces, but the geomorphology of these areas has had little study.

Cryolls have a cryic temperature regime and a udic, ustic, or xeric moisture regime.

The vegetation on the Cryolls on the plains was mostly grasses. The Cryolls in the mountains have either forest or grass vegetation. On the Cryolls in Alaska, spruce, birch, and aspen trees are common.

Definition

Cryolls are the Mollisols that:

1. Have a cryic soil temperature regime;

2. Do not have *all* of the following:

a. An argillic or natric horizon; *and*

b. An albic horizon that has chroma of 2 or less, that has its lower boundary 18 cm or more below the mineral soil surface, and either lies directly below the mollic epipedon or separates horizons that together meet all of the requirements for a mollic epipedon; *and*

c. In one or more subhorizons of the albic horizon and/or of the argillic or natric horizon and within 100 cm of the mineral soil surface, redox concentrations in the form of masses or concretions, or both, and also aquic conditions for some time in normal years (or artificial drainage);

3. Do not have the characteristics defined for Aquolls; *and*

4. Have *one or more* of the following:

a. Either within or directly below the mollic epipedon, mineral soil materials less than 7.5 cm in diameter that have a $CaCO_3$ equivalent of less than 40 percent; *or*

b. A mollic epipedon 50 cm or more thick; *or*

c. An argillic or calcic horizon.

Key to Great Groups

IDA. Cryolls that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Duricryolls, p. 579

IDB. Other Cryolls that have a natric horizon.

Natricryolls, p. 582

IDC. Other Cryolls that have *both*:

1. An argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface; *and*

2. A texture finer than loamy fine sand in all horizons above the argillic horizon.

Palecryolls, p. 583

IDD. Other Cryolls that have an argillic horizon.

Argicryolls, p. 575

IDE. Other Cryolls that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. In all parts above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Calcicryolls, p. 578

IDF. Other Cryolls.

Haplocryolls, p. 579

Argicryolls

These are the Cryolls that have an argillic horizon close to the surface. Commonly, the upper part of the argillic horizon is in the mollic epipedon. Some of these soils have a Bk horizon below the argillic horizon. Argicryolls do not have a natric horizon or a duripan.

Argicryolls formed mainly in Pleistocene or Holocene deposits or are on surfaces of equivalent ages. They have cool or short summers.

Most Argicryolls in the United States are in the mountains of the Western States. A few are in Alaska. In other countries at high latitudes, Argicryolls also developed on plains. In the United States, the vegetation at the time of settlement was either forest or grass. Many of the soils had grasses and scattered conifer trees. Most of the soils are used as rangeland or forest. Some are cultivated and used for small grain or for hay.

Definition

Argicryolls are the Cryolls that:

1. Have an argillic horizon that has its upper boundary less than 60 cm below the mineral soil surface or have a texture of loamy fine sand or coarser in all horizons above the argillic horizon;

2. Do not have a natric horizon; *and*

3. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IDDA. Argicryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argicryolls

IDDB. Other Argicryolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argicryolls

IDDC. Other Argicryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argicryolls

IDDD. Other Argicryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argicryolls

IDDE. Other Argicryolls that have an argillic horizon that, with increasing depth, has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within its upper 7.5 cm.

Abruptic Argicryolls

IDDF. Other Argicryolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Argicryolls

IDDG. Other Argicryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argicryolls

IDDH. Other Argicryolls that have a mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand.

Pachic Argicryolls

IDDI. Other Argicryolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argicryolls

IDDJ. Other Argicryolls that have an ustic moisture regime.

Ustic Argicryolls

IDDK. Other Argicryolls that have a xeric moisture regime.

Xeric Argicryolls

IDDL. Other Argicryolls.

Typic Argicryolls

Definition of Typic Argicryolls

Typic Argicryolls are the Argicryolls that:

1. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below the upper boundary;

2. Do not have *either*:

a. An albic horizon or another horizon above the argillic horizon that has a color value too high for a mollic epipedon and chroma too high for an albic horizon; *or*

b. A glossic horizon, *or* interfingering of albic materials in the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm or more of the argillic horizon;

3. Do not have, throughout a cumulative thickness of 18 cm

or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

4. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

5. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

6. Do not have a lithic contact within 50 cm of the mineral soil surface;

7. Have a udic moisture regime;

8. Have a mollic epipedon that is less than 40 cm thick or has a texture of loamy fine sand or coarser; *and*

9. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Argicryolls.—The central concept or Typic subgroup of Argicryolls is fixed on freely drained soils that have a udic moisture regime and have a mollic epipedon less than 40 cm thick. These soils do not have an albic horizon or an abrupt boundary to the argillic horizon and do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials.

An albic horizon indicates that the soils had forest vegetation and is the basis for defining intergrades to Alfisols. Redox concentrations and shallow ground water are properties of Aquolls and are the basis for defining the Aquic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. The vegetation on the Argicryolls on broad plains was mostly grasses. The Argicryolls in the mountains have either forest or grass vegetation. Most Argicryolls are used as rangeland, forest, or wildlife habitat.

Abruptic Argicryolls.—These soils have an abrupt textural change at the top of the argillic horizon, and most also have an albic horizon. In the Abruptic Argicryolls in the United States, the argillic horizon commonly has columnar structure but does not have the sodium or magnesium necessary for a natric horizon. The vegetation is mostly grass and shrubs. Slopes are gentle to moderately steep. Most of the soils are used as rangeland, pasture, or wildlife habitat.

Alfic Argicryolls.—These soils have an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon above the argillic horizon, or they have a glossic horizon in the upper part of the argillic horizon. They either have a gradual transition between those horizons or have only a moderate contrast between the percentages of clay in the two horizons. These soils are of moderate extent in the mountains of the Western United States. Slopes range from gentle to steep. Some of these soils currently have forest vegetation, but others support mostly grass. Alfic Argicryolls are used mostly as forest or rangeland, but a few are used as hayland.

Andic and Vitrandic Argicryolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of very small extent in the mountains of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of the soils are used as forest, rangeland, or wildlife habitat.

Aquic Argicryolls.—Ground water fluctuates at some depth in these soils, and redox concentrations are in the horizons that are saturated part of the time. These soils are of small extent in the mountains of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of the soils are used as forest, rangeland, or wildlife habitat.

Lithic Argicryolls.—These soils have a lithic contact within 50 cm of the mineral soil surface. Slopes are gentle to steep. The vegetation on these soils is mostly grass and shrubs, but some of the soils support forest vegetation. Most of the soils are used as rangeland.

Oxyaquic Argicryolls.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are not known to occur in the United States.

Pachic Argicryolls.—These soils have a thick mollic epipedon. The argillic horizon generally is in the lower part of the mollic epipedon. Slopes of the Pachic Argicryolls in the United States range from gentle to steep. The soils are extensive in the high mountains of the Western States. Most of the soils are used for summer grazing, but some are used as forest.

Ustic Argicryolls.—These soils have an ustic moisture regime. They are considered to be transitional to Ustolls. They commonly are used as rangeland or are in sparse forests with widely spaced trees. They are of small extent in the United States.

Vertic Argicryolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. The thickness of the mollic epipedon, the distribution of organic carbon in the epipedon, and the presence of redoximorphic features or other evidence of wetness are not definitive of this subgroup. These soils are of small extent in the mountains of the Western United States.

Xeric Argicryolls.—These soils have a xeric moisture regime. They are considered to be transitional to Xerolls. They commonly are in forests with widely spaced trees. They are of small extent in the United States.

Calcicryolls

These are the Cryolls that have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface. They are calcareous, or would be calcareous if plowed, in all parts of the pedon above the calcic horizon, or they have a texture of loamy fine sand or coarser in all parts above the calcic or petrocalcic horizon. The mollic epipedon commonly includes part of the calcic horizon. These soils formed in materials that have a moderate to high percentage of carbonates. Many of the soils are in areas of deposits that originated from limestone.

Calcicryolls occur in areas of cool or short summers. In the United States, the vegetation at the time of settlement was either grass or forest. The soils are of moderate extent in the mountains of the Western United States. Most of the soils are used as rangeland, forest, or wildlife habitat. A few areas are cultivated and used for small grain or hay.

Definition

Calcicryolls are the Cryolls that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Either are calcareous or have a texture of loamy fine sand or coarser in all parts above the calcic or petrocalcic horizon after the materials between the soil surface and a depth of 18 cm have been mixed;

3. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have a natric or argillic horizon.

Key to Subgroups

IDEA. Calcicryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcicryolls

IDEB. Other Calcicryolls that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Calcicryolls

IDEC. Other Calcicryolls that have a mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand.

Pachic Calcicryolls

IDED. Other Calcicryolls that have an ustic moisture regime.

Ustic Calcicryolls

IDEE. Other Calcicryolls that have a xeric moisture regime.

Xeric Calcicryolls

IDEF. Other Calcicryolls.

Typic Calcicryolls

Definition of Typic Calcicryolls

Typic Calcicryolls are the Calcicryolls that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Have a mollic epipedon that is less than 40 cm thick or has a texture of loamy fine sand or coarser;

3. Have a udic moisture regime; *and*

4. Do not have a petrocalcic horizon with its upper boundary within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Calcicryolls.—The central concept or Typic subgroup of Calcicryolls is fixed on soils that have a udic moisture regime and have a mollic epipedon less than 40 cm thick. These soils do not have a lithic contact within 50 cm of the mineral soil surface. A thick mollic epipedon is the basis for defining the Pachic subgroup. The vegetation on the Typic Calcicryolls on broad plains was mostly grasses and shrubs. The Typic Calcicryolls in the mountains have either grass or forest vegetation. Most Typic Calcicryolls are used as rangeland or forest, but a few are used as cropland.

Lithic Calcicryolls.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are of small extent in the mountains of the Western United States. Their slopes are gentle to steep. The vegetation on these soils is mostly grass and shrubs, but some of the soils support widely spaced trees. Most of the soils are used as rangeland.

Pachic Calcicryolls.—These soils have a thick, calcareous mollic epipedon that extends into the calcic horizon or is directly underlain by the calcic horizon. They formed mainly in calcareous sediments. The vegetation in broad areas is mostly grasses and shrubs. The more sloping soils in the mountains have either grass or forest vegetation. Most of the soils are used as rangeland, but a few are used as forest or cropland.

Petrocalcic Calcicryolls.—These soils have a petrocalcic horizon with its upper boundary within 100 cm of the mineral soil surface. They do not have a lithic contact within 50 cm of the mineral soil surface. They are of limited extent in the Western United States. They are used for grazing by livestock.

Ustic Calcicryolls.—These soils are like Typic Calcicryolls, but they have an ustic moisture regime. They are considered to be transitional to Calciustolls. Ustic Calcicryolls commonly are used as rangeland or are in forests with widely spaced trees. They are of small extent in the United States.

Xeric Calcicryolls.—These soils are like Typic Calcicryolls, but they have a xeric moisture regime. They are considered to be transitional to Calcixerolls. Xeric Calcicryolls commonly are in forests with widely spaced trees. They are of small extent in the United States.

Duricryolls

These are the Cryolls that have a duripan that has its upper boundary within 100 cm of the mineral soil surface. They are of small extent in mountain valleys of the Western United States. Many had grasses and widely spaced conifer trees. Most of the soils are used as rangeland or forest.

Definition

Duricryolls are the Cryolls that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IDAA. Duricryolls that have an argillic horizon.

Argic Duricryolls

IDAB. Other Duricryolls.

Typic Duricryolls

Definition of Typic Duricryolls

Typic Duricryolls are the Duricryolls that do not have an argillic horizon.

Description of Subgroups

Typic Duricryolls.—The central concept or Typic subgroup of Duricryolls is fixed on soils that do not have an argillic horizon above the duripan. These soils are of small extent. They are at high elevations in the Western United States. The natural vegetation is either grass and shrubs or trees. The soils are used as rangeland or forest.

Argic Duricryolls.—These soils are like the Typic subgroup of Duricryolls, but they have an argillic horizon above the duripan. Argic Duricryolls are of small extent. They are at high elevations in the Western United States. The natural vegetation is either grass and shrubs or trees. These soils are used as rangeland or forest.

Haplocryolls

These are the Cryolls that do not have an argillic or natric horizon. Most Haplocryolls have a cambic horizon. Some have a calcic horizon. Haplocryolls do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface. They do not have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface unless some part of the soil above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either is not calcareous or has a texture finer than loamy fine sand.

Haplocryolls formed mainly in Pleistocene or Holocene deposits or on surfaces of equivalent ages. They have cool or short summers. They are extensive in the United States. The vegetation at the time of settlement was either forest or grass. Many of the soils had grasses and scattered conifer trees. Most of the soils are used as rangeland or forest. Some are cultivated and used for small grain or hay.

Definition

Haplocryolls are the Cryolls that:

1. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have a natric or argillic horizon; *and*

3. Do not meet *both* of the following:

   a. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

   b. In all parts above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Key to Subgroups

IDFA. Haplocryolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryolls

IDFB. Other Haplocryolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or

more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplocryolls

IDFC. Other Haplocryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplocryolls

IDFD. Other Haplocryolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplocryolls

IDFE. Other Haplocryolls that have:

1. A mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent; *and*

4. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cumulic Haplocryolls

IDFF. Other Haplocryolls that have:

1. A mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent.

Cumulic Haplocryolls

IDFG. Other Haplocryolls that have *both*:

1. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

2. In one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Fluvaquentic Haplocryolls

IDFH. Other Haplocryolls that have, in one or more horizons within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryolls

IDFI. Other Haplocryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryolls

IDFJ. Other Haplocryolls that have *both*:

1. A mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand; *and*

2. A calcic horizon either within or directly below the mollic epipedon, but no argillic horizon in the lower part of the mollic epipedon.

Calcic Pachic Haplocryolls

IDFK. Other Haplocryolls that have a mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand.

Pachic Haplocryolls

IDFL. Other Haplocryolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Haplocryolls

IDFM. Other Haplocryolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Haplocryolls

IDFN. Other Haplocryolls that have an ustic moisture regime.

Ustic Haplocryolls

IDFO. Other Haplocryolls that have a xeric moisture regime.

Xeric Haplocryolls

IDFP. Other Haplocryolls.

Typic Haplocryolls

Definition of Typic Haplocryolls

Typic Haplocryolls are the Haplocryolls that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

3. Do not have, in any horizon within 100 cm of the mineral soil surface, distinct or prominent redox concentrations and also aquic conditions;

4. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

5. Do not have a calcic horizon within 100 cm of the mineral soil surface;

6. Have a mollic epipedon that is less than 40 cm thick or that has a texture of loamy fine sand or coarser;

7. Have a udic soil moisture regime;

8. *Either* have a regular decrease in organic-carbon content with increasing depth and, unless a densic, lithic, or paralithic contact is at some depth between 50 and 125 cm below the soil surface, have an organic-carbon content of 0.3 percent or less at a depth within 125 cm of the mineral soil surface *or* have a slope of 25 percent or more; *and*

9. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Haplocryolls.—The central concept or Typic subgroup of Haplocryolls is fixed on freely drained soils that have a udic soil moisture regime and that do not have a calcic horizon within 100 cm or hard rock within 50 cm of the soil surface. The horizon sequence is normally a noncalcareous mollic epipedon of moderate thickness over a cambic horizon.

These soils do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. In addition, they do not have a high shrink-swell potential, a thick mollic epipedon, or an irregular decrease in organic-carbon content.

Redox concentrations and shallow ground water are properties of Aquolls and are the basis for defining Aquic and combination Aquic subgroups. A calcic horizon within a depth of 100 cm is characteristic of Calcicryolls and is the basis for defining Calcic and combination Calcic subgroups. A thick mollic epipedon is the basis for defining Pachic and combination Pachic subgroups.

The vegetation on the Typic Haplocryolls on broad plains was mostly grasses. The Typic Haplocryolls in the mountains have either forest or grass vegetation. Most Typic Haplocryolls are used as rangeland, forest, or wildlife habitat.

Andic and Vitrandic Haplocryolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of very small extent in the mountains of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of these soils are used as forest, rangeland, or wildlife habitat.

Aquic Cumulic Haplocryolls.—Ground water fluctuates at some depth in these soils, and redox concentrations are in the horizons that are saturated part of the time. The soils have a thick mollic epipedon, and their content of organic carbon decreases irregularly with increasing depth. The soils are of small extent in mountain valleys of the Western United States. The vegetation is mostly grass, shrubs, and widely spaced trees. Most of these soils are used as rangeland, pasture, or cropland, but some are used as forest or wildlife habitat.

Aquic Haplocryolls.—Ground water fluctuates at some depth in these soils, and redox concentrations are in the horizons that are saturated part of the time. These soils are of small extent in mountain valleys of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of the soils are used as forest, rangeland, or wildlife habitat.

Calcic Haplocryolls.—These soils have a calcic horizon within 100 cm of the mineral soil surface, but they are otherwise like Typic Haplocryolls. Calcic Haplocryolls are of small extent. The vegetation is mostly forest or grass and widely spaced trees. Most of these soils are used as forest, rangeland, or wildlife habitat, but a few are used as cropland.

Calcic Pachic Haplocryolls.—These soils have a thick mollic epipedon and a calcic horizon within 100 cm of the mineral soil surface. They are of small extent. The vegetation is mostly forest or grass and widely spaced trees. Most of these soils are used as forest, rangeland, or wildlife habitat, but a few are used as cropland.

Cumulic Haplocryolls.—These soils have a thick mollic epipedon, and their content of organic carbon decreases irregularly with increasing depth. The soils formed in positions where they receive fresh sediments at a rate slow enough for this material to become incorporated in the mollic epipedon. These soils are on flood plains or have concave slopes. They are of small extent in Alaska and in mountain valleys of the Western United States. The vegetation is mostly grass, shrubs, and widely spaced trees. Most of these soils are used as rangeland, pasture, or cropland, but some are used as forest or wildlife habitat.

Fluvaquentic Haplocryolls.—These soils are like Typic Haplocryolls, but ground water fluctuates at some depth in the soils and redox concentrations are in the horizons that are saturated part of the time. Fluvaquentic Haplocryolls have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface. These soils formed mostly in recent alluvium on flood plains. They are of small extent in mountain valleys of the Western United States. The vegetation is mostly grass, shrubs, and widely spaced trees. Most of the soils are used as rangeland or pasture, but some are used as wildlife habitat.

Fluventic Haplocryolls.—These soils are like Typic Haplocryolls, but they have an irregular decrease in organic-carbon content with increasing depth or have an organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Haplocryolls.—These soils have a shallow lithic contact. They are of moderate extent in the mountains of the Western United States. Their slopes are gentle to steep. The vegetation is mostly grass and shrubs, but some of the soils support forest vegetation. Lithic Haplocryolls are used mostly as rangeland or forest.

Oxyaquic Haplocryolls.—These soils are like Typic Haplocryolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are not known to occur in the United States.

Pachic Haplocryolls.—These soils are like Typic Haplocryolls, but they have a thick mollic epipedon. Slopes of the Pachic Haplocryolls in the United States range from gentle to steep. The soils commonly are used as rangeland or support forest vegetation. Some support grass and widely spaced trees. The soils are extensive in the high mountains of the Western States. They are used mostly as rangeland or forest. A few of the soils are used as cropland or hayland.

Ustic Haplocryolls.—These soils are like Typic Haplocryolls, but they have an ustic moisture regime. They are considered to be transitional to Ustolls. Ustic Haplocryolls commonly are used as rangeland or are in forests with widely spaced trees. They are of small extent in the United States.

Vertic Haplocryolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. The thickness of the mollic epipedon, the distribution of organic carbon in the epipedon, and the presence of redoximorphic features or other evidence of wetness are not definitive of this subgroup. These soils are of very small extent in the mountains of the Western United States.

Xeric Haplocryolls.—These soils are like Typic Haplocryolls, but they have a xeric moisture regime. They are considered to be transitional to Xerolls. Xeric Haplocryolls commonly are in forests with widely spaced trees. They are of small extent in the United States.

Natricryolls

These are the Cryolls that have a natric horizon but do not have a duripan. The soils are rare in the United States and probably elsewhere. Few series have been established in the United States for this group, and subgroups have not been developed. Because these soils are of such limited extent and have a small range of properties, few subgroups seem to be needed.

Definition

Natricryolls are the Cryolls that have a natric horizon but do not have a duripan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IDBA. All Natricryolls.

Typic Natricryolls

Palecryolls

These are the Cryolls that have an argillic horizon with an upper boundary more than 60 cm below the surface. Most of the Palecryolls in the United States are in the mountains of the Western States. In other countries at high latitudes, Palecryolls also developed on plains.

Palecryolls have cool or short summers. In the United States, the vegetation at the time of settlement was either forest or grass. Many of the soils had grasses and scattered conifer trees. Most of the soils are used as rangeland or forest. Some are cultivated and used for small grain or hay.

Definition

Palecryolls are the Cryolls that:

1. Have an argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface and have a texture of loamy very fine sand or finer in some horizon above the argillic horizon;

2. Do not have a natric horizon; *and*

3. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IDCA. Palecryolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palecryolls

IDCB. Other Palecryolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*
2. 30 or more cumulative days.

Oxyaquic Palecryolls

IDCC. Other Palecryolls that have an argillic horizon that, with increasing depth, has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within its upper 7.5 cm.

Abruptic Palecryolls

IDCD. Other Palecryolls that have a mollic epipedon that is 40 cm or more thick and has a texture finer than loamy fine sand.

Pachic Palecryolls

IDCE. Other Palecryolls that have an ustic moisture regime.

Ustic Palecryolls

IDCF. Other Palecryolls that have a xeric moisture regime.

Xeric Palecryolls

IDCG. Other Palecryolls.

Typic Palecryolls

Definition of Typic Palecryolls

Typic Palecryolls are the Palecryolls that:

1. Do not have an argillic horizon that has an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm below its upper boundary;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days;

4. Have a mollic epipedon that is less than 40 cm thick; *and*

5. Have a udic moisture regime.

Description of Subgroups

Typic Palecryolls.—The central concept or Typic subgroup of Palecryolls is fixed on freely drained soils that have a udic moisture regime and have a mollic epipedon less than 40 cm thick. These soils do not have an abrupt boundary to the argillic horizon.

Redox concentrations and shallow ground water are properties of Aquolls and are the basis for defining the Aquic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. The vegetation on Typic Palecryolls is either forest or grass and shrubs. Most of these soils are used as forest, grazing land, or wildlife habitat.

Abruptic Palecryolls.—These soils have an abrupt textural change at the top of the argillic horizon, and most also have an albic horizon. The vegetation is either forest or grass and shrubs. Most of these soils are used as forest, grazing land, or wildlife habitat.

Aquic Palecryolls.—Ground water fluctuates at some depth in these soils, and redox concentrations are in the horizons that are saturated part of the time. These soils are not known to occur in the United States.

Oxyaquic Palecryolls.—These soils are like Typic Palecryolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are not known to occur in the United States.

Pachic Palecryolls.—These soils are like Typic Palecryolls, but they have a thick mollic epipedon. The argillic horizon generally is in the lower part of the mollic epipedon. Slopes of the Pachic Palecryolls in the United States range from gentle to steep. The soils are moderately extensive in the mountains of the Western States. The vegetation is either forest or grass and shrubs. Most of these soils are used as forest, grazing land, or wildlife habitat.

Ustic Palecryolls.—These soils are like Typic Palecryolls, but they have an ustic moisture regime. They are considered to be transitional to Ustolls. Ustic Palecryolls are not known to occur in the United States.

Xeric Palecryolls.—These soils are like Typic Palecryolls, but they have a xeric moisture regime. They are considered to be transitional to Xerolls. Xeric Palecryolls are not known to occur in the United States.

Rendolls

These are the Mollisols that are of humid regions and that formed in highly calcareous parent materials, such as limestone, chalk, drift composed mainly of limestone, or shell bars. These soils have a mollic epipedon that rests on the calcareous parent materials or on a cambic horizon that is rich in carbonates. A few of the soils are so rich in finely divided lime that the mollic epipedon has a color lighter than normal but is nevertheless rich in dark colored humus and is within the limits of a mollic epipedon. Rendolls have a cryic soil temperature regime or a udic moisture regime, or both.

These soils are not extensive in the United States, but they are extensive in some parts of the world. They formed under forest vegetation or under grass and shrubs.

Definition

Rendolls are the Mollisols that:

1. Have a mollic epipedon that is less than 50 cm thick;

2. Have a $CaCO_3$ equivalent of 40 percent or more on the basis of the whole soil, including coarse fragments as much as 7.5 cm in size in or directly below the mollic epipedon;

3. Do not have an argillic or calcic horizon;

4. Have a udic moisture regime or a cryic temperature regime, or both; *and*

5. Do not have both aquic conditions and the colors defined for Aquolls.

Key to Great Groups

ICA. Rendolls that have a cryic soil temperature regime.
Cryrendolls, p. 584

ICB. Other Rendolls.
Haprendolls, p. 585

Cryrendolls

These are the Rendolls that have a cryic soil temperature regime. The Cryrendolls in the United States are rare and occur only in the mountains of the Western States. The vegetation is mostly grass and shrubs. Some of the soils have widely spaced coniferous trees.

Definition

Cryrendolls are the Rendolls that have a cryic soil temperature regime.

Key to Subgroups

ICAA. Cryrendolls that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Cryrendolls

ICAB. Other Cryrendolls.
Typic Cryrendolls

Definition of Typic Cryrendolls

Typic Cryrendolls are the Rendolls that do not have a lithic contact within 50 cm of the mineral soil surface.

Description of Subgroups

Typic Cryrendolls.—These soils are more than 50 cm deep to any lithic contact. Most of the soils have a high content of small limestone fragments. Typic Cryrendolls are of small extent. They are in the mountains of Nevada and Wyoming. The vegetation is mostly grass and shrubs. Some of the soils have widely spaced coniferous trees. Most of the soils are used as rangeland or wildlife habitat.

Lithic Cryrendolls.—These soils have a shallow lithic contact, but they are otherwise like Typic Cryrendolls. The lithic contact is with limestone. Most Lithic Cryrendolls have a high content of small limestone fragments. They are of small extent and are in the mountains of the Western United States. The vegetation is mostly grass and shrubs. Some of the soils have widely spaced coniferous trees. Most of the soils are used as rangeland or wildlife habitat.

Haprendolls

These are the Rendolls that have a udic moisture regime and a soil temperature regime warmer than cryic. Haprendolls are rare in the United States.

Definition

Haprendolls are the Rendolls that have a udic moisture regime and a soil temperature regime warmer than cryic.

Key to Subgroups

ICBA. Haprendolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haprendolls

ICBB. Other Haprendolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haprendolls

ICBC. Other Haprendolls that have a cambic horizon.

Inceptic Haprendolls

ICBD. Other Haprendolls that have a color value, dry, of 6 or more either in the upper 18 cm of the mollic epipedon, after mixing, or in an Ap horizon 18 cm or more thick.

Entic Haprendolls

ICBE. Other Haprendolls.

Typic Haprendolls

Definition of Typic Haprendolls

Typic Haprendolls are the Rendolls that:

1. Do not have a cambic horizon;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. Have a dry color value of 5 or less in the upper 18 cm, after mixing, or in any Ap horizon that is thicker than 18 cm.

Description of Subgroups

Typic Haprendolls.—The central concept or Typic subgroup of Haprendolls in fixed on freely drained soils that have a dark mollic epipedon when dry, do not have a cambic horizon, and do not have a lithic contact within a depth of 50 cm.

A cambic horizon in all or part of each pedon is an extra horizon that indicates development toward Inceptisols. A high dry color value in the mollic epipedon suggests weak development of that horizon and is the basis for defining the Entic subgroup. A shallow lithic contact is the basis for defining the Lithic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks are properties of Vertisols and are the basis for defining the intergrades toward soils of that order.

Typic Haprendolls are of small extent. They are in the humid parts of the United States. They occur from Puerto Rico to Michigan. The native vegetation is mostly trees and shrubs. Some of the soils support shrubs and widely spaced trees. Most of the soils are used as forest, pasture, or wildlife habitat.

Entic Haprendolls.—These soils formed in chalk or marl and have a color value, dry, of 6 or more, mainly because finely divided lime is abundant and acts as a white pigment. The soils do not have a high shrink-swell potential, a cambic horizon, or a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States, but they are extensive in some parts of the world.

Inceptic Haprendolls.—These soils have a cambic horizon in at least some part of each pedon and generally in the major part or all of the pedon. The soils are of small extent in the humid parts of the United States. They occur from Puerto Rico to Michigan. The native vegetation is mostly trees and shrubs. Some of the soils support shrubs and widely spaced trees. Most of the soils are used as cropland, forest, pasture, or wildlife habitat.

Lithic Haprendolls.—These soils have a shallow lithic contact but are otherwise like Typic Haprendolls. The underlying rock is limestone, and there are many small fragments of the limestone in most of these soils. Lithic

Haprendolls are in the humid parts of the United States. They occur from Florida to Michigan. The native vegetation is mostly trees and shrubs. Some of the soils support shrubs and widely spaced trees. Most of the soils are used as forest, pasture, or wildlife habitat or for urban development.

Vertic Haprendolls.—These soils have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. They are not known to occur in the United States. The subgroup is provided for use if needed elsewhere.

Udolls

Udolls are the more or less freely drained Mollisols of humid climates. In addition to the mollic epipedon, these soils may have a cambic, calcic, natric, or argillic horizon. They formed mainly in late-Pleistocene or Holocene deposits or on surfaces of comparable ages. In the United States, their vegetation at the time of settlement was dominantly a tall grass prairie, but some of the soils on Pleistocene surfaces appear to have supported at some time a boreal forest that was supplanted by grasses several thousand years ago.

Udolls formed in sediments and on surfaces of varying ages from Holocene to mid Pleistocene or earlier. The Udolls that have a thermic or warmer temperature regime, in particular, may have formed during two or more glacial and interglacial stages.

Most of the Udolls are in the eastern part of the Great Plains or are east of the Great Plains. The soils are most extensive in Illinois, Iowa, and adjacent states. Their temperature regime is frigid or warmer, and their moisture regime is udic. Where slopes are not too steep, nearly all of these soils are cultivated. Maize (corn) and soybeans are the major crops.

Definition

Udolls are the Mollisols that:

1. Have a udic moisture regime;

2. Do not have both an albic horizon and, within 100 cm of the mineral soil surface, any subhorizon of the albic horizon and/or of the argillic or natric horizon that has redox concentrations in the form of masses or concretions, or both, and also aquic conditions;

3. Do not have both aquic conditions and the colors defined for Aquolls;

4. Do not have a calcareous horizon that lies directly under the mollic epipedon at a depth of less than 50 cm and that has a $CaCO_3$ equivalent of more than 40 percent, including coarse fragments smaller than 7.5 cm, unless the soil also has an argillic or calcic horizon or a mollic epipedon 50 cm or more thick; *and*

5. Do not have a cryic soil temperature regime.

Key to Great Groups

IGA. Udolls that have a natric horizon.

Natrudolls, p. 597

IGB. Other Udolls that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have an argillic horizon above the calcic or petrocalcic horizon; *and*

3. In all parts above the calcic or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Calciudolls, p. 592

IGC. Other Udolls that have *one or more* of the following:

1. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

2. *All* of the following:

a. No densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

b. Within 150 cm of the mineral soil surface, a clay decrease, with increasing depth, of less than 20 percent (relative) from the maximum clay content (noncarbonate clay); *and*

c. An argillic horizon with *one or more* of the following:

(1) In 50 percent or more of the matrix of one or more subhorizons in its lower half, hue of 7.5YR or redder and chroma of 5 or more; *or*

(2) In 50 percent or more of the matrix of horizons that total more than one-half the total thickness, hue of 2.5YR or redder, a value, moist, of 3 or less, and a value, dry, of 4 or less; *or*

(3) Many redox concentrations with hue of 5YR or redder or chroma of 6 or more, or both, in one or more subhorizons; *or*

3. A frigid temperature regime; *and both*

a. An argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface; *and*

b. A texture finer than loamy fine sand in all horizons above the argillic horizon.

Paleudolls, p. 599

IGD. Other Udolls that have an argillic horizon.

Argiudolls, p. 587

IGE. Other Udolls that have a mollic epipedon that:

1. Either below an Ap horizon or below a depth of 18 cm from the mineral soil surface, contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows; *and*

2. Either rests on a lithic contact or has a transition zone to the underlying horizon in which 25 percent or more of the soil volume consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and from the underlying horizon.

Vermudolls, p. 601

IGF. Other Udolls.

Hapludolls, p. 593

Argiudolls

These are the Udolls that have a relatively thin argillic horizon or one in which the percentage of clay decreases rapidly with increasing depth. The mollic epipedon commonly is black to very dark brown, and the argillic horizon is mostly brownish. Many of these soils are noncalcareous to a considerable depth below the argillic horizon. Some of the soils have a Bk horizon in which secondary carbonates are concentrated.

Argiudolls formed mostly in late-Wisconsinan deposits or on surfaces of that age. Many or most of these soils during the Pleistocene supported boreal forests that were replaced by tall grass prairies during the Holocene. Argiudolls are extensive soils in Iowa, Illinois, and adjacent states.

Definition

Argiudolls are the Udolls that:

1. Do not have a natric horizon;

2. Do not have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface unless there is an argillic horizon above the calcic horizon;

3. Do not have a petrocalcic horizon with its upper boundary within 150 cm of the mineral soil surface; *and*

4. Have an argillic horizon and a clay distribution in which the clay content decreases by 20 percent or more from the maximum clay content within 150 cm of the surface if:

a. Hue is redder than 10YR and chroma of more than 4 is dominant in the matrix in at least the lower part of the argillic horizon; *or*

b. There are many coarse redox concentrations that have hue redder than 7.5YR or chroma of more than 5.

Key to Subgroups

IGDA. Argiudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiudolls

IGDB. Other Argiudolls that have *both*:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Directly below the mollic epipedon, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Argiudolls

IGDC. Other Argiudolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. In normal years saturation with water in one or more

layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Vertic Argiudolls

IGDD. Other Argiudolls that have:

1. A texture finer than loamy fine sand *and either*:

a. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

b. A mollic epipedon 50 cm or more thick; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Vertic Argiudolls

IGDE. Other Argiudolls that have:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon; *and*

3. *Either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Alfic Vertic Argiudolls

IGDF. Other Argiudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiudolls

IGDG. Other Argiudolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argiudolls

IGDH. Other Argiudolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argiudolls

IGDI. Other Argiudolls that have aquic conditions for some time in normal years (or artificial drainage) *either*:

1. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

2. Directly below the mollic epipedon, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

a. A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

b. Hue of 10YR or redder and chroma of 2 or less; *or*

c. Hue of 2.5Y or yellower and chroma of 3 or less.

Aquic Argiudolls

IGDJ. Other Argiudolls that have a texture finer than loamy fine sand *and either*:

1. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

2. A mollic epipedon 50 cm or more thick.

Pachic Argiudolls

IGDK. Other Argiudolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argiudolls

IGDL. Other Argiudolls that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Argiudolls

IGDM. Other Argiudolls that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Argiudolls

IGDN. Other Argiudolls that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more.

Arenic Argiudolls

IGDO. Other Argiudolls that have an argillic horizon that, with increasing depth, has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within its upper 7.5 cm.

Abruptic Argiudolls

IGDP. Other Argiudolls that have:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argiudolls

IGDQ. Other Argiudolls that have an apparent CEC of less than 24 cmol(+)/kg clay (by 1N NH_4OAc pH 7) in 50 percent or more either of the argillic horizon if less than 100 cm thick or of its upper 100 cm.

Oxic Argiudolls

IGDR. Other Argiudolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Argiudolls

IGDS. Other Argiudolls.

Typic Argiudolls

Definition of Typic Argiudolls

Typic Argiudolls are the Argiudolls that:

1. Do not have aquic conditions for some time in normal years *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Directly below the mollic epipedon, in horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a lithic contact within 50 cm of the mineral soil surface;

4. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

6. Have an apparent CEC (by 1N NH_4OAc pH 7) of 24 or more in 50 percent or more of the argillic horizon or in 50 percent or more of the upper 100 cm of the argillic horizon if the argillic horizon is thicker than 100 cm;

7. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

8. Do not have a calcic horizon within 100 cm of the soil surface;

9. Do not have a texture finer than loamy fine sand *and either*:

a. A mollic epipedon 50 cm or more thick; *or*

b. A mollic epipedon 40 cm or more thick and a frigid temperature regime;

10. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon;

11. Do not have an argillic horizon that, with increasing depth, has a clay increase of 20 percent or more (absolute, in the fine-earth fraction) within its upper 7.5 cm;

12. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

13. Do not have:

a. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *and*

b. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Description of Subgroups

Typic Argiudolls.—The central concept or Typic subgroup of Argiudolls is fixed on soils that show little evidence of wetness within a depth of 40 cm or more, that do not have a shallow lithic contact, that have a loamy or clayey particle-size class in at least the argillic horizon, and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years.

Shallow ground water and redoximorphic features are properties of Aquolls and are the basis for defining the Aquic and Oxyaquic subgroups. A shallow lithic contact is the basis for defining the Lithic subgroup. An argillic horizon that has a sandy particle-size class or consists either entirely or partly of thin lamellae is weakly developed and is the basis for defining Psammentic and Lamellic subgroups. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup. An albic or glossic horizon or another horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon above the argillic horizon, interfingering of albic materials into the upper part of the argillic horizon, and skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon are considered characteristics of Alfisols and are the basis for defining the Alfic subgroup.

Typic Argiudolls are of large extent in the United States. They are mostly on the eastern Great Plains but occur throughout much of the country. Most of these soils supported tall grasses, and most are now used as cropland.

Abruptic Argiudolls.—These soils have an abrupt textural change at the top of the argillic horizon. They show no evidence of the development of an albic horizon. They are of very small extent in the United States and occur mostly in Minnesota. These soils supported chiefly tall grasses. They commonly are used as cropland.

Alfic Argiudolls.—These soils have an albic or glossic horizon or another horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon above the argillic horizon, have interfingering of albic materials into the upper part of the argillic horizon, or have skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon. These soils are of very small extent in the United States and occur mostly in Minnesota. They supported mostly tall grasses. They commonly are used as cropland.

Alfic Vertic Argiudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They also have an albic or glossic horizon or another horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon above the argillic horizon, have interfingering of albic materials into the upper part of the argillic horizon, or have skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon. These soils are of very small extent in the United States and occur mostly in North Dakota. They supported mostly tall grasses. They commonly are used as cropland.

Andic and Vitrandic Argiudolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are not known to occur in the United States.

Aquertic Argiudolls.—These soils have lower chroma than Typic Argiudolls and commonly have faint redoximorphic features and either shallow ground water at some time during the year or artificial drainage. They also have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. These soils are of moderate extent in the United States and occur mostly on the northern Great Plains. They supported mostly tall grasses and commonly are used as cropland.

Aquic Argiudolls.—These soils have lower chroma than Typic Argiudolls and commonly have faint redoximorphic features and either shallow ground water at some time during the year or artificial drainage. They are extensive soils in the glaciated regions of the northern Great Plains of the United States. They commonly occur in areas between Aquolls and Typic Argiudolls. Slopes generally are nearly level. Most Aquic Argiudolls have been artificially drained. They supported chiefly tall grasses and commonly are used as cropland.

Arenic Argiudolls.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of the argillic horizon at a depth of 50 cm or more. The argillic horizon most commonly is at a depth of 75 to 100 cm. These soils formed in Pleistocene deposits. They are of very small extent in the United States and occur mostly in North Dakota and Minnesota. They supported chiefly tall grasses and commonly are used as cropland.

Calcic Argiudolls.—These soils have a calcic horizon within 100 cm of the soil surface. They are not known to occur in the United States. They were established for use in Argentina.

Lamellic Argiudolls.—These soils are like Typic Argiudolls in defined properties, but they have an argillic horizon that consists entirely or partially of lamellae. Most Lamellic Argiudolls have a sandy particle-size class, and the upper boundary of the argillic horizon or the upper lamella may be below a depth of 60 cm. The upper several lamellae are commonly broken or discontinuous horizontally. These soils are not known to occur in the United States.

Lithic Argiudolls.—These soils have a shallow lithic contact but are otherwise like Typic Argiudolls. Slopes are commonly moderate to steep. Lithic Argiudolls are of small extent in the United States. They are mostly on the eastern Great Plains. Most of the soils supported tall grasses and some widely spaced trees. Most are now used as cropland or pasture.

Oxic Argiudolls.—These soils have a low cation-exchange capacity in half or more of the argillic horizon (if this horizon is less than 100 cm thick) or of its upper 100 cm. They are mostly in areas of warm and humid climates and are not known to occur in the United States.

Oxyaquic Argiudolls.—These soils are like Typic Argiudolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are moderately extensive soils in the glaciated regions of the northern Great Plains of the United States. They commonly are in areas between the Aquic and Typic subgroups of Argiudolls. Slopes generally are gentle. Oxyaquic Argiudolls supported mostly tall grasses and commonly are used as cropland.

Oxyaquic Vertic Argiudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are of small extent on the Great Plains of the United States. Slopes generally are gentle. These soils supported mostly tall grasses and commonly are used as cropland.

Pachic Argiudolls.—These soils are like Typic Argiudolls, but they have a thick mollic epipedon. The argillic horizon generally starts in the lower part of the mollic epipedon. Slopes of the Pachic Argiudolls in the United States range from gentle to steep. The soils are of small extent on the Great Plains of the United States. Most of the soils are used as cropland.

Pachic Vertic Argiudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They also have a thick mollic epipedon. The argillic horizon generally starts in the lower part of the mollic epipedon. These soils are of very small extent in the United States and occur mostly in North Dakota. They supported chiefly tall grasses and commonly are used as cropland.

Psammentic Argiudolls.—These soils formed mostly in sandy Pleistocene deposits, either dunes or glacial outwash. The argillic horizon most commonly is 75 to 100 cm below the soil surface. These soils are of very small extent in the United States. They supported mostly tall grasses and commonly are used as cropland.

Vertic Argiudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They are of small extent in the United States. They occur throughout the Great Plains. They supported mostly tall grasses and commonly are used as cropland.

Calciudolls

These are the Udolls with a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface. Calciudolls do not have an argillic horizon above the calcic or petrocalcic horizon. They are calcareous in all subhorizons overlying the calcic horizon after the upper 18 cm has been mixed, unless the texture is coarser than loamy very fine sand or very fine sand. These soils are of small extent on the northern Great Plains of the United States. They are important in Argentina.

Definition

Calciudolls are the Udolls that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface;

2. Are calcareous in all parts of all horizons above the calcic horizon after the upper 18 cm has been mixed, unless the texture is coarser than loamy very fine sand or very fine sand;

3. Do not have an argillic horizon above the calcic or petrocalcic horizon; *and*

4. Do not have a natric horizon.

Key to Subgroups

IGBA. Calciudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciudolls

IGBB. Other Calciudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciudolls

IGBC. Other Calciudolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciudolls

IGBD. Other Calciudolls that have a slope of less than 25 percent; *and either*:

1. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a lithic or paralithic contact if shallower.

Fluventic Calciudolls

IGBE. Other Calciudolls.

Typic Calciudolls

Definition of Typic Calciudolls

Typic Calciudolls are the Udolls that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface; *and*

2. Do not have *either*:

   a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

   b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

3. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions; *and*

4. Do not have a slope of less than 25 percent and *either* of the following:

   a. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

   b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a lithic or paralithic contact if shallower.

Description of Subgroups

Typic Calciudolls.—The central concept or Typic subgroup of Calciudolls is fixed on deep soils that show little evidence of wetness within a depth of 40 cm or more and are calcareous throughout.

Shallow ground water and redoximorphic features are properties of Aquolls and are the basis for defining the Aquic subgroup. A shallow lithic contact is the basis for defining the Lithic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup.

Typic Calciudolls are of small extent on the northern Great Plains of the United States. Most of these soils supported tall grasses and are used as cropland.

Aquic Calciudolls.—These soils have ground water at a moderate depth in the calcic horizon at some time during the year, and they have redox depletions with low chroma. The epipedon also commonly has low chroma. These soils are of small extent on the northern Great Plains of the United States. They generally are nearly level and formed in late-Wisconsinan drift. Nearly all of these soils supported tall grasses and are used as cropland.

Fluventic Calciudolls.—These soils are freely drained and formed in alluvium deposited recently enough for the content of organic carbon to decrease irregularly with increasing depth or to remain relatively high in the deep layers. The soils are subject to overflow, primarily when snow melts. Most of these soils are cultivated if they occur in areas suitable in size and shape. Fluventic Calciudolls are of very small extent in the United States. Most are used as cropland.

Lithic Calciudolls.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are otherwise similar to Typic Calciudolls. Lithic Calciudolls are not known to occur in the United States.

Vertic Calciudolls.—These soils are like Typic Calciudolls, but they have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. Vertic Calciudolls are not known to occur in the United States.

Hapludolls

These are the Udolls that generally have a cambic horizon below a mollic epipedon. There may be a Bk horizon below the cambic horizon, and a few of the soils have enough secondary carbonates for a calcic horizon.

Hapludolls formed mostly in Holocene or late-Pleistocene deposits or on surfaces of that age. Slopes generally are gentle, and most of the soils are cultivated. Hapludolls are extensive soils in Iowa, Minnesota, and adjacent states.

Definition

Hapludolls are the Udolls that:

1. Do not have an argillic or natric horizon;

2. Do not have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface if all parts above the calcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser; *and*

3. Have less than 50 percent (by volume) wormholes, wormcasts, and filled animal burrows in the mollic epipedon below any plow layer if the epipedon rests on a densic, lithic, or paralithic contact or have a transition between the mollic epipedon and the underlying horizon in which less than 25 percent (by volume) consists of wormholes, wormcasts, and filled animal burrows.

Key to Subgroups

IGFA. Hapludolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludolls

IGFB. Other Hapludolls that have *both*:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Directly below the mollic epipedon, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquertic Hapludolls

IGFC. Other Hapludolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludolls

IGFD. Other Hapludolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and aluminum plus $^1/_2$ iron percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludolls

IGFE. Other Hapludolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Hapludolls

IGFF. Other Hapludolls that have:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon 40 cm or more thick, of which less than 50 percent has a sandy or sandy-skeletal particle-size class, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon 60 cm or more thick, of which 50 percent or more of the thickness has a texture finer than loamy fine sand; *and*

2. *Either* 0.3 percent or more organic carbon at a depth of 125 cm below the mineral soil surface *or* an irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of 25 percent or less; *and*

4. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cumulic Hapludolls

IGFG. Other Hapludolls that have:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon 40 cm or more thick, of which less than 50 percent has a sandy or sandy-skeletal particle-size class, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon 60 cm or more thick, of which 50 percent or more of the thickness has a texture finer than loamy fine sand; *and*

2. *Either* 0.3 percent or more organic carbon at a depth of 125 cm below the mineral soil surface *or* an irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of 25 percent or less.

Cumulic Hapludolls

IGFH. Other Hapludolls that have *both*:

1. Aquic conditions for some time in normal years (or artificial drainage) *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Directly below the mollic epipedon, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less; *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Hapludolls

IGFI. Other Hapludolls that have aquic conditions for some time in normal years (or artificial drainage) *either*:

1. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

2. Directly below the mollic epipedon, in one or more horizons with a total thickness of 15 cm or more that have *one or more* of the following:

a. A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

b. Hue of 10YR or redder and chroma of 2 or less; *or*

c. Hue of 2.5Y or yellower and chroma of 3 or less.

Aquic Hapludolls

IGFJ. Other Hapludolls that have a texture finer than loamy fine sand *and either*:

1. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

2. A mollic epipedon 50 cm or more thick.

Pachic Hapludolls

IGFK. Other Hapludolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludolls

IGFL. Other Hapludolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Hapludolls

IGFM. Other Hapludolls that have *both*:

1. A mollic epipedon 60 cm or more thick that has a texture finer than loamy fine sand and contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows either below an Ap horizon or below a depth of 18 cm from the mineral soil surface; *and*

2. Either do not have a cambic horizon and do not, in the lower part of the mollic epipedon, meet all of the requirements for a cambic horizon, except for the color requirements, or have carbonates throughout either the cambic horizon or the lower part of the mollic epipedon.

Vermic Hapludolls

IGFN. Other Hapludolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Hapludolls

IGFO. Other Hapludolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet all of the requirements for a cambic horizon, except for the color requirements; *or*

2. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Hapludolls

IGFP. Other Hapludolls.

Typic Hapludolls

Definition of Typic Hapludolls

Typic Hapludolls are the Hapludolls that:

1. Do not have aquic conditions for some time in normal years *either*:

a. Within 40 cm of the mineral soil surface, in horizons that also have redoximorphic features; *or*

b. Directly below the mollic epipedon, in horizons with a total thickness of 15 cm or more that have *one or more* of the following:

(1) A color value, moist, of 4 or more and redox depletions with chroma of 2 or less; *or*

(2) Hue of 10YR or redder and chroma of 2 or less; *or*

(3) Hue of 2.5Y or yellower and chroma of 3 or less;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Have a mollic epipedon that is less than 60 cm thick or has a texture of loamy fine sand or coarser if it is 60 cm or more thick;

4. Have a cambic horizon or, in the lower part of the mollic epipedon, meet all of the requirements for a cambic horizon, except for the color requirments, and either the cambic horizon or the lower part of the epipedon is free of carbonates in some part;

5. *Either* have a regular decrease in organic-carbon content with increasing depth and, unless a densic, lithic, or paralithic contact is at some depth between 50 and 125 cm below the soil surface, have an organic-carbon content of 0.3 percent or less at a depth within 125 cm of the surface *or* have a slope of 25 percent or more;

6. Do not have a lithic contact within 50 cm of the mineral soil surface;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

8. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

9. Do not have a calcic horizon within 100 cm of the soil surface; *and*

10. Do not have a texture finer than loamy fine sand *and either*:

a. A mollic epipedon 50 cm or more thick; *or*

b. A mollic epipedon 40 cm or more thick and a frigid temperature regime.

Description of Subgroups

Typic Hapludolls.—The central concept or Typic subgroup of Hapludolls is fixed on soils in which there is little evidence of wetness within a depth of 40 cm or more, in which there is a thin or moderately thick mollic epipedon, and in which a cambic horizon is free of carbonates in some part or the lower part of the mollic epipedon is free of carbonates and resembles a cambic horizon. These soils do not have a shallow lithic contact; do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years; and show evidence of only a small amount of animal activity.

Low chroma and redoximorphic features are properties of Aquolls and are the basis for defining Aquic and combination Aquic subgroups of Hapludolls. An irregular decrease in organic-carbon content with increasing depth and a relatively high organic-carbon content in the deep layers indicate recent alluvium and are the basis for defining the Fluventic subgroup or, if the soils also are saturated with water at some period, the Fluvaquentic subgroup. An overthickened epipedon and a relatively high content of organic carbon in the deep layers indicate slow accumulation of materials at the surface and, in part, are the basis for defining the Cumulic subgroup. The absence of a cambic horizon or the presence of carbonates throughout the cambic horizon suggests weak weathering and is the basis for defining the Entic subgroup. A shallow lithic contact is the basis for defining the Lithic subgroup. Intensive animal activity is a property of Vermudolls and is the basis for defining the Vermic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup.

Typic Hapludolls are of large extent in the United States. They are mostly in Iowa, in Minnesota, and throughout the eastern Great Plains. Some Typic Hapludolls occur throughout much of the country. Most supported tall grasses, and most are now used as cropland.

Andic and Vitrandic Hapludolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of very small extent in Oregon in the United States.

Aquertic Hapludolls.—These soils have lower chroma than Typic Hapludolls and commonly have faint redoximorphic features and either shallow ground water at some time during the year or artificial drainage. They also have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. These soils are of small extent in the United States and occur mostly in Minnesota and Iowa. They supported mostly tall grasses and commonly are used as cropland.

Aquic Hapludolls.—These soils have lower chroma than Typic Hapludolls, commonly have faint redoximorphic features, and either have shallow ground water at some time during the year or have been artificially drained. These are extensive soils in the glaciated regions of the northern Great Plains of the United States. They commonly are in areas between Aquolls and Typic Hapludolls. Slopes generally are nearly level, and most of the soils have been artificially drained. Aquic Hapludolls supported mostly tall grasses and commonly are used as cropland.

Aquic Cumulic Hapludolls.—These soils have an overthickened mollic epipedon. They also have lower chroma than Typic Hapludolls, commonly have faint redoximorphic features, and either have shallow ground water at some time during the year or have been artificially drained. They are at the base of slopes or on flood plains, where they receive fresh sediments at a rate slow enough for the material to become incorporated into the mollic epipedon. Some of the soils are calcareous throughout their thickness. Aquic Cumulic Hapludolls are of small extent and are mostly in Iowa. Slopes are gentle and are mostly plane or concave. These soils supported mostly tall grasses and commonly are used as cropland.

Calcic Hapludolls.—These soils are similar to Typic Hapludolls but have a calcic horizon within 100 cm of the soil surface. They are of small extent, mostly in Minnesota, in the United States. They supported mostly tall grasses and commonly are used as cropland.

Cumulic Hapludolls.—These soils have an overthickened mollic epipedon. They are at the base of slopes or on flood plains, where they receive fresh sediments at a rate slow enough for the material to become incorporated into the mollic epipedon. These soils are permitted, but not required, to have a cambic horizon. They may be calcareous throughout their thickness. Slopes are gentle and are mostly plane or concave. These soils are of large extent and are widely distributed in the United States. Many of the soils supported tall grasses, but some supported trees and shrubs. Most are used as cropland.

Entic Hapludolls.—These soils either do not have a cambic horizon or are calcareous in the lower part of the mollic epipedon or throughout any cambic horizon. Most of the soils are sandy and show relatively weak horizon development. Slopes are moderate to strong and are convex. These soils are of small extent, mostly in Iowa and Minnesota, in the United States. They supported mostly tall grasses and commonly are used as cropland.

Fluvaquentic Hapludolls.—These soils have lower chroma than Typic Hapludolls, have faint redoximorphic features, and either have shallow ground water at some time during the year or have been artificially drained. They are on flood plains and formed in recent alluvium in which there are buried A horizons or in which the content of organic carbon is relatively high in deep layers. These soils are of moderate extent and are widely distributed in the United States. Slopes are gentle and are mostly plane or concave. Many of the soils supported tall grasses, but some supported trees and shrubs. Most are used as cropland.

Fluventic Hapludolls.—These soils are freely drained and are on flood plains. They formed in recent alluvium in which there are buried A horizons or in which the content of organic carbon is relatively high in deep layers. Many of the soils do not have a cambic horizon. The soils are otherwise like Typic Hapludolls. Fluventic Hapludolls are of moderate extent and are widely distributed in the United States. Slopes are gentle and are mostly plane or concave. Many of the soils supported tall grasses, but some supported trees and shrubs. Most are used as cropland.

Lithic Hapludolls.—These soils have a shallow lithic contact. The mollic epipedon commonly extends to the rock. Some of the soils have impeded drainage because of shallow, impermeable rock. Lithic Hapludolls are of moderate extent and are widely distributed in the United States. Slopes are gentle to very steep. Many of the soils supported grasses, but some supported trees and shrubs. Most are used as rangeland or wildlife habitat.

Oxyaquic Hapludolls.—These soils are like Typic Hapludolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are of small extent but are widely distributed in the United States. They commonly are in areas between the Aquic and Typic subgroups of Hapludolls. Slopes generally are gentle. Oxyaquic Hapludolls supported mostly tall grasses and commonly are used as cropland.

Pachic Hapludolls.—These soils are like Typic Hapludolls, but they have a thick mollic epipedon. Slopes range from gentle to moderately steep. Pachic Hapludolls are of small extent, mostly on the northern Great Plains of the United States. They supported mostly tall grasses and commonly are used as cropland.

Vermic Hapludolls.—These soils show strong evidence of intensive animal activity, mainly of earthworms and their predators. The soils are thought to be developing toward Vermudolls. They do not occur in significant areas in the United States.

Vertic Hapludolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They are of small extent in the United States and are widely distributed. They supported mostly tall grasses and commonly are used as cropland.

Natrudolls

These are the Udolls that have a natric horizon. Below the natric horizon, there is normally one horizon or more in which carbonates, sulfates, or other soluble salts have accumulated. Most Natrudolls are in small areas. The soils are most common in Argentina and on the northern Great Plains of the United States, where many of the parent materials contain salts. Most areas of these soils are small and are nearly level or concave.

Definition

Natrudolls are the Udolls that have a natric horizon.

Key to Subgroups

IGAA. Natrudolls that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Natrudolls

IGAB. Other Natrudolls that have *both*:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Vertic Natrudolls

IGAC. Other Natrudolls that have:

1. A glossic horizon or interfingering of albic materials into the natric horizon; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Glossic Vertic Natrudolls

IGAD. Other Natrudolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrudolls

IGAE. Other Natrudolls that have visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface.

Leptic Natrudolls

IGAF. Other Natrudolls that have a glossic horizon or interfingering of albic materials into the natric horizon.

Glossic Natrudolls

IGAG. Other Natrudolls that have a calcic horizon within 100 cm of the mineral soil surface.

Calcic Natrudolls

IGAH. Other Natrudolls.

Typic Natrudolls

Definition of Typic Natrudolls

Typic Natrudolls are the Natrudolls that:

1. Do not have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have visible crystals or nests of gypsum or more soluble salts within 40 cm of the mineral soil surface;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

4. Do not have a glossic horizon or interfingering of albic materials into the natric horizon.

Description of Subgroups

Typic Natrudolls.—The central concept or Typic subgroup of Natrudolls is fixed on soils that do not have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface. These soils do not have a glossic horizon or an albic horizon that interfingers into the natric horizon. An albic horizon commonly is above the natric horizon. If there is no albic horizon, there generally are some skeletans and the color of the lower part of the mollic epipedon approaches that of an albic horizon.

Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface adversely affect the use of these soils and are the basis for defining the Leptic subgroup. An albic horizon that has an irregular lower boundary or thick skeletans on the peds in the upper part of the natric horizon are considered evidence of partial destruction of the natric horizon and are the basis for defining Glossic and combination Glossic subgroups.

Typic Natrudolls are of small extent in the United States. They are mostly on the northern Great Plains of the United States. They supported mostly salt-tolerant grasses and shrubs. Slopes are commonly gentle, and many of the soils are cultivated. Some of the soils are used as rangeland or hayland.

Calcic Natrudolls.—These soils are similar to Typic Natrudolls but have a calcic horizon within 100 cm of the soil surface. They are of small extent in the United States and are important in Argentina. They supported mostly grasses and are used mostly as cropland.

Glossic Natrudolls.—These soils show evidence of destruction of the natric horizon. Commonly, they have more exchangeable magnesium and less sodium than Typic Natrudolls, at least in the upper part of the natric horizon. Some Glossic Natrudolls receive more moisture, either as precipitation or as runoff, than the soils of the Typic subgroup. Glossic Natrudolls are mostly on the northern Great Plains of the United States. Most of the Glossic Natrudolls in the United States are nearly level and are used as cropland.

Glossic Vertic Natrudolls.—These soils have both a high shrink-swell potential and a glossic horizon or interfingering of albic materials into the natric horizon. The soils do not have a petrocalcic horizon within 100 cm or soluble salts, including gypsum, within 40 cm of the soil surface. These soils occur in the Dakotas and are used for small grain or alfalfa.

Leptic Natrudolls.—These soils have visible evidence of salts at least as soluble as gypsum within 40 cm of the soil surface. They have thinner sola than those of the Typic subgroup, and the close proximity of the soluble salts to the surface restricts plant growth. Leptic Natrudolls are moderately extensive on the northern Great Plains of the United States. They are on gentle slopes and are used primarily as rangeland.

Leptic Vertic Natrudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They also have visible evidence of salts at least as soluble as gypsum within 40 cm of the soil surface. They have thinner sola than those of the Vertic subgroup, and the close proximity of the soluble salts to the surface restricts plant growth. Leptic Vertic Natrudolls are of small extent in the United States. They are recognized only in South Dakota. They supported mostly grasses and shrubs. Most of the soils are used as rangeland.

Petrocalcic Natrudolls.—These soils are similar to Typic Natrudolls but have a petrocalcic horizon within 100 cm of the soil surface. They are not known to occur in the United States but are important in Argentina. They supported mostly grasses and are used mostly as cropland.

Vertic Natrudolls.—These soils are like Typic Natrudolls, but they have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of small extent in the United States. They are recognized only in South Dakota. They supported mostly grasses and shrubs. Most of the soils are used as cropland or rangeland.

Paleudolls

These are the Udolls that have a thick or deep argillic horizon. Most of the soils have a reddish hue and a content of clay that decreases slowly with increasing depth. Paleudolls are mainly on surfaces older than Wisconsinan and are thought to have formed during at least one glacial stage and one interglacial stage. These soils are mostly on the southern Great Plains and in the mountains of the Western United States. They are extensive only locally. Slopes are gentle to steep.

Definition

Paleudolls are the Udolls that:

1. Do not have a natric horizon; *and*

2. Have a petrocalcic horizon and do not have an argillic horizon above the petrocalcic horizon; *and*

 a. In all parts above the petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous; *or*

 b. Have a texture of loamy fine sand or coarser; *or*

3. Have an argillic horizon and a clay distribution in which the clay content does not decrease by as much as 20 percent from the maximum clay content within 150 cm of the soil surface, do not have a densic, lithic, or paralithic contact within that depth, and also have *one or both* of the following:

 a. Hue of 7.5YR or redder and chroma of 5 or more dominant in the matrix in some part of the lower half of the argillic horizon; *or*

 b. Many coarse redox concentrations that have hue redder than 7.5YR or chroma higher than 5; *or*

4. Have a frigid temperature regime and both an argillic horizon that has its upper boundary 60 cm or more below the mineral soil surface and a texture finer than loamy fine sand in all horizons above the argillic horizon.

Key to Subgroups

IGCA. Paleudolls that have *one or both* of the following:

 1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

 2. A linear extensibility of 6.0 cm or more between the

mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudolls

IGCB. Other Paleudolls that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Paleudolls

IGCC. Other Paleudolls that have, in one or more subhorizons within the upper 50 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudolls

IGCD. Other Paleudolls that have a texture finer than loamy fine sand and a mollic epipedon 50 cm or more thick.

Pachic Paleudolls

IGCE. Other Paleudolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudolls

IGCF. Other Paleudolls that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. In all parts above the calcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Calcic Paleudolls

IGCG. Other Paleudolls.

Typic Paleudolls

Definition of Typic Paleudolls

Typic Paleudolls are the Paleudolls that:

1. Do not have, in any subhorizon within the upper 50 cm of the argillic horizon, redox depletions with chroma of 2 or less and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

4. Do not have a petrocalcic horizon within 150 cm of the mineral soil surface;

5. Do not have a calcic horizon within 100 cm of the soil surface; *and*

6. Do not have a texture finer than loamy fine sand and a mollic epipedon 50 cm or more thick.

Description of Subgroups

Typic Paleudolls.—The central concept or Typic subgroup of Paleudolls is fixed on soils that show little evidence of wetness within a depth of 100 cm, that have a mollic epipedon less than 50 cm thick, and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years. These soils do not have a petrocalcic horizon or a shallow calcic horizon.

Shallow ground water and redoximorphic features are properties of Aquolls and are the basis for defining the Aquic and Oxyaquic subgroups. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup.

Typic Paleudolls are of small extent in the United States. They are mostly on the southern Great Plains but also are in the mountains in the western part of the United States. Most of these soils supported tall grasses. Many of the soils on plains are now used as cropland. The soils in the mountains are used mostly as rangeland or wildlife habitat.

Aquic Paleudolls.—These soils have redox depletions with low chroma in the upper part of the argillic horizon (within the upper 50 cm), and, at some time during the year, ground water stands in the redox-depleted horizon unless the soils have been artificially drained. The soils are otherwise like Typic Paleudolls. Aquic Paleudolls are of small extent in the United States. They occur on the southern Great Plains of the United States. Most of these soils supported tall grasses. Many have gentle slopes and are used as cropland.

Calcic Paleudolls.—These soils are like Typic Paleudolls, but they have a calcic horizon within 100 cm of the soil surface. They are not known to occur in the United States. They were established for use in other countries.

Oxyaquic Paleudolls.—These soils are like Typic Paleudolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. Oxyaquic Paleudolls are not known to occur in the United States. They were established for use in other countries.

Pachic Paleudolls.—These soils are like Typic Paleudolls, but they have a thick mollic epipedon. The argillic horizon generally starts in the lower part of the mollic epipedon. Slopes of the Pachic Paleudolls in the United States range from gentle to steep. The soils are of small extent, mostly in the mountains of the Western United States. Many of the soils supported grasses and shrubs, but some supported trees. Most are used as rangeland, but some are used as grazeable woodland.

Petrocalcic Paleudolls.—These soils have a petrocalcic horizon within 150 cm, commonly within 100 cm, of the mineral soil surface. They are not known to occur in the United States. They were established for use in other countries.

Vertic Paleudolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in some years have deep cracks. They are of very small extent in the United States. They supported mostly tall grasses and commonly are used as cropland.

Vermudolls

Vermudolls are the Udolls that have been intensively mixed by earthworms or other burrowing animals and their predators. The most common horizon sequence is the mollic epipedon consisting of many wormcasts overlying soil material containing many worm channels filled with dark material from the mollic epipedon. These soils are not known to occur in significant areas of the United States, but they are important in other countries.

Definition

Vermudolls are the Udolls that:

1. Have a mollic epipedon below any Ap horizon, or below a depth of 18 cm from the mineral soil surface, that has 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows and that either rests on a densic, lithic, or paralithic contact or has a transition to the underlying horizon in which 25 percent or more of the material consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and the underlying horizon;

2. Do not have an argillic or natric horizon; *and*

3. Do not have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface if all parts above the calcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Key to Subgroups

IGEA. Vermudolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vermudolls

IGEB. Other Vermudolls that have a mollic epipedon less than 75 cm thick.

Haplic Vermudolls

IGEC. Other Vermudolls.

Typic Vermudolls

Definition of Typic Vermudolls

Typic Vermudolls are the Vermudolls that:

1. Have a mollic epipedon that is 75 cm or more thick;

2. Do not have a lithic contact within 50 cm of the mineral soil surface.

Description of Subgroups

Typic Vermudolls.—The central concept or Typic subgroup of Vermudolls is fixed on soils that are deep to a lithic contact and have a mollic epipedon 75 cm or more thick. These soils are not known to occur in the United States.

Haplic Vermudolls.—These soils have a mollic epipedon less than 75 cm thick. They are otherwise like Typic Vermudolls. Haplic Vermudolls are of very small extent in the United States. They are known to occur only in South Dakota and Minnesota. These soils supported tall grasses. Most of the soils are now used as cropland.

Lithic Vermudolls.—These soils have a lithic contact at a depth of 50 cm or less from the mineral soil surface. They are not known to occur in the United States.

Ustolls

Ustolls are the more or less freely drained Mollisols of subhumid to semiarid climates. Rainfall occurs mainly during a growing season, often in heavy showers, but is erratic. Drought is frequent and may be severe. During a drought, soil blowing becomes a problem. Without irrigation, the low supply of moisture usually limits crop yields. Ustolls are extensive soils on the western Great Plains in the United States.

In addition to the mollic epipedon, most Ustolls have a Bk horizon that has identifiable secondary carbonates or have a calcic horizon, but a few of the soils that formed in noncalcareous materials do not have secondary lime. Ustolls may also have a cambic, argillic, kandic, petrocalcic, or natric horizon. If there is a natric horizon, there may be an albic horizon overlying it, or if there is a cambic or argillic horizon, there may be a duripan below it. The presence or absence of these horizons is used, in part, as the basis for defining the great groups of Ustolls.

Most of the Ustolls on the Great Plains in the United States had a grass vegetation when the country was settled. Some of the Ustolls in the mountains of the Western States supported forest vegetation. The Aridic subgroups supported mostly short grasses, and the others supported mixtures of short and tall grasses.

Ustolls formed in sediments and on surfaces of varying ages from Holocene to mid Pleistocene or earlier. Those that have a thermic or warmer temperature regime, in particular, may have formed during two or more glacial and interglacial stages.

The temperature regimes of Ustolls are warmer than cryic. The moisture regimes are dominantly ustic, but a few of the soils that are marginal to Aridisols have an aridic (torric) regime.

Definition

Ustolls are the Mollisols that:

1. Have an ustic moisture regime or an aridic moisture regime that borders on ustic;

2. Have a temperature regime warmer than cryic;

3. Do not have both an albic horizon and, within 100 cm of the mineral soil surface, any subhorizon of the albic horizon and/or of the argillic or natric horizon that has redox concentrations in the form of masses or concretions, or both, and also aquic conditions; *and*

4. Do not have both aquic conditions and the colors defined for Aquolls.

Key to Great Groups

IFA. Ustolls that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durustolls, p. 612

IFB. Other Ustolls that have a natric horizon.

Natrustolls, p. 622

IFC. Other Ustolls that:

1. Have either a calcic or gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface or a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *and*

2. Do not have an argillic horizon above the calcic, gypsic, or petrocalcic horizon; *and*

3. In all parts above the calcic, gypsic, or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Calciustolls, p. 608

IFD. Other Ustolls that have *either*:

1. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

2. An argillic horizon that has *one or both* of the following:

a. With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content (noncarbonate clay) within 150 cm of the mineral soil surface (and there is no densic, lithic, or paralithic contact within that depth); *and either*

(1) Hue of 7.5YR or redder and chroma of 5 or more in the matrix; *or*

(2) Common redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

b. 35 percent or more clay in its upper part and a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface).

Paleustolls, p. 625

IFE. Other Ustolls that have an argillic horizon.

Argiustolls, p. 602

IFF. Other Ustolls that have a mollic epipedon that:

1. Either below an Ap horizon or below a depth of 18 cm from the mineral soil surface, contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows; *and*

2. Either rests on a lithic contact or has a transition zone to the underlying horizon in which 25 percent or more of the soil volume consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and from the underlying horizon.

Vermustolls, p. 629

IFG. Other Ustolls.

Haplustolls, p. 613

Argiustolls

These are the Ustolls that have an argillic horizon in or below the mollic epipedon. They do not have a natric or petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface or a duripan that has its upper boundary within 100 cm of the mineral soil surface. Most of these soils have an argillic horizon that, with increasing depth, has a clay decrease of 20 percent or more (relative) from the maximum clay content within 150 cm of the mineral soil surface. Some of the soils have a densic, lithic, or paralithic contact within 150 cm, and some have no hues of 7.5YR or redder or have chroma of 4 or less.

Most Argiustolls have a Bk or calcic horizon below the argillic horizon, and some have a Bz or By horizon below the

Bk horizon. Argiustolls formed mostly in late-Pleistocene deposits or on surfaces of comparable age. They occur in relatively stable positions. Slopes generally are moderate to nearly level, and most of the soils are cultivated. Argiustolls are extensive soils on the western Great Plains and also occur in the mountains and valleys of the Western United States.

Definition

Argiustolls are the Ustolls that:

1. Have an argillic horizon that has *both*:

a. A vertical clay distribution in which the clay content decreases by more than 20 percent from the maximum clay content (noncarbonate clay) within a depth of less than 150 cm from the soil surface if:

(1) Hue in the matrix is redder than 10YR, and chroma is higher than 4; *or*

(2) There are common redox concentrations that have hue of 7.5YR or redder or chroma higher than 5; *and*

b. Less than 35 percent clay in the upper part or an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm or an increase of less than 15 percent clay (absolute) within a vertical distance of 2.5 cm at the upper boundary, or there is a densic, lithic, or paralithic contact within 50 cm of the mineral soil surface;

2. Do not have a duripan that has its upper boundary within 100 cm of the soil surface;

3. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface;

4. Do not have a natric horizon; *and*

5. Do not have calcic or gypsic horizon that has its upper boundary within 100 cm of the soil surface unless there is an argillic horizon above the calcic or gypsic horizon or some part of the soil above the calcic or gypsic horizon either is noncalcareous or has a texture finer than loamy fine sand after the materials between the soil surface and a depth of 18 cm have been mixed.

Key to Subgroups

IFEA. Argiustolls that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Aridic Lithic Argiustolls

IFEB. Other Argiustolls that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. Above the argillic horizon, either an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon.

Alfic Lithic Argiustolls

IFEC. Other Argiustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argiustolls

IFED. Other Argiustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Torrertic Argiustolls

IFEE. Other Argiustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udertic Argiustolls

IFEF. Other Argiustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argiustolls

IFEG. Other Argiustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argiustolls

IFEH. Other Argiustolls that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Argiustolls

IFEI. Other Argiustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argiustolls

IFEJ. Other Argiustolls that have a texture finer than loamy fine sand *and either*:

1. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

2. A mollic epipedon 50 cm or more thick.

Pachic Argiustolls

IFEK. Other Argiustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Argiustolls

IFEL. Other Argiustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argiustolls

IFEM. Other Argiustolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argiustolls

IFEN. Other Argiustolls that have *both*:

1. A calcic horizon with its upper boundary within 100 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Calcidic Argiustolls

IFEO. Other Argiustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Argiustolls

IFEP. Other Argiustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Argiustolls

IFEQ. Other Argiustolls that have a brittle horizon that is within 100 cm of the mineral soil surface, is 15 cm or more thick, and has either some opal coatings or 20 percent or more (by volume) durinodes.

Duric Argiustolls

IFER. Other Argiustolls.

Typic Argiustolls

Definition of Typic Argiustolls

Typic Argiustolls are the Argiustolls that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a brittle horizon that is 15 cm or more thick, is within 100 cm of the soil surface, and has some opal coatings or 20 percent or more (by volume) durinodes;

4. Do not have a lithic contact within 50 cm of the mineral soil surface;

5. Do not have *either*:

a. An albic horizon or another horizon above the argillic horizon that has a color value too high for a mollic epipedon and chroma too high for an albic horizon; *or*

b. A glossic horizon, *or* interfingering of albic materials in the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering more than half the faces of peds in the upper 5 cm or more of the argillic horizon;

6. Do not have a texture finer than loamy fine sand *and either*:

a. A mollic epipedon 50 cm or more thick; *or*

b. A mollic epipedon 40 cm or more thick and a frigid temperature regime;

7. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C and is dry for more than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C;

8. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

9. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus 1/2 acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

10. Do not have a calcic horizon with its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Argiustolls.—The central concept or Typic subgroup of Argiustolls is fixed on deep, freely drained soils that have some available moisture during most of the growing season and do not have a calcic horizon, an albic horizon, a glossic horizon, interfingering of albic materials, or a horizon that has color values too high for a mollic epipedon above the argillic horizon. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years.

Shallow ground water or artificial drainage and redox depletions with low chroma are properties shared with Aquolls and are the basis for defining Aquic and Oxyaquic subgroups. A shallow lithic contact is the basis for defining Lithic and combination Lithic subgroups. An albic horizon above the argillic horizon is characteristic of Alfisols and is the basis for defining the Alfic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. Argiustolls that are moist for longer periods of time than is described for the Typic subgroup are assigned to the Udic subgroup, and those that are dry for longer periods are assigned to the Aridic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup.

Typic Argiustolls are of large extent in the United States. They are mostly on the Great Plains but also are in the mountains in the western part of the United States. Most of these soils supported grasses and shrubs. Some of the soils, mostly those in the mountains, supported trees or grass and widely spaced trees. Many of the soils on plains are now used as cropland. The soils in the mountains are used mostly as rangeland or wildlife habitat.

Alfic Argiustolls.—These soils have an albic horizon or an eluvial horizon that is too light in color for a mollic epipedon above the argillic horizon, or they have a glossic horizon, interfingering of albic materials, or skeletans of clean silt and sand covering more than half the faces of peds in the upper 5 cm or more of the argillic horizon. The vegetation on these soils commonly is grass and scattered conifer trees. The soils are of small extent, mostly in the mountains of Colorado. They are used mostly as rangeland or wildlife habitat.

Alfic Lithic Argiustolls.—These soils have a lithic contact within 50 cm of the soil surface and have an albic horizon or an eluvial horizon that is too light in color for a mollic epipedon above the argillic horizon, or they have a glossic horizon, interfingering of albic materials, or skeletans of clean silt and sand covering more than half the faces of peds in the upper 5 cm or more of the argillic horizon.

These soils are of very small extent and are known to occur only in Texas in the United States. They are used as rangeland.

Andic and Vitrandic Argiustolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of very small extent in the mountains of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of these soils are used as forest, rangeland, or wildlife habitat.

Aquic Argiustolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. The color value and chroma of these soils commonly are lower than those of Typic Argiustolls. Aquic Argiustolls developed mostly in nearly level upland areas that commonly are concave. They are of small extent in the United States. Most of the soils are used as cropland.

Aridic Argiustolls.—These soils are drier than Typic Argiustolls, and they do not have a calcic horizon. It is common but is not required that the color value and chroma are higher and the depth to carbonates is less than in Typic Argiustolls. A Bz horizon and a Bk horizon are more common than in soils of the Typic subgroup. Aridic Argiustolls generally receive less precipitation than the soils of the Typic subgroup, or they lose more water through runoff. A few Aridic Argiustolls that are associated with Aridisols may receive runoff from other soils.

Aridic Argiustolls are extensive and widely distributed in the Western United States. The largest extent is on the western part of the Great Plains. Slopes range from nearly level to steep. In the United States, many Aridic Argiustolls that have suitable slopes are used as cropland. Winter wheat and grain sorghum are common crops. If the temperature regime is frigid or mesic, many of the soils are fallowed in alternate years to store moisture. Some of the soils are irrigated, and many of the more sloping soils are used as rangeland.

Aridic Lithic Argiustolls.—These soils have a lithic contact within 50 cm of the mineral soil surface and a soil moisture regime that borders on aridic. They occur on the western Great Plains of the United States and are used mainly as rangeland.

Calcidic Argiustolls.—These soils are drier than Typic Argiustolls and have a calcic horizon with its upper boundary within 100 cm of the soil surface. Calcidic Argiustolls do not have a high shrink-swell potential or a lithic contact within 50 cm of the soil surface. They also do not have an albic horizon above the argillic horizon, a mollic epipedon 50 cm or more thick, saturation within 100 cm of the soil surface, or a significant amount of volcanic glass. These soils occur in the southwestern part of the United States and are used mostly for grazing by livestock.

Duric Argiustolls.—These soils have a brittle horizon that is within 100 cm of the mineral soil surface, is 15 cm or more thick, and has either some opal coatings or 20 percent or more durinodes. They are otherwise like Typic Argiustolls in their defined properties and in most other properties. Duric Argiustolls are not known to occur in the United States.

Lithic Argiustolls.—These soils have a shallow lithic contact. They may have identifiable secondary carbonates above the rock, but this feature is not common in the United States. These soils are of large extent, mostly in the mountains of the Western United States. They have moderate to very steep slopes. The vegetation commonly is grass and shrubs, but some of the soils support forest vegetation. Lithic Argiustolls are used mostly as rangeland or forest.

Oxyaquic Argiustolls.—These soils are like Typic Argiustolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are of very small extent in the United States.

Pachic Argiustolls.—These soils have a thick mollic epipedon that commonly includes at least part of the argillic horizon. Some of these soils receive extra water as runoff from other soils. Pachic Argiustolls are extensive in the United States. They are widely distributed on the Great Plains and in the mountains of the Western United States. Slopes are nearly level to steep. Many of these soils supported grasses and shrubs, but some supported trees. Most of the soils on plains are used as cropland. Most of the soils in the mountains are used as rangeland, but some are used as grazeable woodland.

Torrertic Argiustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than Vertic Argiustolls. Torrertic Argiustolls are of small extent in the United States and occur on the western Great Plains. The natural vegetation was mostly grasses and shrubs. Slopes generally are gentle, and many are concave. Most of these soils are used as cropland, but some are used as rangeland.

Udertic Argiustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in many years have deep cracks. They are more moist than Vertic Argiustolls because they either receive more precipitation or receive runoff from other soils. Udertic Argiustolls are of small extent in the United States and occur on the southern Great Plains. The natural vegetation was mostly grasses. Slopes generally are gentle, and many are concave. Most of these soils are used as cropland, but some are used as rangeland.

Udic Argiustolls.—These soils are more moist than Typic Argiustolls because they either receive more precipitation or receive runoff from other soils. Most of the Udic Argiustolls in the United States are in areas between Typic Argiustolls and Udolls. Udic Argiustolls are extensive soils in the southeastern part of the Great Plains. The natural vegetation was mostly grasses and shrubs. Slopes generally are gentle. Most of these soils are used as cropland.

Vertic Argiustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They formed mostly in material weathered from smectite-rich shale or in material weathered from limestone. They are associated on the landscape with Usterts and with other Ustolls. Vertic Argiustolls occur throughout the Great Plains in the United States and are moderately extensive soils. The natural vegetation was mostly grasses. Slopes generally are gentle, and most of these soils are used as cropland.

Vitritorrandic Argiustolls.—These soils have significant amounts of cinders, pumice, and pumicelike fragments or glass and have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface or a high shrink-swell potential. These soils are not known to occur in the United States.

Calciustolls

These are the Ustolls that have a gypsic, calcic, or petrocalcic horizon and that are calcareous in all overlying horizons. These soils do not have a duripan or an argillic or natric horizon above the calcic, gypsic, or petrocalcic horizon. Either the parent materials had more carbonates than the limited rainfall could remove from the upper horizons, or there is a continuing external source of carbonates in dust or water.

Calciustolls formed mostly in Pleistocene sediments or in older materials on surfaces of comparable age. In the United States, their vegetation was dominantly grass before the soils were cultivated. Calciustolls are most extensive on the Great Plains in the United States, but some are in the intermountain valleys of the Western States.

Definition

Calciustolls are the Ustolls that:

1. Have a calcic or gypsic horizon that has its upper boundary within 100 cm of the soil surface or a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface and are calcareous in all parts of all horizons above the calcic, petrocalcic, or gypsic horizon after the upper 18 cm has been

mixed, unless the texture is coarser than loamy very fine sand or very fine sand;

2. Do not have an argillic horizon above the calcic, gypsic, or petrocalcic horizon;

3. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have a natric horizon.

Key to Subgroups

IFCA. Calciustolls that have a salic horizon that has its upper boundary within 75 cm of the mineral soil surface.

Salidic Calciustolls

IFCB. Other Calciustolls that have a petrocalcic horizon and a lithic contact within 50 cm of the mineral soil surface.

Lithic Petrocalcic Calciustolls

IFCC. Other Calciustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calciustolls

IFCD. Other Calciustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Torrertic Calciustolls

IFCE. Other Calciustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udertic Calciustolls

IFCF. Other Calciustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calciustolls

IFCG. Other Calciustolls that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Calciustolls

IFCH. Other Calciustolls that have a gypsic horizon with its upper boundary within 100 cm of the mineral soil surface.

Gypsic Calciustolls

IFCI. Other Calciustolls that have a texture finer than loamy fine sand *and either*:

1. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

2. A mollic epipedon 50 cm or more thick.

Pachic Calciustolls

IFCJ. Other Calciustolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calciustolls

IFCK. Other Calciustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Calciustolls

IFCL. Other Calciustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Calciustolls

IFCM. Other Calciustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for four-tenths or less of the consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Calciustolls

IFCN. Other Calciustolls.

Typic Calciustolls

Definition of Typic Calciustolls

Typic Calciustolls are the Calciustolls that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a lithic contact within 50 cm of the soil surface;

4. Do not have a texture finer than loamy fine sand *and either*:

a. A mollic epipedon 50 cm or more thick; *or*

b. A mollic epipedon 40 cm or more thick and a frigid temperature regime;

5. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

6. Do not have a salic horizon that has its upper boundary within 75 cm of the mineral soil surface;

7. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC and is dry for more than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC;

8. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

9. Do not have a gypsic horizon with its upper boundary within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Calciustolls.—The central concept or Typic subgroup of Calciustolls is fixed on soils that do not have a fluctuating ground water table in their deep layers accompanied by redoximorphic features, that have an ustic moisture regime, that have a mollic epipedon of moderate thickness, that have a calcic horizon rather than a petrocalcic horizon, and that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years.

Redox concentrations and a ground water table that fluctuates within 100 cm of the mineral soil surface are properties shared with Aquolls and are the basis for defining Aquic and Oxyaquic subgroups. A shallow lithic contact is the basis for defining Lithic and combination Lithic subgroups. A thick mollic epipedon is the basis for defining the Pachic subgroup. A petrocalcic horizon indicates development that is more intensive than normal and is the basis for defining the Petrocalcic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks that are evident in normal years are characteristics of Vertisols and are the basis for defining the Vertic subgroup.

Typic Calciustolls are of moderately large extent in the United States. They are widely distributed. The largest extent is on the Great Plains from Montana to Texas. The soils also are on tropical islands and in some valleys in the mountains of the Western United States. Most Typic Calciustolls supported grasses and shrubs. Most of the soils on plains are now used as cropland. The soils in the mountains are used mostly as rangeland or wildlife habitat.

Aquic Calciustolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. The color value and chroma of these soils commonly are lower than those of Typic Calciustolls. Aquic Calciustolls developed mostly in nearly level upland areas that commonly are concave. These soils are of small extent in the United States. Most are used as cropland.

Aridic Calciustolls.—These soils are drier than Typic Calciustolls. They generally receive less precipitation than the soils in the Typic subgroup, or they lose more water through runoff. A few of the soils that are associated with Aridisols may receive runoff from other soils. Aridic Calciustolls are moderately extensive and widely distributed in the Western United States. The largest extent is on the western part of the Great Plains. Slopes range from nearly level to steep. In the United States, many of the soils that have suitable slopes are used as cropland. If the temperature regime is frigid or mesic, many of the soils are fallowed in alternate years to store moisture. Some of the soils are irrigated, and most of the more sloping soils are used as rangeland.

Gypsic Calciustolls.—These soils have a gypsic horizon. They do not have a high shrink-swell potential, a salic or petrocalcic horizon, or a lithic contact within 50 cm of the mineral soil surface. These soils are not extensive but occur in southeastern New Mexico and western Texas. They are used as rangeland.

Lithic Calciustolls.—These soils have a shallow lithic contact but are otherwise like Typic Calciustolls in defined characteristics. Lithic Calciustolls soils are of small extent, mostly in the Western United States. They have moderate to very steep slopes. The vegetation is mostly grass and shrubs, but a few of the soils support forest vegetation. The soils are used mostly as rangeland or forest.

Lithic Petrocalcic Calciustolls.—These soils have a petrocalcic horizon overlying hard bedrock within a depth of 50 cm. Typically, the fractures in the underlying bedrock are filled with cemented secondary carbonates. Most of these soils are drier than Typic Calciustolls. Slopes are gentle. Lithic Petrocalcic Calciustolls formed on surfaces older than the Pleistocene. These soils are extensive locally in Texas. They are used almost exclusively as rangeland.

Oxyaquic Calciustolls.—These soils are like Typic Calciustolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are of very small extent in the United States.

Pachic Calciustolls.—These soils have a thick mollic epipedon. Most of the soils are nearly level or concave. Many are on terraces or very broad, flat upland ridges. Pachic Calciustolls are of small extent on the Great Plains in the United States. Nearly all of them are used as cropland and are summer fallowed.

Petrocalcic Calciustolls.—These soils have a petrocalcic horizon but are otherwise like Typic Calciustolls in defined properties. In most Petrocalcic Calciustolls, depth to the petrocalcic horizon is less than 50 cm. Some of the soils that have a petrocalcic horizon below a depth of 50 cm are underlain by hard bedrock. Petrocalcic Calciustolls are extensive on the Great Plains of the United States. The largest extent is in Texas. Most of the soils are used as rangeland.

Salidic Calciustolls.—These soils have a salic horizon in the upper part of the profile. They are not known to occur in the United States.

Torrertic Calciustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than Vertic Calciustolls. Torrertic Calciustolls are of very small extent in the United States.

Udertic Calciustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are more moist than Vertic Calciustolls because they generally receive more precipitation. Udertic Calciustolls are of very small extent.

Udic Calciustolls.—These soils are more moist than Typic Calciustolls because they generally receive more precipitation. The Udic Calciustolls in the United States are in areas between Typic Calciustolls and Udolls. Udic Calciustolls are of small extent and are extensive only in Texas. The natural vegetation is mostly grasses and shrubs. Slopes generally are gentle. Most of these soils are used as cropland.

Vertic Calciustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They formed mostly in material weathered from smectite-rich shale or in material weathered from limestone. They are associated on the landscape with Usterts and with other Ustolls. Vertic Calciustolls occur mostly in Texas on the Great Plains and are of small extent. The natural vegetation was mostly grasses. Slopes are mainly gentle, and most of the soils are used as cropland.

Durustolls

These are Ustolls that have a duripan with its upper boundary within 100 cm of the soil surface. These soils formed in the vicinity of cinders and ash falls. Their parent materials are mainly siliceous tuffs, volcanic ash, cinders, and basic volcanic rocks. In the United States, the natural vegetation is mostly grasses and shrubs. These soils are of small extent. They formed in late-Pleistocene deposits. They are on alluvial fans and terraces, on nearly level to rolling cinder fans and plains, and on hilly to very steep cinder cones. They may be common on the leeward sides of volcanic islands in the Lesser Antilles.

Definition

Durustolls are the Ustolls that have a duripan that has an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IFAA. Durustolls that have a natric horizon above the duripan.

Natric Durustolls

IFAB. Other Durustolls that:

1. Do not have an argillic horizon above the duripan; *and*

2. Have an aridic moisture regime that borders on ustic.

Haploduridic Durustolls

IFAC. Other Durustolls that have an aridic moisture regime that borders on ustic.

Argiduridic Durustolls

IFAD. Other Durustolls that do not have an argillic horizon above the duripan.

Entic Durustolls

IFAE. Other Durustolls that have a duripan that is strongly cemented or less cemented in all subhorizons.

Haplic Durustolls

IFAF. Other Durustolls.

Typic Durustolls

Definition of Typic Durustolls

Typic Durustolls are the Durustolls that:

1. Have an argillic horizon above the duripan;

2. Have a duripan that is massive and platy and that has half or more of its upper boundary coated or indurated with opal and silica, with or without sesquioxides, or that is indurated in some subhorizon below its upper boundary;

3. Do not have a natric horizon above the duripan; *and*

4. Do not have an aridic moisture regime.

Description of Subgroups

Typic Durustolls.—The central concept or Typic subgroup of Durustolls is fixed on soils that have an argillic horizon above a strongly developed duripan and that have an ustic moisture regime. An aridic moisture regime is drier than that of the Typic subgroup and, if the soils also have an argillic horizon, is the basis for defining intergrades to Argids. Soils that do not have an argillic horizon and that have a moisture regime drier than that of the Typic subgroup are assigned to the Haploduridic subgroup.

The Typic subgroup is not the most extensive subgroup, but it furnishes the best basis for the definition of subgroups. Typic Durustolls are not known to occur in the United States.

Argiduridic Durustolls.—These soils have an aridic moisture regime that borders on ustic, but they are otherwise like Typic Durustolls in their defined properties. The Argiduridic Durustolls in the United States generally are nearly level to strongly sloping. They are not extensive in the United States, but they are moderately extensive locally in Arizona. The natural vegetation is mostly grasses and shrubs. Most of the soils are used as rangeland. Some used as wildlife habitat or recreational areas.

Entic Durustolls.—These soils do not have an argillic horizon and have an ustic moisture regime. They are not known to occur in the United States.

Haplic Durustolls.—These soils have an ustic moisture regime and have a duripan that is strongly cemented or less cemented in all subhorizons. They do not have an argillic horizon. These soils are not known to occur in the United States.

Haploduridic Durustolls.—These soils have an aridic moisture regime that borders on ustic and do not have an argillic horizon. In the United States, they are nearly level to moderately sloping. These soils are of small extent in the United States, but they are important locally in Arizona. The natural vegetation is mostly grasses and shrubs, and most of the soils are used as rangeland.

Natric Durustolls.—These soils have a natric horizon. They occur on the western Great Plains and are used as rangeland.

Haplustolls

Most of these soils have a cambic horizon below the mollic epipedon, and most have a horizon in which carbonates or soluble salts have accumulated. A few have a calcic horizon. A few that formed in noncalcareous sediments do not have a horizon of carbonate accumulation. These are the Ustolls that do not have a duripan or a natric, petrocalcic, or argillic horizon. They do not have a calcic or gypsic horizon unless part of the soil above the calcic or gypsic horizon either is noncalcareous or has a texture coarser than loamy fine sand after the materials between the soil surface and a depth of 18 cm have been mixed.

Haplustolls formed mainly in late-Pleistocene or Holocene deposits or on surfaces of comparable age. Their vegetation has been dominantly grasses and forbs. They are extensive soils on the Great Plains of North America, in Eastern Europe, and on the Pampas in South America. Where slopes are suitable, most of the soils are used for grain and feed crops.

Definition

Haplustolls are the Ustolls that:

1. Do not have an argillic or natric horizon;

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a calcic or gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after the surface soil to a depth of 18 cm has been mixed or the texture to this depth is loamy very fine sand or finer;

4. Have a transition layer between the mollic epipedon and the underlying horizon that is less than 25 percent (by volume) wormholes, wormcasts, or filled animal burrows; *and*

5. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface.

Key to Subgroups

IFGA. Haplustolls that have a salic horizon that has its upper boundary within 75 cm of the mineral soil surface.
Salidic Haplustolls

IFGB. Other Haplustolls that have, in part of each pedon, a lithic contact within 50 cm of the mineral soil surface.
Ruptic-Lithic Haplustolls

IFGC. Other Haplustolls that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Haplustolls

IFGD. Other Haplustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Torrertic Haplustolls

IFGE. Other Haplustolls that have *all* of the following:

1. A mollic epipedon 50 cm or more thick with a texture finer than loamy fine sand; *and*

a and b. (Deleted text)

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

3. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Pachic Udertic Haplustolls

IFGF. Other Haplustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udertic Haplustolls

IFGG. Other Haplustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haplustolls

IFGH. Other Haplustolls that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years remains moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. An apparent CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower. (If the ratio of [percent water retained at 1500 kPa tension minus percent organic carbon] to the percentage of measured clay is 0.6 or more, then the percentage of clay is considered to equal either the measured percentage of clay or three times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100.)

Torroxic Haplustolls

IFGI. Other Haplustolls that have an apparent CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the soil volume between a depth of 25 cm from the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact if shallower. (If the ratio of [percent water retained at 1500 kPa tension minus percent organic carbon] to the percentage of measured clay is 0.6 or more, then the percentage of clay is considered to equal either the measured percentage of clay or three times [percent water retained at 1500 kPa tension minus percent organic carbon], whichever value is higher, but no more than 100.)

Oxic Haplustolls

IFGJ. Other Haplustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplustolls

IFGK. Other Haplustolls that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Haplustolls

IFGL. Other Haplustolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haplustolls

IFGM. Other Haplustolls that have:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon 40 cm or more thick, of which less than 50 percent has a sandy or sandy-skeletal particle-size class, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent; *and*

4. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cumulic Haplustolls

IFGN. Other Haplustolls that have:

1. *Either*:

a. A frigid soil temperature regime and a mollic epipedon 40 cm or more thick, of which less than 50 percent has a sandy or sandy-skeletal particle-size class, and there is no densic or paralithic contact and no sandy or sandy-skeletal particle-size class at a depth between 40 and 50 cm from the mineral soil surface; *or*

b. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent.

Cumulic Haplustolls

IFGO. Other Haplustolls that have anthraquic conditions.

Anthraquic Haplustolls

IFGP. Other Haplustolls that have *both*:

1. In one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Haplustolls

IFGQ. Other Haplustolls that have a texture finer than loamy fine sand *and either*:

1. A frigid temperature regime and a mollic epipedon 40 cm or more thick; *or*

2. A mollic epipedon 50 cm or more thick.

Pachic Haplustolls

IFGR. Other Haplustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in most years (or artificial drainage).

Aquic Haplustolls

IFGS. Other Haplustolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustolls

IFGT. Other Haplustolls that have *both*:

1. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90

consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Torrifluventic Haplustolls

IFGU. Other Haplustolls that:

1. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *and*

2. *Either*:

a. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet all of the requirements for a cambic horizon except color; *or*

b. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Torriorthentic Haplustolls

IFGV. Other Haplustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Haplustolls

IFGW. Other Haplustolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more at a depth of 125 cm below the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Haplustolls

IFGX. Other Haplustolls that have a brittle horizon that is within 100 cm of the mineral soil surface, is 15 cm or more thick, and has either some opal coatings or 20 percent or more (by volume) durinodes.

Duric Haplustolls

IFGY. Other Haplustolls that:

1. When neither irrigated nor fallowed to store moisture, have *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

2. Either do not have a cambic horizon and do not, in the lower part of the mollic epipedon, meet the requirements for a cambic horizon, except for the color requirements, or have carbonates throughout either the cambic horizon or the lower part of the mollic epipedon.

Udorthentic Haplustolls

IFGZ. Other Haplustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Haplustolls

IFGZa. Other Haplustolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet all of the requirements for a cambic horizon except color; *or*

2. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Haplustolls

IFGZb. Other Haplustolls.

Typic Haplustolls

Definition of Typic Haplustolls

Typic Haplustolls are the Haplustolls that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have anthraquic conditions;

4. Do not have a texture finer than loamy fine sand *and either*:

a. A mollic epipedon 50 cm or more thick; *or*

b. A mollic epipedon 40 cm or more thick and a frigid temperature regime;

5. Do not have a brittle horizon that is 15 cm or more thick, is within 100 cm of the mineral soil surface, and has some opal coatings or some durinodes (less than 20 percent, by volume);

6. Have a cambic horizon or in the lower part of the mollic epipedon, meet the requirements for a cambic horizon, except for the color and organic-carbon content requirements, and either the cambic horizon or the lower part of the mollic epipedon is free of carbonates in some part;

7. Have a regular decrease in organic-carbon content with increasing depth to a level of 0.3 percent or less within 125 cm of the mineral soil surface unless a densic, lithic, or paralithic contact occurs at a shallower depth or the slope is 25 percent or more;

8. Do not have a lithic contact within 50 cm of the mineral soil surface in any part of each pedon;

9. Do not have a salic horizon that has its upper boundary within 75 cm of the mineral soil surface;

10. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in most years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

11. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C and is dry for more than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C;

12. Have an apparent CEC (by 1N NH_4OAc pH 7) of 24 or more cmol(+)/kg clay in the major part of the soil below a depth of 25 cm but above 100 cm or a densic, lithic, or paralithic contact if one is shallower than 100 cm; *and*

13. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus ½ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Haplustolls.—The central concept or Typic subgroup of Haplustolls is fixed on moderately deep or deeper, freely drained soils that have a mollic epipedon less than 50 cm thick and either have a cambic horizon or resemble a cambic horizon in the lower part of the epipedon. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in most years. They generally are on uplands.

Ground water in the deep layers, redox depletions with low chroma, and a salic horizon are the basis for defining Aquic and Salidic subgroups. A thick mollic epipedon in soils that receive little sediment is the basis for defining the Pachic subgroup. A moisture regime that borders on udic characterizes the Udic subgroup. If a cambic horizon is absent and the lower part of the epipedon does not resemble a cambic horizon, that feature is considered evidence of weak horizon development and is the basis for defining the Entic subgroup. A thick epipedon that shows evidence of accumulation of materials on the surface is the basis for defining Cumulic and combination Cumulic subgroups. An irregular decrease in organic-carbon content with increasing depth or a relatively high content of organic carbon in the deep layers is a property of Fluvents and is the basis for defining the Fluventic subgroup or, if ground water is present and there are redox depletions with low chroma, the Fluvaquentic subgroup. A clayey texture, slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks in normal years are properties shared with Vertisols and are the basis for defining the Vertic subgroup.

Typic Haplustolls are of large extent in the United States. They are mostly on the Great Plains but also are in the mountains in the western part of the United States and on some tropical islands. Most of these soils supported grasses and shrubs. Some of the soils, mostly those in the mountains or on islands, supported trees or grass and widely spaced trees. Most of the soils on plains are now used as cropland. The soils in the mountains are used mostly as rangeland or wildlife habitat.

Andic and Vitrandic Haplustolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of very small extent in the mountains of the Western United States. The vegetation is mostly forest or grass and widely spaced trees. Most of these soils are used as forest, rangeland, or wildlife habitat.

Anthraquic Haplustolls.—These soils are like Typic Haplustolls, but they have been irrigated for the production of paddy rice for many years and have developed anthraquic conditions. They are permitted, but not required, to have redox depletions with chroma of 2 or less in layers that also have aquic conditions in normal years. They are not extensive and are not known to occur in the United States. They have level or nearly level slopes.

Aquic Cumulic Haplustolls.—These soils have a thick mollic epipedon. They are on flood plains or in concave areas where fresh sediments have accumulated slowly enough to have become incorporated in the mollic epipedon. The soils have ground water and redox depletions with low chroma in their deep layers. They have ground water when streams are at high water levels or when they overflow. These soils are of very small extent in the United States. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as cropland or hayland, except for areas that are very small, that have an irregular shape, or that are subject to frequent flooding.

Aquic Haplustolls.—These soils have ground water and redox depletions with low chroma in their deep layers. Most of the soils are in positions where they receive runoff in addition to the water that falls on the surface. Slopes are gentle or concave. The epipedon commonly has a low color value or chroma, or both. The depth to secondary carbonates may be greater than normal, and the soils are not required to have a cambic horizon if the particle-size class is sandy. Some of the soils are salty. Aquic Haplustolls are mainly in depressions or on flood plains. They are of small extent in the United States. The vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as cropland, hayland, rangeland, or wildlife habitat.

Aridic Haplustolls.—These soils receive less moisture or lose more water through runoff than Typic Haplustolls, but they are otherwise like the Typic Haplustolls in defined properties. A few Aridic Haplustolls that are associated with Aridisols receive runoff from other soils. Other things being equal, the depth to carbonates and the organic-carbon content are less in these soils than in soils of the Typic subgroup. Aridic Haplustolls are extensive and widely distributed in the Western United States. The largest extent is in the western part of the Great Plains. Slopes range from nearly level to steep. In the United States, many of the soils that have suitable slopes are used as cropland. Winter wheat and grain sorghum are common crops. If the temperature regime is frigid or mesic, many of the soils are fallowed in alternate years to store moisture. Some of the soils are irrigated, and many of the more sloping soils are used as rangeland.

Cumulic Haplustolls.—These soils have a thick mollic epipedon and are on flood plains and alluvial fans where fresh sediments have accumulated slowly enough to have become incorporated in the mollic epipedon. The mollic epipedon may be very thick, or there may be a series of thin buried epipedons. Consequently, there may not be either a cambic horizon or an accumulation of secondary carbonates in the soils. These soils are moderately extensive on the Great Plains and in the intermountain areas of the southwestern part of the United States. The natural vegetation is mostly grass and widely spaced trees. Some of these soils are used as cropland or hayland, except for areas that are very small, that have an irregular shape, or are subject to frequent flooding. Other areas are used for grazing by livestock.

Duric Haplustolls.—These soils have a brittle horizon that is within 100 cm of the mineral soil surface, is 15 cm or more thick, and has either some opal coatings or 20 percent or more durinodes. They are otherwise like Typic Haplustolls in their defined properties and in most other properties. Duric Haplustolls are inextensive on the western Great Plains of the United States.

Entic Haplustolls.—These soils do not have a cambic horizon, and either the epipedon is mostly calcareous or the lower part of the epipedon has a coarser texture than is required for a cambic horizon. Many of the soils have an epipedon that is calcareous throughout its thickness. Others have a shallow densic or paralithic contact, and the epipedon extends to the contact. Entic Haplustolls formed mostly in late-Holocene sediments or are on surfaces of similar age. These soils are moderately extensive on the Great Plains of the United States. Slopes are gentle to very steep. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as rangeland. If slopes are suitable, some of the soils are used as cropland.

Fluvaquentic Haplustolls.—These soils formed in relatively recent sediments and have ground water and redox depletions with low chroma. Either the organic-carbon content decreases irregularly with increasing depth, or it is relatively high in the deep layers. Most of these soils are in low positions on flood plains. They have ground water when streams are at high water levels or when they overflow. These soils are of small extent in the United States. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as cropland or hayland, except for areas that are very small, that have an irregular shape, or that are subject to frequent flooding.

Fluventic Haplustolls.—These soils formed mostly in recent alluvium. The epipedon is between 25 and 50 cm thick, and either the content of organic carbon decreases irregularly with increasing depth or it is high in the deep layers. These soils commonly are calcareous throughout their depth, and they have few or no identifiable secondary carbonates or do not have a cambic horizon. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Slopes of the Fluventic Haplustolls in the United States are gentle. Most of the soils are used as cropland or hayland, except for areas that are very small, that have an irregular shape, or that are subject to frequent flooding.

Lithic Haplustolls.—These soils have a shallow lithic contact. Commonly, the mollic epipedon extends to the rock, and the soils have neither a cambic horizon nor a horizon that contains identifiable secondary carbonates. These soils are of large extent, mostly in the mountains of the Western United States. They have moderate to very steep slopes. The vegetation is mostly grass and shrubs, but some of the soils support forest vegetation. The soils are used mostly as rangeland or forest.

Oxic Haplustolls.—These soils have a CEC that is too low and epipedons that may be too thick or an organic-carbon content that is too high at a depth of 125 cm to qualify as Typic Haplustolls. Slopes range from gentle to steep. Oxic Haplustolls are of moderate extent at the lower elevations in Hawaii. Sugarcane is the dominant crop.

Oxyaquic Haplustolls.—These soils are like Typic Haplustolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The soils are of small extent, mostly on the northern Great Plains in the United States. The natural vegetation is mostly grass and some shrubs. Most of the soils are used as cropland or hayland.

Pachic Haplustolls.—These soils have a thick mollic epipedon. Some of the soils receive runoff but little sediment from the higher adjacent soils. Pachic Haplustolls are extensive in the United States. They are widely distributed on the Great Plains and in the mountains of the Western United States. Slopes are nearly level to steep. Many of these soils supported grasses and shrubs, but some supported trees. Most of the soils on plains are used as cropland. Most of the soils in the mountains are used as rangeland, but some are used as grazeable woodland.

Pachic Udertic Haplustolls.—These soils have a thick mollic epipedon, a moisture regime that borders on udic, and a high shrink-swell potential. They receive runoff and are used for corn, oats, soybeans, or alfalfa. These soils occur in South Dakota and Iowa.

Ruptic-Lithic Haplustolls.—These soils have a lithic contact within 50 cm of the surface in part of each pedon, but the lithic contact is deeper than 50 cm in the rest of the pedon. In the deeper parts, there is a cambic horizon and the soils have the other defined properties of Typic Haplustolls. Ruptic-Lithic Haplustolls are of very small extent, mostly in the mountains of the Western United States. They have moderate to very steep slopes. The vegetation is mostly grass and shrubs, but some of the soils support forest vegetation.

Salidic Haplustolls.—These soils have a shallow salic horizon. Depth to the ground water fluctuates. In the United States, the soils are known to occur only on flood plains in arid parts of the intermountain valleys of the Western States. These soils are used as rangeland.

Torrertic Haplustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than Vertic Haplustolls. Torrertic Haplustolls are of small extent in the United States and occur mostly on the western Great Plains. Slopes of the Torrertic Haplustolls in the United States are gentle or moderate. The natural vegetation was mostly grasses and shrubs. Most of the soils are used as cropland, but some are used as rangeland.

Torrifluventic Haplustolls.—These soils are drier than Typic Haplustolls and formed in alluvium recent enough for the content of organic carbon to decrease irregularly with increasing depth or to remain high in the deep layers. The mollic epipedon is between 25 and 50 cm thick. These soils are on flood plains or low terraces. Most of them receive some additional water from flooding. Many are calcareous throughout and are associated on the landscape with Torrifluvents. Torrifluventic Haplustolls are of small extent, mostly on the western Great Plains of the United States. Slopes generally are nearly level. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as cropland or hayland, except for areas that are very small, that have an irregular shape, or that are subject to frequent flooding. Some of the soils are used as rangeland.

Torriorthentic Haplustolls.—These soils are drier than Typic Haplustolls, and the epipedon is mostly calcareous or the lower part of the epipedon has a coarser texture than is required for a cambic horizon. Many of the soils have an epipedon that is calcareous throughout its thickness. Others have a shallow densic or paralithic contact, and the epipedon extends to the contact. Torriorthentic Haplustolls formed mostly in late-Holocene sediments or are on surfaces of similar age. These soils are moderately extensive in the United States. They are mostly on the western Great Plains, but some are in the mountains of the Western United States. Slopes are gentle to very steep. The natural vegetation is mostly grass, and some of the soils support widely spaced trees. Most of the soils are used as rangeland. If slopes are suitable, some of the soils are used as cropland.

Torroxic Haplustolls.—These soils have a CEC that is too low to qualify as Typic Haplustolls and are drier than Typic Haplustolls. In addition, they may have epipedons too thick or an organic-carbon content too high at a depth of 125 cm, and they basically have few or no carbonates. Slopes are gentle or moderate. The soils are of moderate extent at the lower elevations in Hawaii. They are used mostly as cropland. Pineapple and irrigated sugarcane are the principal crops. Many areas are used as grazing land.

Udertic Haplustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in many years have deep cracks. They are more moist than Vertic Haplustolls because they either receive more precipitation or receive runoff from other soils. Most of the Udertic Haplustolls in the United States are on the Great Plains. The natural vegetation was mostly grasses. Slopes generally are gentle, and many are concave. Most of the soils are used as cropland, but some are used as rangeland.

Udic Haplustolls.—These soils are more moist than Typic Haplustolls because they either receive more precipitation or receive runoff from other soils. Most of the Udic Haplustolls in the United States are in areas between Typic Haplustolls and Udolls. Udic Haplustolls are moderately extensive soils, mostly in the southeastern part of the Great Plains. The natural vegetation was mostly grasses and shrubs. Slopes generally are gentle. Most of the soils are used as cropland.

Udorthentic Haplustolls.—These soils are more moist than Typic Haplustolls because they either receive more precipitation or receive runoff from other soils. They do not have a cambic horizon, and either the epipedon is mostly calcareous or the lower part of the epipedon has a coarser texture than is required for a cambic horizon. Some of the soils have a shallow densic or paralithic contact, and the epipedon extends to the contact. Udorthentic Haplustolls formed mostly in late-Holocene sediments or are on surfaces of similar age. These soils are of small extent on the Great Plains of the United States. Slopes are gentle to very steep. The natural vegetation is mostly grass. Most of the soils are used as rangeland. If slopes are suitable, some of the soils are used as cropland.

Vertic Haplustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in many years have deep cracks. They are otherwise similar to Typic Haplustolls. Most of the Vertic Haplustolls in the United States are on the Great Plains. The natural vegetation was mostly grasses. Slopes generally are gentle. Most of the soils are used as cropland, but some are used as rangeland.

Vitritorrandic Haplustolls.—These soils have significant amounts of cinders, pumice, and pumicelike fragments or glass and have a soil moisture regime that borders on aridic. They do not have a salic horizon within 75 cm of the soil surface, a lithic contact within 50 cm of the soil surface, a low CEC, or a high shrink-swell potential. These soils are not known to occur in the United States.

Natrustolls

These are the Ustolls that have a natric horizon. The most common horizon sequence is either a natric horizon in the lower part of the mollic epipedon or a thin albic horizon over a columnar natric horizon in which there may or may not be skeletans on the upper few centimeters of the columns. Below the natric horizon, there generally is a Bk or Bz horizon. Most of the areas of these soils are small and are nearly level or concave. The soils formed mostly in late-Pleistocene sediments.

Definition

Natrustolls are the Ustolls that:

1. Have a natric horizon; *and*

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IFBA. Natrustolls that have *all* of the following:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Leptic Torrertic Natrustolls

IFBB. Other Natrustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC.

Torrertic Natrustolls

IFBC. Other Natrustolls that have *both* of the following:

1. Visible crystals of gypsum and/or more soluble salts within 40 cm of the mineral soil surface; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Leptic Vertic Natrustolls

IFBD. Other Natrustolls that have *both*:

1. A glossic horizon or interfingering of albic materials into a natric horizon; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Glossic Vertic Natrustolls

IFBE. Other Natrustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrustolls

IFBF. Other Natrustolls that have *both*:

1. Visible crystals of gypsum or of more soluble salts, or both, within 40 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ºC; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ºC.

Aridic Leptic Natrustolls

IFBG. Other Natrustolls that have visible crystals of gypsum or of more soluble salts, or both, within 40 cm of the mineral soil surface.

Leptic Natrustolls

IFBH. Other Natrustolls that have, in one or more horizons at a depth between 50 and 100 cm from the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one* of the following:

1. 50 percent or more chroma of 1 or less and hue of 2.5Y or yellower; *or*

2. 50 percent or more chroma of 2 or less and redox concentrations; *or*

3. 50 percent or more chroma of 2 or less and also a higher exchangeable sodium percentage (or sodium

adsorption ratio) between the mineral soil surface and a depth of 25 cm than in the underlying horizon.

Aquic Natrustolls

IFBI. Other Natrustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for four-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Natrustolls

IFBJ. Other Natrustolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Natrustolls

IFBK. Other Natrustolls that have a glossic horizon or interfingering of albic materials into a natric horizon.

Glossic Natrustolls

IFBL. Other Natrustolls.

Typic Natrustolls

Definition of Typic Natrustolls

Typic Natrustolls are the Natrustolls that:

1. Do not have, in any horizon at a depth between 50 and 100 cm from the mineral soil surface, aquic conditions and *any* of the following:

a. 50 percent or more chroma of 1 or less throughout and hue of 2.5Y or yellower in some part; *or*

b. 50 percent or more chroma of 2 or less and redox concentrations; *or*

c. 50 percent or more chroma of 2 or less and also a higher exchangeable sodium percentage (or sodium adsorption ratio) between the mineral soil surface and a depth of 25 cm than in the underlying horizon;

2. Do not have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist;

3. Do not have a glossic horizon or interfingering of albic materials into a natric horizon;

4. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C and is dry for more than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C;

5. Do not have visible crystals of gypsum or of more soluble salts, or both, within 40 cm of the mineral soil surface; *and*

6. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Natrustolls.—The central concept or Typic subgroup of Natrustolls is fixed on soils that do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years. These soils do not have low chroma and do not have redox concentrations accompanied by ground water within 100 cm of the surface. They show little or no evidence of destruction of the natric horizon and have no visible crystals of gypsum or of more soluble salts, or both, within 40 cm of the mineral soil surface. Some of these soils are saturated with water above the natric horizon.

A glossic horizon and interfingering of albic materials in the upper part of the natric horizon are considered evidence of destruction of the natric horizon and are the basis for defining the Glossic subgroup.

Typic Natrustolls are of small extent in the United States. They are mostly on the northern Great Plains of the United States. They supported mostly salt-tolerant grasses and shrubs. Slopes generally are gentle, and many of these soils are cultivated. Some of the soils are used as rangeland or hayland.

Aquic Natrustolls.—These soils have redox depletions with low chroma in the upper part of the natric horizon and, at some time during the year, have ground water in the redox-depleted horizon unless the soils are artificially drained. The soils are of very small extent on the Great Plains of the United States. Most of the soils supported grasses. The soils have gentle slopes and are used mostly as cropland.

Aridic Leptic Natrustolls.—These soils are drier than those in the Typic subgroup because they receive less precipitation or lose more water through runoff. They do not have a glossic horizon or interfingering of albic materials into the natric horizon and do not have a high shrink-swell potential. They are of small extent on the Great Plains of the United States. Many of the soils supported grasses. The soils have gentle slopes and are used mostly as rangeland.

Aridic Natrustolls.—These soils are drier than those in the Typic subgroup because they receive less precipitation or lose more water through runoff. They are otherwise like Typic Natrustolls in defined properties. Aridic Natrustolls do not have gypsum or more soluble salts close to the surface. They are of small extent on the Great Plains of the United States. Many of the soils supported grasses. The soils have gentle slopes and are used mostly as cropland or rangeland.

Duric Natrustolls.—These soils have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. They are otherwise like Typic Natrustolls in their defined properties. Duric Natrustolls are not known to occur in the United States.

Glossic Natrustolls.—These soils show evidence of destruction of the natric horizon in the form of a glossic horizon or interfingering of albic materials into the natric horizon. Commonly, they have more exchangeable magnesium and less sodium than Typic Natrustolls, at least in the upper part of the natric horizon. Some Glossic Natrustolls receive more moisture, either as precipitation or as runoff, than the soils of the Typic subgroup. Glossic Natrustolls are mostly on the northern Great Plains of the United States and supported grasses. In the United States, most of the soils are nearly level and are used as cropland.

Glossic Vertic Natrustolls.—These soils have a high shrink-swell potential and either a glossic horizon or interfingering of albic materials into a natric horizon. These soils occur in the Dakotas and are used for small grain.

Leptic Natrustolls.—These soils have visible crystals of gypsum or salts at least as soluble as gypsum within 40 cm of the soil surface, and their moisture regime does not border on aridic. Otherwise, these soils are similar to those of the Typic subgroup. They are of small extent on the northern Great Plains of the United States. They supported mostly grasses. In the United States, most of the soils are nearly level and are used as rangeland.

Leptic Torrertic Natrustolls.—These soils have gypsum or soluble salts close to the surface, a high shrink-swell potential, and a soil moisture regime that borders on aridic. They are inextensive on the western Great Plains and are used as rangeland.

Leptic Vertic Natrustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They also have visible evidence of salts at least as soluble as gypsum within 40 cm of the soil surface. They have thinner sola than those of the Vertic subgroup, and the close proximity of the soluble salts to the surface restricts plant growth. Leptic Vertic Natrustolls are of very small extent in the United States. They are recognized only in North Dakota. They supported mostly grasses and shrubs. Most of the soils are used as rangeland.

Torrertic Natrustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than the soils in the Vertic subgroup because they receive less precipitation or lose more water through runoff. Torrertic Natrustolls are of very small extent in the United States. They are recognized only in North Dakota. They supported mostly grasses and shrubs. Most of the soils are used as cropland or rangeland.

Vertic Natrustolls.—These soils are like Typic Natrustolls, but they have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of small extent on the Great Plains of the United States. They supported mostly grasses and shrubs. Most of the soils are used as cropland or rangeland.

Paleustolls

These are the Ustolls on old stable surfaces. They may commonly have a thick, reddish argillic horizon, or, more commonly, a clayey argillic horizon that has an abrupt upper boundary, or they may have a petrocalcic horizon. They commonly have been partly or completely calcified during the Holocene, and a Bk or calcic horizon is common in the argillic horizon. The Paleustolls in the United States are mainly in the central and southern parts of the Great Plains. At the time of settlement, they had mostly grass vegetation. Their history during the Pleistocene has had little study. The petrocalcic horizon, where it occurs, may be complex, suggesting a number of alternating cycles of humidity and aridity and slow accretion of dust and sediment from the arid regions to the west.

Definition

Paleustolls are the Ustolls that:

1. Have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface and either have an argillic horizon or are noncalcareous in some subhorizon above the petrocalcic horizon after the surface soil to a depth of 18 cm has been mixed or have an argillic horizon that has *either or both*:

a. A vertical clay distribution in which the clay content does not decrease by as much as 20 percent from the maximum clay content (noncarbonate clay) within 150 cm of the soil surface (and there is no densic, lithic, or paralithic contact within that depth); and *one or both* of the following:

(1) Hue redder than 10YR and chroma greater than 4 in the matrix of at least the lower part; *or*

(2) Common redox concentrations that have hue of 7.5YR or redder or chroma greater than 5; *or*

b. 35 percent or more clay in the upper part and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary and no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface;

2. Do not have a duripan that has its upper boundary within 100 cm of the soil surface; *and*

3. Do not have a natric horizon.

Key to Subgroups

IFDA. Paleustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C.

Torrertic Paleustolls

IFDB. Other Paleustolls that have *both*:

1. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udertic Paleustolls

IFDC. Other Paleustolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleustolls

IFDD. Other Paleustolls that have a texture finer than loamy fine sand and a mollic epipedon 50 cm or more thick.

Pachic Paleustolls

IFDE. Other Paleustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleustolls

IFDF. Other Paleustolls that have a petrocalcic horizon within 150 cm of the mineral soil surface.

Petrocalcic Paleustolls

IFDG. Other Paleustolls that:

1. Have a calcic horizon within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 100 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 50 cm of the mineral soil surface; *or*

c. Any other class and within 60 cm of the mineral soil surface; *and*

2. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Calcidic Paleustolls

IFDH. Other Paleustolls that, when neither irrigated nor fallowed to store moisture, have *one* of the following:

1. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

3. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some or all parts for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Paleustolls

IFDI. Other Paleustolls that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for

four-tenths or less of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C.

Udic Paleustolls

IFDJ. Other Paleustolls have a calcic horizon within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 100 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 50 cm of the mineral soil surface; *or*

3. Any other class and within 60 cm of the mineral soil surface.

Calcic Paleustolls

IFDK. Other Paleustolls that are calcareous throughout after the surface soil has been mixed to a depth of 18 cm.

Entic Paleustolls

IFDL. Other Paleustolls.

Typic Paleustolls

Definition of Typic Paleustolls

Typic Paleustolls are the Paleustolls that:

1. Are not calcareous throughout after the surface soil has been mixed to a depth of 18 cm;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Do not have a texture finer than loamy fine sand and a mollic epipedon 50 cm or more thick;

4. Do not have a petrocalcic horizon within 150 cm of the mineral soil surface;

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

6. When neither irrigated nor fallowed to store moisture, have *one* of the following:

a. A frigid temperature regime and a moisture control section that in normal years is dry in all parts for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

b. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some or all parts for more than four-tenths but less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 ^{o}C; *or*

c. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is moist in some or all parts for 90 or more consecutive days per year or is dry for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C and is dry for more than 120 cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 8 ^{o}C; *and*

7. Do not have a calcic horizon with its upper boundary within 100 cm of the soil surface.

Description of Subgroups

Typic Paleustolls.—The central concept or Typic subgroup of Paleustolls is fixed on deep, freely drained soils that are noncalcareous in some part, have a mollic epipedon less than 50 cm thick, and do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. These soils do not have a petrocalcic horizon and commonly have an abrupt increase in content of clay near the top of the argillic horizon.

A calcic horizon is a property of Calcic great groups and is the basis for defining intergrades to Calcids and Calciustolls. Redox depletions with low chroma and ground water are properties of Aquolls and are the basis for defining the Aquic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. A petrocalcic horizon is considered evidence of more than normal development. Its presence in a soil that has an ustic moisture regime is the basis for defining the Petrocalcic subgroup.

A moisture regime that borders on udic is the basis for defining the Udic subgroup. A clayey texture, slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks in normal years are properties shared with Vertisols and are the basis for defining the Vertic subgroup. An ustic moisture regime that approaches aridic or a moisture regime that is aridic is the basis for defining the Aridic subgroup.

Typic Paleustolls are of small extent in the United States. They are on the Great Plains and in mountain valleys in the western part of the United States. Most of these soils supported grasses and shrubs and are used as cropland or rangeland.

Aquic Paleustolls.—These soils have ground water within 100 cm of the surface for extended periods and have redox depletions with low chroma in the saturated zone. Slopes are gentle. These soils are of very small extent in the United States.

Aridic Paleustolls.—These soils are drier than those in the Typic subgroup but are otherwise like Typic Paleustolls in defined properties. As a group, however, they have less organic carbon than the soils of the Typic subgroup. Aridic Paleustolls are moderately extensive in the southwestern part of the Great Plains in the United States. Slopes are gentle. Most of the soils supported grasses and shrubs. Many are used as cropland and commonly are irrigated.

Calcic Paleustolls.—These soils have a calcic horizon in the argillic horizon. Nearly all are reddish and have a thick, calcified argillic horizon. They are developing toward Calciustolls, but the argillic horizon can still be identified. Calcic Paleustolls are of very small extent in the United States.

Calcidic Paleustolls.—These soils have a calcic horizon in or below the argillic horizon and are drier than Typic Paleustolls. Nearly all Calcidic Paleustolls are reddish and have a thick, calcified argillic horizon. They occur only on the southern Great Plains and in intermountain areas in the Western United States, where they are moderately extensive. Most of these soils supported grasses and shrubs. Many are used as cropland, but some are used as rangeland.

Entic Paleustolls.—These soils are calcareous throughout after the surface soil to a depth of 18 cm has been mixed and do not have a calcic horizon. They are not known to occur in the United States.

Pachic Paleustolls.—These soils are like Typic Paleustolls, but they have a thick mollic epipedon. The argillic horizon generally starts in the lower part of the mollic epipedon. Slopes of the Pachic Paleustolls in the United States are mostly gentle. The soils are of small extent, mostly in Texas on the southern Great Plains of the United States. Most of the soils supported grasses and shrubs and are used as cropland.

Petrocalcic Paleustolls.—These soils are like Typic Paleustolls, but they have a petrocalcic horizon within 150 cm of the surface. They may be calcareous throughout. In the United States, they are moderately extensive on the southern Great Plains and in the Southwestern States. These soils supported grasses and shrubs. Slopes are gentle. Most of the soils are used for grazing. Some are used as irrigated cropland if water is available.

Torrertic Paleustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than Vertic Paleustolls. Torrertic Paleustolls are of small extent in the United States and occur mostly on the southwestern Great Plains. Slopes of the Torrertic Paleustolls in the United States are gentle or moderate. The natural vegetation was mostly grasses and shrubs. Most of the soils are used as cropland, mostly irrigated, but some are used as rangeland.

Udertic Paleustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are more moist than Vertic Paleustolls. They have more precipitation than Typic Paleustolls. Udertic Paleustolls are moderately extensive soils in the eastern part of the southern Great Plains. The natural vegetation was mostly grasses and shrubs. Slopes are gentle, and nearly all of the soils are used as cropland.

Udic Paleustolls.—These soils are more moist than Typic Paleustolls and generally have carbonates at a greater depth. Slopes of the Udic Paleustolls in the United States are mostly gentle. The soils are of moderate extent, mostly on the southern Great Plains of the United States. Most of the soils supported grasses and shrubs and are used as cropland.

Vertic Paleustolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They may have a mollic epipedon that is more than 50 cm thick. These soils are of small extent in the United States and commonly occur on gentle slopes on the Great Plains. The natural vegetation was mostly grasses and shrubs. Most of the soils are used as cropland, but some are used as rangeland.

Vermustolls

These are the Ustolls that have been intensively and repeatedly mixed by animals, mainly by earthworms and their predators. The most common horizon sequence is a mollic epipedon that consists mostly of wormcasts and rests on parent materials that contain many worm channels filled with dark materials from the epipedon. There may be a horizon in which carbonates have precipitated, but mixing by animals may have destroyed such a horizon or prevented its formation. These soils are not known to occur in North America, but they are extensive in Eastern Europe.

Definition

Vermustolls are the Ustolls that:

1. Have a mollic epipedon that:

   a. Either below an Ap horizon or below a depth of 18 cm from the mineral soil surface, contains 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows; *and*

   b. Either rests on a lithic contact or has a transition zone to the underlying horizon in which 25 percent or more of the soil volume consists of discrete wormholes, wormcasts, or animal burrows filled with material from the mollic epipedon and from the underlying horizon;

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have an argillic or natric horizon; *and*

4. Do not meet *both* of the following:

a. Have a calcic or gypsic horizon that has its upper boundary within 100 cm of the soil surface or a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *and*

b. In all parts above the calcic, gypsic, or petrocalcic horizon, after the materials between the soil surface and a depth of 18 cm have been mixed, either are calcareous or have a texture of loamy fine sand or coarser.

Key to Subgroups

IFFA. Vermustolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Vermustolls

IFFB. Other Vermustolls that have, in one or more horizons within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Vermustolls

IFFC. Other Vermustolls that have a mollic epipedon 75 cm or more thick.

Pachic Vermustolls

IFFD. Other Vermustolls that have a mollic epipedon less than 50 cm thick.

Entic Vermustolls

IFFE. Other Vermustolls.

Typic Vermustolls

Definition of Typic Vermustolls

Typic Vermustolls are the Vermustolls that:

1. Have a mollic epipedon that is 50 cm to 75 cm thick;

2. Do not have a lithic contact within 50 cm of the mineral soil surface; *and*

3. Do not have, in any horizon within 100 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions.

Description of Subgroups

Typic Vermustolls.—The central concept or Typic subgroup of Vermustolls is fixed on soils that are deep to a lithic contact and have a mollic epipedon 50 to 75 cm or more thick. These soils are not known to occur in the United States.

Aquic Vermustolls.—These soils have aquic conditions and redox depletions with chroma of 2 or less within 100 cm of the soil surface. They do not have a lithic contact within 50 cm of the soil surface. They are rare and are not known to occur in the United States.

Entic Vermustolls.—These soils have a mollic epipedon less than 50 cm thick. They are otherwise like Typic Vermustolls. Entic Vermustolls are not known to occur in the United States.

Lithic Vermustolls.—These soils have a lithic contact at a depth of 50 cm or less from the mineral soil surface. They are not known to occur in the United States.

Pachic Vermustolls.—These soils have a mollic epipedon more than 75 cm thick. They are otherwise like Typic Vermustolls. Pachic Vermustolls are not known to occur in the United States.

Xerolls

These soils are Mollisols of regions that have Mediterranean climates. As their name implies, they generally have a xeric moisture regime. Some Xerolls that are marginal to Aridisols, however, have an aridic moisture regime. Xerolls are dry for extended periods in summer, but moisture moves through most of the soils in winter and is stored throughout the part of the soils above the deep layers or above bedrock in normal years. Soft, white winter wheat is the most common crop on the Xerolls in the United States where there is no irrigation and the temperature regime is mesic. Where the temperature regime is frigid, the soils are used for spring wheat or for grazing. With irrigation, many crops are grown, especially where the temperature regime is thermic or mesic. The soils that have steep slopes mainly support natural vegetation of native annual or perennial grasses and of shrubs or trees. These soils are used mainly for grazing in spring or late in fall. The native perennial grasses remain dormant during the dry summers, and the annual grasses grow mainly in spring but sometimes also in fall if rains occur before the temperature drops too low.

Characteristically, Xerolls have a relatively thick mollic epipedon, a cambic or argillic horizon, and an accumulation of carbonates in the lower part of the B horizon and are neutral in most horizons.

The Xerolls in the United States formed mainly in late-Pleistocene loess that varies in thickness and that overlies bedrock on nearly level to steep older surfaces. Tertiary lake sediments, older crystalline rocks, and alluvium are common parent materials in some areas. The vegetation at the time of settlement in the areas that have a mesic or frigid temperature regime was dominantly bunchgrass and shrubs with wheatgrass (*Agropyron*), fescue (*Festuca*), and bluegrass (*Poa*) species in association with sagebrush (*Artemisia*), bitterbrush (*Purshia*), and rabbitbrush (*Chrysothamnus*) species and some scattered juniper (*Juniperus*) and pine (*Pinus*) species. In the Willamette Valley of Oregon, the vegetation was a savanna of perennial grasses, oaks, and Douglas-fir. In the areas in

California that have thermic temperature regimes, the vegetation was a savanna of annual grasses and oak species.

Xerolls are not extensive soils in the world, but they are extensive in parts of Turkey and of northern Africa near the Mediterranean Sea, in some of the southern republics of the former USSR, and in Washington, Oregon, Idaho, Utah, Nevada, and California in the United States. The temperature regimes are mostly mesic or frigid, but some are thermic.

Definition

Xerolls are the Mollisols that:

1. Have a mean annual soil temperature lower than 22 °C and mean summer and mean winter soil temperatures at a depth of 50 cm that differ by 5 °C or more;

2. Do not have both an albic horizon and, within 100 cm of the mineral soil surface, any subhorizon of the albic horizon and/or of the argillic or natric horizon that has redox concentrations in the form of masses or concretions, or both, and also aquic conditions;

3. Do not have both aquic conditions and the colors defined for Aquolls;

4. Have a xeric moisture regime or have a moisture regime that is aridic bordering on xeric; *and*

5. Do not have a cryic temperature regime.

Key to Great Groups

IEA. Xerolls that have a duripan within 100 cm of the mineral soil surface.

Durixerolls, p. 639

IEB. Other Xerolls that have a natric horizon.

Natrixerolls, p. 650

IEC. Other Xerolls that have *either*:

1. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

2. An argillic horizon that has *one or both* of the following:

a. With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content (noncarbonate clay) within 150 cm of the mineral soil surface (and there is no densic, lithic, or paralithic contact within that depth); *and either*

(1) Hue of 7.5YR or redder and chroma of 5 or more in the matrix; *or*

(2) Common redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

b. A clayey or clayey-skeletal particle-size class in its upper part and, at its upper boundary, a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface).

Palexerolls, p. 652

IED. Other Xerolls that:

1. Have a calcic or gypsic horizon that has its upper boundary within 150 cm of the mineral soil surface; *and*

2. In all parts above the calcic or gypsic horizon, after the surface soil has been mixed to a depth of 18 cm, either are calcareous or have a texture of loamy fine sand or coarser.

Calcixerolls, p. 637

IEE. Other Xerolls that have an argillic horizon.

Argixerolls, p. 631

IEF. Other Xerolls.

Haploxerolls, p. 642

Argixerolls

These are the Xerolls that have a relatively thin argillic horizon or one in which the percentage of clay decreases rapidly with increasing depth. Generally, the mollic epipedon is very dark brown and the argillic horizon is dark brown. Most of these soils have a Bk or calcic horizon below or in the lower part of the argillic horizon. Argixerolls formed mostly in mid-Pleistocene or earlier deposits or on surfaces of Tertiary age. Slopes range from nearly level to very steep. The natural vegetation is mostly grasses and shrubs, but some of the soils support coniferous forest vegetation with a grass and shrub understory and some have an open forest or savanna.

Definition

Argixerolls are the Xerolls that:

1. Do not have a natric horizon;

2. Have an argillic horizon that has:

a. A vertical clay distribution in which the content of clay decreases by more than 20 percent from the maximum clay content (noncarbonate clay) within a depth of less than 150 cm from the soil surface if:

(1) Hue is redder than 10YR and chroma is greater than 4 in the matrix; *or*

(2) There are common redox concentrations that have hue of 7.5YR or redder or chroma greater than 5; *and*

b. Less than 35 percent clay in the upper part or an increase of less than 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within 2.5 cm at the upper boundary, or there is a densic, lithic, or paralithic contact within 50 cm of the soil surface;

3. Do not have a duripan that has its upper boundary within 100 cm of the soil surface;

4. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface; *and*

5. Do not have a calcic or gypsic horizon that has its upper boundary within 150 cm of the mineral soil surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates or has a texture that is coarser than loamy very fine sand after the upper 18 cm has been mixed.

Key to Subgroups

IEEA. Argixerolls that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either the mineral soil surface or an Ap horizon, whichever is deeper, and the lithic contact.

Lithic Ultic Argixerolls

IEEB. Other Argixerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Argixerolls

IEEC. Other Argixerolls that have *both*:

1. An aridic moisture regime; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Argixerolls

IEED. Other Argixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Argixerolls

IEEE. Other Argixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Argixerolls

IEEF. Other Argixerolls that have *both*:

1. An aridic moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Argixerolls

IEEG. Other Argixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Argixerolls

IEEH. Other Argixerolls that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Argixerolls

IEEI. Other Argixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Argixerolls

IEEJ. Other Argixerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Argixerolls

IEEK. Other Argixerolls that have *either*:

1. Above the argillic horizon, an albic horizon or a horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon; *or*

2. A glossic horizon, *or* interfingering of albic materials into the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon.

Alfic Argixerolls

IEEL. Other Argixerolls that have *both*:

1. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface; *and*

2. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand.

Calcic Pachic Argixerolls

IEEM. Other Argixerolls that have *both*:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Ultic Argixerolls

IEEN. Other Argixerolls that have a mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand.

Pachic Argixerolls

IEEO. Other Argixerolls that have *both*:

1. An aridic moisture regime; *and*

2. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Argiduridic Argixerolls

IEEP. Other Argixerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Argixerolls

IEEQ. Other Argixerolls that have *both*:

1. An aridic moisture regime; *and*

2. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface.

Calciargidic Argixerolls

IEER. Other Argixerolls that have an aridic moisture regime.

Aridic Argixerolls

IEES. Other Argixerolls that have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

3. Any other class and within 110 cm of the mineral soil surface.

Calcic Argixerolls

IEET. Other Argixerolls that have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Argixerolls

IEEU. Other Argixerolls.

Typic Argixerolls

Definition of Typic Argixerolls

Typic Argixerolls are the Argixerolls that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have *either*:

a. An albic horizon or another horizon above the argillic horizon that has a color value too high for a mollic epipedon and chroma too high for an albic horizon; *or*

b. A glossic horizon, *or* interfingering of albic materials in the upper part of the argillic horizon, *or* skeletans of clean silt and sand covering more than half the faces of peds in the upper 5 cm or more of the argillic horizon;

4. Do not have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface;

5. Do not have a horizon within 100 cm of the mineral soil surface that is more than 15 cm thick and that either has at least 20 percent durinodes or is brittle and has a firm rupture-resistance class when moist;

6. Do not have a lithic contact within 50 cm of the soil surface;

7. Have a xeric moisture regime;

8. Have a mollic epipedon that is less than 50 cm thick or has a texture of loamy fine sand or coarser if it is 50 cm or more thick;

9. Have a base saturation (by sum of cations) of more than 75 percent in all horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower;

10. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

11. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. A bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent; *or*

b. Fragments coarser than 2.0 mm constituting more than

35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus 1/2 Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Argixerolls.—The central concept or Typic subgroup of Argixerolls is fixed on deep soils that have a mollic epipedon less than 50 cm thick and do not have redox depletions and aquic conditions within 75 cm of the mineral soil surface. These soils do not have an albic horizon above the argillic horizon, nor do they have a glossic horizon or interfingering of albic materials into the upper part of the argillic horizon. They are deep to secondary carbonates, but they have a high base saturation. They do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years. These soils do not have, within a depth of 100 cm, a horizon that is more than 15 cm thick and that has 20 percent or more durinodes or is brittle and has a firm rupture-resistance class when moist. They are dry in summer, but they receive and store enough water in winter and early spring to provide moisture for spring and early summer crops.

Shallow ground water or artificial drainage and redox depletions with low chroma are properties of Aquolls and are the basis for defining the Aquic subgroup. An albic horizon above the argillic horizon is characteristic of Alfisols and is the basis for defining the Alfic subgroup. A calcic horizon or identifiable secondary carbonates at a moderate depth indicate an intergrade to Calcixerolls and Calcids and are the basis for defining Calcic and combination Calcic subgroups. A brittle horizon and the presence of durinodes indicate an intergrade to Durixerolls and Durids and are the basis for defining the Duric subgroup. A shallow lithic contact is the basis for defining Lithic and combination Lithic subgroups. An aridic moisture regime is a property of Aridisols and is the basis for defining the Aridic subgroup. A thick mollic epipedon is the basis for defining Pachic and combination Pachic subgroups. Low base saturation is a property of Ultisols and is the basis for defining Ultic and combination Ultic subgroups. Slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks that are evident in normal years are properties of Vertisols and are the basis for defining the Vertic subgroup.

The Typic subgroup is the most extensive subgroup of Argixerolls and is extensive in parts of the Western United States. The natural vegetation is mostly grasses and shrubs, but some of the soils support trees. The soils that have gentle slopes commonly are used as cropland, some of which is irrigated. The soils that have moderate slopes are used for dry-farmed crops. The steep soils are used as rangeland or grazeable forest.

Alfic Argixerolls.—These soils have an albic or glossic horizon or another horizon that has color values too high for a mollic epipedon and chroma too high for an albic horizon above the argillic horizon, have interfingering of albic materials into the upper part of the argillic horizon, or have skeletans of clean silt and sand covering 50 percent or more of the faces of peds in the upper 5 cm of the argillic horizon. These soils are of small extent in the United States and occur mostly in Idaho and Utah. Some supported grasses and shrubs, and some supported forest vegetation. Slopes range from nearly level to very steep. The soils that have gentle to moderately steep slopes are used mostly as cropland. Other soils, mostly those that have very steep slopes, are used as forest or rangeland.

Andic and Vitrandic Argixerolls.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials. These soils are of large extent, mostly in the mountains of Washington, Oregon, and Idaho in the Western United States. The vegetation either is mostly grass and shrubs and some widely spaced trees or is coniferous forest. Slopes range from nearly level to very steep. Many of the less sloping soils are used as cropland. Most of the other soils are used as rangeland, forest, or wildlife habitat.

Aquic Argixerolls.—These soils have redox depletions with low chroma and either have moderately deep ground water at some time of the year or have artificial drainage. They are gently sloping or nearly level. They are of small extent in the United States. The natural vegetation is mostly grass and shrubs. Most of the soils are used as cropland, but some are used as rangeland or pasture.

Aquultic Argixerolls.—These soils have redox depletions with low chroma and either have moderately deep ground water at some time of the year or have artificial drainage, and they have a lower base saturation than that in the soils of the Typic subgroup. Aquultic Argixerolls are rare in the United States. They are on gently sloping or nearly level, broad valley terraces. Most of the soils are used as cropland. Truck crops and orchard crops are commonly grown under irrigation.

Argiduridic Argixerolls.—These soils have an aridic moisture regime that borders on xeric, and they have a subhorizon within 100 cm of the surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle when wet and has a firm rupture-resistance class when moist. These soils are of small extent in the United States. The natural vegetation is mostly grass and shrubs. The soils generally have gentle or moderate slopes and are used mostly as rangeland. Some of the less sloping soils are used as cropland. Some of the cropland is irrigated.

Aridic Argixerolls.—These soils have an aridic moisture regime but are otherwise like Typic Argixerolls in their defined properties. It is common but not required that the color value of these soils is higher and the content of organic carbon is less than in soils of the Typic subgroup. Slopes of the Aridic Argixerolls in the United States are nearly level to very steep. The soils generally receive less precipitation or lose more water through runoff and evapotranspiration than the soils of the Typic subgroup. Aridic Argixerolls are extensive in parts of the Western United States. The natural vegetation is mostly grass and shrubs. Most of the soils are used as rangeland or pasture. Some of the less sloping soils are used as cropland. Some of the cropland is irrigated.

Calciargidic Argixerolls.—These soils have an aridic moisture regime that borders on xeric and have a calcic horizon or identifiable secondary carbonates at a moderate depth. The Calciargidic Argixerolls in the United States have nearly level to steep slopes. They are extensive in parts of the Western United States. The natural vegetation is mostly grass and shrubs. Most of the soils are used as rangeland or pasture. Some of the less sloping soils are used as cropland. Some of the cropland is irrigated.

Calcic Argixerolls.—These soils have a calcic horizon or identifiable secondary carbonates at a moderate depth but are otherwise like Typic Argixerolls in their defined properties. Slopes are nearly level to very steep. Calcic Argixerolls are extensive in parts of the Western United States. The natural vegetation is mostly grass and shrubs. Most of the soils are used as rangeland or pasture. Many of the less sloping soils are used as cropland. A small amount of the cropland is irrigated.

Calcic Pachic Argixerolls.—These soils have a calcic horizon or identifiable secondary carbonates at a moderate depth and have a mollic epipedon that is thicker than the one in the Typic subgroup. Slopes are nearly level to steep. The natural vegetation is mostly grass and shrubs. Most of the soils are used as rangeland or pasture. Many of the less sloping soils are used as cropland. A small amount of the cropland is irrigated.

Duric Argixerolls.—These soils have a subhorizon within 100 cm of the surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. The soils are rare in the United States. They are nearly level or sloping and are used as irrigated cropland or as rangeland.

Lithic Argixerolls.—These soils have a shallow lithic contact and are permitted, but not required, to have a calcic horizon or free carbonates beneath the surface layer. They are extensive in the Western United States. Slopes range from nearly level to very steep. The natural vegetation is mostly grass and shrubs. Most of the soils are used as rangeland, as watersheds, or as habitat for wildlife.

Lithic Ultic Argixerolls.—These soils have a shallow lithic contact and have less than 75 percent base saturation above the lithic contact. They are of small extent in the Western United States. Slopes range from gentle to very steep. The natural vegetation is mostly a coniferous forest with widely spaced trees and a grass and shrub understory. Some of the soils support mostly grasses and shrubs. Most of the soils are used as grazeable woodland or as rangeland, but some are used as watersheds or as wildlife habitat.

Oxyaquic Argixerolls.—These soils are like Typic Argixerolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. Oxyaquic Argixerolls are of very small extent in the United States.

Pachic Argixerolls.—These soils have a thick mollic epipedon that commonly includes part of the argillic horizon. They are extensive soils in parts of the Western United States. Slopes are nearly level to very steep. The natural vegetation is mostly grass and shrubs. Some of the soils supported forest vegetation or oak savanna. Many of the less sloping soils are used as cropland. The rest of the soils are used mostly as rangeland or pasture.

Pachic Ultic Argixerolls.—These soils have a thick mollic epipedon that commonly includes part of the argillic horizon. They have a base saturation of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. These soils are extensive in parts of the Western United States. Slopes are nearly level to very steep. The natural vegetation either is mostly a coniferous forest with a grass and shrub understory or is mostly grasses and shrubs. Some of the soils supported an open forest or savanna. Many of the less sloping soils are used as cropland. The rest of the soils are used mostly as rangeland, pasture, or grazeable forest.

Torrertic Argixerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are drier than Vertic Argixerolls. Torrertic Argixerolls are of small extent in the United States and occur mostly in Idaho.

Ultic Argixerolls.—These soils have a base saturation of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, but they otherwise are like Typic Argixerolls in their defined properties. Ultic Argixerolls are extensive in parts of the Western United States. Slopes range from nearly level to very steep. The natural vegetation either is mostly a coniferous forest with a grass and shrub understory or is mostly grasses and shrubs. Some of the soils supported an open forest or savanna. Many of the less sloping soils are used as cropland. The rest of the soils are used mostly as rangeland, pasture, or grazeable forest.

Vertic Argixerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of small extent in the United States. They formed mostly in fine textured lake sediments. They are associated on the landscape with Xererts and other Xerolls. The natural vegetation is mostly grass and shrubs. Most Vertic Argixerolls are nearly level or gently sloping. They are used mostly as cropland. Some of the cropland is irrigated.

Vitritorrandic Argixerolls.—These soils have an aridic moisture regime that borders on xeric and have a surface mantle or layer in the upper 75 cm that consists of slightly or moderately weathered pyroclastic materials. They are of small extent, mostly in Nevada and Washington in the Western United States. The vegetation is mostly grass and shrubs. Slopes range from nearly level to steep. Most of the soils are used as rangeland or wildlife habitat. Many of the less sloping soils are used as cropland.

Calcixerolls

These are the Xerolls that have a calcic or gypsic horizon and that are calcareous in all overlying horizons. Either the parent materials had more carbonates than the water from the rainfall could remove from the upper horizons, or there is a continuing external source of carbonates in dust or water.

Calcixerolls formed mostly in late-Pleistocene sediments or older materials on surfaces of comparable age. In the United States, their native vegetation was mostly grass and shrubs. These soils are most extensive in the Great Basin of the Western United States. Slopes range from nearly level to very steep.

Definition

Calcixerolls are the Xerolls that:

1. Have a calcic or gypsic horizon that has its upper boundary within 150 cm of the soil surface;

2. Are calcareous in all parts of all horizons above the calcic or gypsic horizon after the upper 18 cm has been mixed, unless the texture is coarser than loamy very fine sand or very fine sand;

3. Do not have a natric horizon;

4. Do not have a duripan within 100 cm of the mineral soil surface;

5. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface; *and*

6. Do not have argillic horizon that has *one or both* of the following:

a. With increasing depth, no clay decrease of 20 percent or more (relative) from the maximum clay content (noncarbonate clay) within 150 cm of the mineral soil surface (and there is no densic, lithic, or paralithic contact within that depth); *and either*

(1) Hue of 7.5YR or redder and chroma of 5 or more in the matrix; *or*

(2) Common redox concentrations with hue of 7.5YR or redder or chroma of 6 or more, or both; *or*

b. A clayey or clayey-skeletal particle-size class in its upper part and, at its upper boundary, a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface).

Key to Subgroups

IEDA. Calcixerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixerolls

IEDB. Other Calcixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Calcixerolls

IEDC. Other Calcixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Calcixerolls

IEDD. Other Calcixerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Calcixerolls

IEDE. Other Calcixerolls that have a mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand.

Pachic Calcixerolls

IEDF. Other Calcixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Calcixerolls

IEDG. Other Calcixerolls that have an aridic moisture regime.

Aridic Calcixerolls

IEDH. Other Calcixerolls that have a mollic epipedon that has, below any Ap horizon, 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows.

Vermic Calcixerolls

IEDI. Other Calcixerolls.

Typic Calcixerolls

Definition of Typic Calcixerolls

Typic Calcixerolls are the Calcixerolls that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox concentrations and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Have a mollic epipedon that is less than 50 cm thick or has a texture of loamy fine sand or coarser if it is 50 cm or more thick;

4. Have a xeric moisture regime;

5. Do not have a lithic contact within 50 cm of the soil surface;

6. Do not have a mollic epipedon that, below any Ap horizon, has 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows;

7. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

8. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Calcixerolls.—The central concept or Typic subgroup of Calcixerolls is fixed on deep soils that have a moderately thick mollic epipedon and have a xeric moisture regime. These soils do not have a fluctuating ground water table accompanied by redox concentrations. They do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years. They are dry in summer, but they receive and store enough water in winter and early spring to provide some moisture for spring and early summer crops.

Redox concentrations and a ground water table that fluctuates within 75 cm of the mineral soil surface are properties shared with Aquolls and are the basis for defining the Aquic subgroup. An aridic moisture regime is drier than that of Typic Calcixerolls and is the basis for defining the Aridic subgroup. A shallow lithic contact is the basis for defining the Lithic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. Soils that have been intensively and repeatedly mixed by animals, mainly by earthworms and their predators, are classified in the Vermic subgroup. Slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks that are evident in normal years are properties of Vertisols and are the basis for defining the Vertic subgroup.

The Typic subgroup is the most extensive subgroup of Calcixerolls. Typic Calcixerolls are moderately extensive in the Western United States. They are nearly level to very steep. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper and pine species. Many of the nearly level and gently sloping soils are used as cropland, much of which is irrigated. Most of the steeper soils are used as rangeland.

Aquic Calcixerolls.—These soils have moderately deep ground water at times or artificial drainage and have redox concentrations. They are of small extent in the Western United States. The natural vegetation is mostly grass and shrubs. The soils generally are nearly level and are used mostly as cropland, hayland, or pasture, much of which is irrigated. Some of the soils are used as rangeland.

Aridic Calcixerolls.—These soils have an aridic moisture regime that borders on xeric but otherwise are like Typic Calcixerolls in their defined properties. Commonly, the calcic horizon is closer to the surface than that in the soils of the Typic subgroup and the mollic epipedon has less organic carbon. Aridic Calcixerolls are nearly as extensive as the soils of the Typic subgroup and are moderately extensive in the Western United States. Slopes are nearly level to very steep. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper species. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland.

Lithic Calcixerolls.—These soils have a lithic contact within 50 cm of the surface and have a xeric moisture regime or one that is aridic but borders on xeric. They are of small extent in parts of Nevada, Utah, and southern Idaho in the United States. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper species. Lithic Calcixerolls have nearly level to very steep slopes. They are used mostly as rangeland.

Oxyaquic Calcixerolls.—These soils have ground water within 100 cm of the mineral soil surface at times during the year. They are of very small extent in the Western United States. The natural vegetation is mostly grass and shrubs. The soils generally are nearly level and are used mostly as cropland, hayland, or pasture, much of which is irrigated. Some of the soils are used as rangeland.

Pachic Calcixerolls.—These soils have a mollic epipedon that is 50 cm or more thick. Otherwise, they are similar to the soils of the Typic subgroup. Pachic Calcixerolls are of small extent in the Western United States. The natural vegetation is mostly grass and shrubs. Many of these soils have nearly level or gentle slopes, but some range to very steep. The nearly level and gently sloping soils are used mostly as cropland, hayland, or pasture, much of which is irrigated. The more sloping soils are used mostly as rangeland.

Vermic Calcixerolls.—These soils have been intensively and repeatedly mixed by animals, mainly earthworms and their predators. The most common horizon sequence is a mollic epipedon overlying parent material that has many worm channels filled with dark material from the epipedon. These soils are not known to occur in the United States. The subgroup is provided for use elsewhere.

Vertic Calcixerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of very small extent in the United States. The natural vegetation is mostly grass and shrubs. These soils generally are nearly level or gently sloping. They are used as cropland or rangeland. Some of the cropland is irrigated.

Vitrandic Calcixerolls.—These soils have significant amounts of cinders, pumice, and pumicelike fragments or glass. They do not have a lithic contact within 50 cm of the soil surface, a high shrink-swell potential, or saturation within 100 cm of the soil surface. These soils are not known to occur in the United States.

Durixerolls

These are the Xerolls that have a duripan that has its upper boundary within 100 cm of the soil surface. They formed mainly in Pleistocene sediments. Some of the materials near the surface of many of these soils are younger than the duripan. The parent materials commonly were derived, at least partially, from basic volcanic rocks, siliceous tuffs, pumice, or volcanic ash. The natural vegetation on the Durixerolls in the United States was grass and shrubs. These soils occur in the Western United States, but they are not extensive. They generally are gently sloping or moderately sloping.

Definition

Durixerolls are the Xerolls that have a duripan within 100 cm of the mineral soil surface.

Key to Subgroups

IEAA. Durixerolls that have, above the duripan, *one or both* of the following:

1. Cracks that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick; *or*

2. A linear extensibility of 6.0 cm or more.

Vertic Durixerolls

IEAB. Other Durixerolls that have *both*:

1. An aridic moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Durixerolls

IEAC. Other Durixerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Durixerolls

IEAD. Other Durixerolls that have, in one or more horizons above the duripan, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Durixerolls

IEAE. Other Durixerolls that have:

1. An aridic moisture regime; *and*

2. An argillic horizon that, with increasing depth, has a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm; *and*

3. A duripan that is neither very strongly cemented nor indurated in any subhorizon.

Paleargidic Durixerolls

IEAF. Other Durixerolls that have *both*:

1. An aridic moisture regime; *and*

2. An argillic horizon that, with increasing depth, has a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm.

Abruptic Argiduridic Durixerolls

IEAG. Other Durixerolls that:

1. Have an aridic moisture regime; *and*

2. Do not have an argillic horizon above the duripan; *and*

3. Have a duripan that is neither very strongly cemented nor indurated in any subhorizon.

Cambidic Durixerolls

IEAH. Other Durixerolls that:

1. Have an aridic moisture regime; *and*

2. Do not have an argillic horizon above the duripan.

Haploduridic Durixerolls

IEAI. Other Durixerolls that have:

1. An aridic moisture regime; *and*

2. A duripan that is neither very strongly cemented nor indurated in any subhorizon.

Argidic Durixerolls

IEAJ. Other Durixerolls that have an aridic moisture regime.

Argiduridic Durixerolls

IEAK. Other Durixerolls that have *both*:

1. An argillic horizon that, with increasing depth, has a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm; *and*

2. A duripan that is neither very strongly cemented nor indurated in any subhorizon.

Haplic Palexerollic Durixerolls

IEAL. Other Durixerolls that have an argillic horizon that, with increasing depth, has a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm.

Palexerollic Durixerolls

IEAM. Other Durixerolls that:

1. Have a duripan that is neither very strongly cemented nor indurated in any subhorizon; *and*

2. Do not have an argillic horizon above the duripan.

Haplic Haploxerollic Durixerolls

IEAN. Other Durixerolls that do not have an argillic horizon above the duripan.

Haploxerollic Durixerolls

IEAO. Other Durixerolls that have a duripan that is neither very strongly cemented nor indurated in any subhorizon.

Haplic Durixerolls

IEAP. Other Durixerolls.

Typic Durixerolls

Definition of Typic Durixerolls

Typic Durixerolls are the Durixerolls that:

1. Have an argillic horizon above the duripan, but the argillic horizon does not have, with increasing depth, a clay increase either of 20 percent or more (absolute) within a vertical distance of 7.5 cm or of 15 percent or more (absolute) within a vertical distance of 2.5 cm;

2. Have a duripan that is either very strongly cemented or indurated in some subhorizon;

3. Have a xeric moisture regime;

4. Do not have, in any horizon above the duripan, redox depletions with chroma of 2 or less and also aquic conditions;

5. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter, of which 5 percent or more is volcanic glass, and [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

6. Do not have *either*:

a. Cracks that are 5 mm or more wide, throughout a layer 30 cm or more thick either within 125 cm of the mineral soil surface or above a duripan if shallower, for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface or above a duripan if shallower; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact or a duripan, whichever is shallower.

Description of Subgroups

Typic Durixerolls.—The central concept or Typic subgroup of Durixerolls is fixed on freely drained soils that have an argillic horizon above a very strongly cemented or indurated duripan. These soils have a relatively gradual increase in content of clay at the upper boundary of the argillic horizon and have a xeric moisture regime.

An abrupt increase in content of clay at the upper boundary of the argillic horizon is a characteristic of soils in which an argillic horizon has apparently formed after the duripan developed. This feature is the basis for defining Palexerollic and combination Palexerollic subgroups and, if the soil also has an aridic moisture regime, the Abruptic Argiduridic and Paleargidic subgroups. A weakly developed duripan is considered less-than-normal development, and its presence is the basis for defining the intergrades to classes of soils that do not have a duripan. An aridic moisture regime is drier than that of the Typic subgroup and is the basis for defining intergrades to Aridisols. Soils that do not have an argillic horizon and that have only weak development of the duripan are classified in Haplic and combination Haplic subgroups. Soils that do not have an argillic horizon above a strongly developed duripan are classified in the Haploxerollic subgroup.

Typic Durixerolls are moderately extensive in the Western United States. These soils generally are nearly level to moderately sloping. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper and pine species. Many of the nearly level and gently sloping soils are used as cropland, some of which is irrigated. Most of the steeper soils are used as rangeland.

Abruptic Argiduridic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is 20 percent (absolute) or more within a vertical distance of 7.5 cm or is 15 percent (absolute) or more within a vertical distance of 2.5 cm at the upper boundary, have an aridic moisture regime that borders on xeric, but are otherwise like Typic Durixerolls in their defined properties. Abruptic Argiduridic Durixerolls are of small extent in the Western United States. They generally are nearly level or gently sloping. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper species. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Aquic Durixerolls.—These soils have redox depletions with low chroma and either have moderately deep ground water at some time of the year or have artificial drainage. They are not known to occur in the United States.

Argidic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is less than 20 percent (absolute) within a vertical distance of 7.5 cm or is less than 15 percent (absolute) within a vertical distance of 2.5 cm at the upper boundary, have an aridic moisture regime that borders on xeric, but are otherwise like Typic Durixerolls in their defined properties. Argidic Durixerolls are of small extent in the United States. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper and pine species. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Argiduridic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is less than 20 percent (absolute) within a vertical distance of 7.5 cm or is less than 15 percent (absolute) within a vertical distance of 2.5 cm at the upper boundary. The soils also have an aridic moisture regime that borders on xeric. These soils are of moderately small extent in the United States. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper species. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Cambidic Durixerolls.—These soils have an aridic moisture regime that borders on xeric and have a duripan that is less developed than that in the Typic subgroup. The soils commonly have a cambic horizon but do not have an argillic horizon above the duripan. They are rare in the United States. They are nearly level to very steep. The natural vegetation is mostly grass and shrubs. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Haplic Durixerolls.—These soils have an argillic horizon, but their duripan is weakly developed. The duripan is less developed than that of the Typic subgroup. These soils are of small extent in the United States. They generally are nearly level to moderately steep. The natural vegetation is mostly grass and shrubs. Many of the nearly level and gently sloping soils are used as cropland, some of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Haplic Haploxerollic Durixerolls.—These soils do not have an argillic horizon and have a weakly developed duripan. They commonly have a cambic horizon above the duripan. These soils are rare in the United States. They are nearly level to very steep. The natural vegetation is mostly grass and shrubs. Many of the nearly level and gently sloping soils are used as cropland. Most of the steeper soils are used as rangeland or wildlife habitat.

Haplic Palexerollic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is 20 percent (absolute) or more within a vertical distance of 7.5 cm or is 15 percent (absolute) or more within a vertical distance of 2.5 cm at the upper boundary. The soils also have a weakly developed duripan. They are not known to occur in the United States.

Haploduridic Durixerolls.—These soils do not have an argillic horizon and have an aridic moisture regime that borders on xeric, but they are otherwise like Typic Durixerolls in their defined properties. Haploduridic Durixerolls commonly have a cambic horizon above the duripan. They are of small extent in the United States. They are nearly level to steep. The natural vegetation is mostly grass and shrubs. Many of the nearly level and gently sloping soils are used as cropland, most of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Haploxerollic Durixerolls.—These soils do not have an argillic horizon above the duripan. They commonly have a cambic horizon above the duripan. They are of small extent in the United States. They are nearly level to very steep. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced juniper and pine species. Some of the nearly level and gently sloping soils are used as cropland. Most of the steeper soils are used as rangeland or wildlife habitat.

Paleargidic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is 20 percent (absolute) or more within a vertical distance of 7.5 cm or is 15 percent (absolute) or more within a vertical distance of 2.5 cm at the upper boundary. The soils also have an aridic moisture regime that borders on xeric and have a weakly developed duripan. They are of small extent in the Western United States. They generally are nearly level or gently sloping. The natural vegetation is mostly grass and shrubs, but some of the soils support widely spaced pine and juniper species. Most of the soils are used as rangeland or wildlife habitat.

Palexerollic Durixerolls.—These soils have an argillic horizon in which the increase in content of clay is 20 percent (absolute) or more within a vertical distance of 7.5 cm or is 15 percent (absolute) or more within a vertical distance of 2.5 cm at the upper boundary. The soils also have a weakly developed duripan. They are of small extent in the Western United States. They generally are nearly level or gently sloping. The natural vegetation is mostly grass and shrubs. Many of the nearly level and gently sloping soils are used as cropland, some of which is irrigated. Most of the steeper soils are used as rangeland or wildlife habitat.

Vertic Durixerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They are of very small extent in the Western United States. The natural vegetation is mostly grass and shrubs. These soils generally are nearly level or gently sloping. They are used mostly as rangeland.

Vitrandic Durixerolls.—These soils have a surface mantle or layer in the upper 75 cm that consists of slightly or moderately weathered pyroclastic materials. They are of small extent, mostly in Washington and Idaho in the Western United States. The vegetation is mostly grass and shrubs, but some of the soils support widely spaced coniferous trees. Slopes range from nearly level to steep. Most of the less sloping soils are used as dry cropland. Most of the steep soils are used as rangeland or wildlife habitat.

Vitritorrandic Durixerolls.—These soils have a surface mantle or layer in the upper 75 cm that consists of slightly or moderately weathered pyroclastic materials. They also have an aridic soil moisture regime that borders on xeric. These soils are of moderate extent, mostly in Washington and Oregon in the Western United States. The vegetation is mostly grass and shrubs, and some of the soils in Oregon have widely spaced juniper trees. Slopes range from nearly level to moderately steep. Most of the soils are used as cropland, but some are used as rangeland or wildlife habitat.

Haploxerolls

These are the more or less freely drained Xerolls that are characterized by little development in the subsoil. Commonly, they have a cambic horizon below the mollic epipedon. Some have only unaltered recent parent materials below the mollic epipedon. Many have horizons in which secondary carbonates have accumulated. A few have a calcic horizon, but at least parts of the surface horizons are free of carbonates.

Haploxerolls formed mainly in late-Pleistocene deposits or on surfaces of comparable age, but some formed on older surfaces. Parent materials of late-Wisconsinan loess mixed with some volcanic ash, glacial outwash or till, and alluvium from mixed sources are common. The natural vegetation is mostly grasses and shrubs, but some of the soils support a coniferous forest with a grass and shrub understory and some support an open forest or savanna. Slopes range from nearly level to very steep.

Definition

Haploxerolls are the Xerolls that:

1. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface;

3. Do not have a calcic or gypsic horizon that has its upper boundary within 150 cm of the mineral soil surface unless some part of some horizon overlying the calcic or gypsic horizon is free of carbonates after the surface soil to a depth of 18 cm has been mixed and the texture is loamy very fine sand, very fine sand, or finer; *and*

4. Do not have an argillic or natric horizon.

Key to Subgroups

IEFA. Haploxerolls that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either the mineral soil surface or an Ap horizon, whichever is deeper, and the lithic contact.

Lithic Ultic Haploxerolls

IEFB. Other Haploxerolls that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerolls

IEFC. Other Haploxerolls that have *both*:

1. An aridic moisture regime; *and*

2. *One or both* of the following:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Torrertic Haploxerolls

IEFD. Other Haploxerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Haploxerolls

IEFE. Other Haploxerolls that have *both*:

1. An aridic moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitritorrandic Haploxerolls

IEFF. Other Haploxerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Haploxerolls

IEFG. Other Haploxerolls that have:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent; *and*

4. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Cumulic Haploxerolls

IEFH. Other Haploxerolls that have:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent; *and*

4. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Cumulic Ultic Haploxerolls

IEFI. Other Haploxerolls that have:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. An irregular decrease in organic-carbon content from a depth of 25 cm below the mineral soil surface to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower; *and*

3. A slope of less than 25 percent.

Cumulic Haploxerolls

IEFJ. Other Haploxerolls that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluvaquentic Haploxerolls

IEFK. Other Haploxerolls that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Aquic Duric Haploxerolls

IEFL. Other Haploxerolls that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Aquultic Haploxerolls

IEFM. Other Haploxerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerolls

IEFN. Other Haploxerolls that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haploxerolls

IEFO. Other Haploxerolls that have *both*:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface.

Calcic Pachic Haploxerolls

IEFP. Other Haploxerolls that have *both*:

1. A mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand; *and*

2. A base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Pachic Ultic Haploxerolls

IEFQ. Other Haploxerolls that have a mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand.

Pachic Haploxerolls

IEFR. Other Haploxerolls that have:

1. An aridic moisture regime; *and*

2. A slope of less than 25 percent; *and either*

a. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

b. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Torrifluventic Haploxerolls

IEFS. Other Haploxerolls that have *both*:

1. An aridic moisture regime; *and*

2. A horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duridic Haploxerolls

IEFT. Other Haploxerolls that have *both*:

1. An aridic moisture regime; *and*

2. A calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface.

Calcidic Haploxerolls

IEFU. Other Haploxerolls that have *both*:

1. An aridic moisture regime; *and*

2. A sandy particle-size class in all horizons within 100 cm of the mineral soil surface.

Torripsammentic Haploxerolls

IEFV. Other Haploxerolls that:

1. Have an aridic moisture regime; *and*

2. *Either*:

a. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet all of the requirements for a cambic horizon except color; *or*

b. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Torriorthentic Haploxerolls

IEFW. Other Haploxerolls that have an aridic moisture regime.

Aridic Haploxerolls

IEFX. Other Haploxerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Haploxerolls

IEFY. Other Haploxerolls that have a sandy particle-size class in all horizons within 100 cm of the mineral soil surface.

Psammentic Haploxerolls

IEFZ. Other Haploxerolls that have a slope of less than 25 percent; *and either*

1. An organic-carbon content of 0.3 percent or more in all horizons within 125 cm of the mineral soil surface; *or*

2. An irregular decrease in organic-carbon content from a depth of 25 cm to a depth of 125 cm or to a densic, lithic, or paralithic contact if shallower.

Fluventic Haploxerolls

IEFZa. Other Haploxerolls that have a mollic epipedon that has granular structure and that has, below any Ap horizon, 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows.

Vermic Haploxerolls

IEFZb. Other Haploxerolls that have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

1. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

2. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

3. Any other class and within 110 cm of the mineral soil surface.

Calcic Haploxerolls

IEFZc. Other Haploxerolls that:

1. Do not have a cambic horizon and do not, in the lower part of the mollic epipedon, meet all of the requirements for a cambic horizon except color; *and*

2. Have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Entic Ultic Haploxerolls

IEFZd. Other Haploxerolls that have a base saturation (by sum of cations) of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Ultic Haploxerolls

IEFZe. Other Haploxerolls that *either*:

1. Do not have a cambic horizon and do not, in any part of the mollic epipedon below 25 cm from the mineral soil surface, meet all of the requirements for a cambic horizon except color; *or*

2. Have free carbonates throughout the cambic horizon or in all parts of the mollic epipedon below a depth of 25 cm from the mineral soil surface.

Entic Haploxerolls

IEFZf. Other Haploxerolls.

Typic Haploxerolls

Definition of Typic Haploxerolls

Typic Haploxerolls are the Haploxerolls that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a calcic horizon or identifiable secondary carbonates within one of the following particle-size class (by weighted average in the particle-size control section) and depth combinations:

a. Sandy or sandy-skeletal and within 150 cm of the mineral soil surface; *or*

b. Clayey, clayey-skeletal, fine, or very-fine and within 90 cm of the mineral soil surface; *or*

c. Any other class and within 110 cm of the mineral soil surface;

4. Have a mollic epipedon that is less than 50 cm thick or has a texture of loamy fine sand or coarser if it is 50 cm or more thick;

5. Do not have a horizon within 100 cm of the mineral soil surface that is more than 15 cm thick and that either has at least 20 percent durinodes or is brittle and has a firm rupture-resistance class when moist;

6. Have a cambic horizon or, in the lower part of the epipedon, meet all of the requirements for a cambic horizon, except for the color requirments, and either the cambic horizon or the lower part of the epipedon is free of carbonates in some part;

7. *Either* have a regular decrease in organic-carbon content with increasing depth and, unless a densic, lithic, or paralithic contact is at some depth between 50 cm and 125 cm below the soil surface, have an organic-carbon content of 0.3 percent or less at a depth within 125 cm of the mineral soil surface *or* have a slope of 25 percent or more;

8. Do not have a lithic contact within 50 cm of the soil surface;

9. Have a base saturation (by sum of cations) of more than 75 percent in all horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or a densic, lithic, or paralithic contact, whichever is shallower;

10. Do not have a mollic epipedon that has granular structure and that, below any Ap horizon, has 50 percent or more (by volume) wormholes, wormcasts, or filled animal burrows;

11. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

12. Have a xeric moisture regime;

13. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *one or more* of the following:

a. Fragments coarser than 2.0 mm constituting more than 35 percent of the whole soil and cinders, pumice, and pumicelike fragments making up more than 66 percent of these fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

14. Do not have a sandy particle-size class throughout all horizons within 100 cm of the mineral soil surface.

Description of Subgroups

Typic Haploxerolls.—The central concept or Typic subgroup of Haploxerolls is fixed on freely drained soils that have a xeric moisture regime and do not have aquic conditions within 75 cm of the mineral soil surface. These soils have a high base saturation, a moderately thick mollic epipedon, and a regular decrease in organic-carbon content with increasing depth. They do not have an accumulation of carbonates at a shallow depth, and they do not show evidence of cementation in the upper meter. They do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks in normal years. Their cambic horizon is not calcareous in some part, or the lower part of the mollic epipedon meets the requirements for a cambic horizon and is not calcareous in some part.

Shallow ground water or artificial drainage and redox depletions with low chroma are properties of Aquolls and are the basis for defining the Aquic and Oxyaquic subgroups. A calcic horizon or identifiable secondary carbonates at a shallow depth indicate an intergrade to Calcixerolls and are the basis for defining Calcic and combination Calcic subgroups. A thick mollic epipedon is the basis for defining Cumulic and Pachic subgroups. The absence of both a cambic horizon and, in the lower part of the epipedon, the properties of a cambic horizon, except for color, or the presence of free carbonates throughout these horizons is considered evidence of weak horizon development and is the basis for defining Entic and combination Entic subgroups. An irregular decrease in organic-carbon content with increasing depth and a relatively high content of organic carbon in the deep layers are properties of Fluvents and, in part, are the basis for defining the Fluventic subgroup or, if the soil is saturated with water at some period, the Fluvaquentic subgroup. A shallow lithic contact is the basis for defining Lithic and combination Lithic subgroups. Low base saturation is a property of Ultisols and is the basis for defining the Ultic subgroup. Soils that have been intensively and repeatedly mixed by animals, mainly by earthworms and their predators, are classified in the Vermic subgroup. A clayey texture, slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks are properties of Vertisols and are the basis for defining the Vertic subgroup. An aridic moisture regime is the basis for defining Aridic and Torric subgroups.

The Typic subgroup is one of the most extensive of the subgroups of Haploxerolls and is extensive in parts of the Western United States. Typic Haploxerolls are nearly level to very steep. The native vegetation is dominantly grasses and shrubs, but some of the soils support widely spaced trees, mostly pine, oak, and juniper trees. Most of the soils that have nearly level to moderate slopes are used as cropland, and some of the nearly level and gently sloping cropland is irrigated. Some of the soils, mostly those on the steeper slopes, are used as rangeland.

Aquic Cumulic Haploxerolls.—These soils have redox depletions with low chroma and either have moderately deep ground water at some time of the year or are artificially drained. They also have a thick mollic epipedon. These soils developed in nearly level areas where they receive more moisture than the amount that falls on the surface. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly willow and cottonwood. The soils are of very small extent in the Western United States. They are used mostly as hayland or pasture, some of which is irrigated.

Aquic Duric Haploxerolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. Also, they have a subhorizon within 100 cm of the mineral soil surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes in a matrix that is not brittle when wet or is brittle when wet and has a firm rupture-resistance class when moist. The native vegetation is dominantly grasses and shrubs. These soils are rare in the United States.

Aquic Haploxerolls.—These soils have redox depletions with low chroma and either have moderately deep ground water at some time of the year or are artificially drained. They are not required to have a cambic horizon, and secondary carbonates, if present, may be shallower than those in the Typic subgroup. Aquic Haploxerolls developed in nearly level areas where they receive more moisture than the amount that falls on the surface. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly pine, willow, and cottonwood. The soils are of small extent in the Western United States. They are used mostly as cropland or pasture, some of which is irrigated.

Aquultic Haploxerolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. Also, they have a base saturation of 75 percent or less in one or more horizons between an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. They are not required to have a cambic horizon. They are nearly level or gently sloping. The native vegetation is mostly trees. These soils are of small extent in the Western United States. The steeper soils are used mainly as forest, and most of the gently sloping soils have been cleared and are used as cropland.

Aridic Haploxerolls.—These soils receive less moisture than Typic Haploxerolls and have an aridic moisture regime. Aridic Haploxerolls are extensive in the Western United States. Slopes are nearly level to very steep. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly juniper species. Most of the soils that have nearly level or gentle slopes are used as cropland, most of which is irrigated. Some of the soils, mostly the steeper ones and those with many rock fragments, are used as rangeland.

Calcic Haploxerolls.—These soils have a calcic horizon or identifiable secondary carbonates at a moderate depth but are otherwise like Typic Haploxerolls in their defined properties. Calcic Haploxerolls are extensive in the Western United States. Slopes range from nearly level to very steep. The native vegetation is dominantly grasses and shrubs. Many of the gently sloping soils are used as cropland, some of which is irrigated. The steeper soils and the soils with many rock fragments are used as rangeland.

Calcic Pachic Haploxerolls.—These soils have a calcic horizon or identifiable secondary carbonates at a moderate depth and have a mollic epipedon thicker than that of Typic Haploxerolls. Calcic Pachic Haploxerolls are of moderate extent in the Western United States. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly oak, juniper, and pine species. The soils have nearly level to very steep slopes. Many of the nearly level to moderately sloping soils are used as cropland, some of which is irrigated. The soils on the steeper slopes are used as rangeland.

Calcidic Haploxerolls.—These soils have an aridic moisture regime that borders on xeric. They also have a calcic horizon or identifiable secondary carbonates at a shallow or moderate depth. They are permitted, but not required, to have a cambic horizon. These soils are extensive in parts of the Western United States. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly juniper and pine species. The soils have nearly level to very steep slopes. Many of the less sloping soils are used as cropland, much of which is irrigated. The soils on the steeper slopes and those with many rock fragments are used as rangeland or wildlife habitat.

Cumulic Haploxerolls.—These soils have a thick mollic epipedon. They are on flood plains or in low areas on stream terraces, or they are in concave areas where fresh sediments accumulate slowly enough to become part of the mollic epipedon. The organic-carbon content decreases irregularly with increasing depth. These soils are permitted, but not required, to have a cambic horizon or accumulations of secondary carbonates at a shallow depth. They are moderately extensive in parts of the Western United States. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly willow and cottonwood. Most of the soils are nearly level or gently sloping. Many of the larger areas are used as cropland, much of which is irrigated. The smaller areas and those dissected by stream channels are used as rangeland, forest, or wildlife habitat.

Cumulic Ultic Haploxerolls.—These soils have a thick mollic epipedon and have a base saturation of 75 percent or less in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. The organic-carbon content decreases irregularly with increasing depth. These soils are permitted, but not required, to have a cambic horizon. They are of small extent in the United States. The native vegetation is mostly mixed forest. These soils are nearly level or gently sloping. Most of the larger areas are used as cropland. The smaller areas and those dissected by stream channels are used as pasture, forest, or wildlife habitat.

Duric Haploxerolls.—These soils have a subhorizon within 100 cm of the mineral soil surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle when wet and has a firm or very firm rupture-resistance class when moist. The soils are otherwise like Typic Haploxerolls. Duric Haploxerolls are not known to occur in the United States.

Duridic Haploxerolls.—These soils have an aridic moisture regime that borders on xeric and have a subhorizon within 100 cm of the mineral soil surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle when wet and has a firm or very firm rupture-resistance class when moist. These soils are not known to occur in the United States.

Entic Haploxerolls.—These soils do not have a cambic horizon, and either the epipedon is calcareous or the lower part of the epipedon is too sandy to be a cambic horizon. Some of these soils are very shallow to a paralithic or densic contact and have only thin soil horizons. Entic Haploxerolls are of small extent in the Western United States. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly oak, juniper, or pine species. Slopes range from nearly level to very steep. The soils are used mostly as rangeland or wildlife habitat, but some of the soils with nearly level to moderate slopes are used as cropland, most of which is irrigated.

Entic Ultic Haploxerolls.—These soils do not have a cambic horizon, and their base saturation is 75 percent or less in one or more horizons between an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. These soils are of small extent in the United States. The native vegetation is forest on some of the soils and grasses and shrubs on others. Slopes range from nearly level to very steep. The soils are used mostly as forest, rangeland, or wildlife habitat. Some of the soils with nearly level to moderate slopes are used as cropland, most of which is irrigated.

Fluvaquentic Haploxerolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. Their organic-carbon content either decreases irregularly with increasing depth or remains relatively high as depth increases. The soils are not required to have a cambic horizon. They developed on nearly level flood plains where they receive more moisture than the amount that falls on the surface. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly willow and cottonwood. Fluvaquentic Haploxerolls are of small extent in the Western United States. They are used mostly as cropland, hayland, or pasture, some of which is irrigated. Some small areas and areas that are dissected by stream channels or are subject to frequent flooding are used as pasture, rangeland, or wildlife habitat.

Fluventic Haploxerolls.—These soils have an organic-carbon content that decreases irregularly with increasing depth or remains high as depth increases. They are permitted, but not required, to have a cambic horizon or to have secondary carbonates at a depth shallower than in soils of the Typic subgroup. Fluventic Haploxerolls are on nearly level flood plains, formed mainly in loamy alluvium, and commonly are stratified as a result of frequent flooding. They are of small extent in the Western United States. They generally are nearly level. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly pine, oak, and cottonwood. The soils are used mostly as cropland, hayland, or pasture, much of which is irrigated. Some small areas and areas that are dissected by stream channels or are subject to frequent flooding are used as pasture, rangeland, or wildlife habitat.

Lithic Haploxerolls.—These soils have a shallow lithic contact. The mollic epipedon commonly extends to bedrock. In some of the soils, a cambic horizon intervenes. Lithic Haploxerolls are extensive in the Western United States. The native vegetation is dominantly grasses and shrubs, and some of the soils support widely spaced trees, mostly pine, juniper, and oak. Slopes are nearly level to very steep. Most of the soils are used as rangeland or grazeable forest.

Lithic Ultic Haploxerolls.—These soils have a shallow lithic contact, and their base saturation is 75 percent or less in some part of the soils above the lithic contact. These soils are moderately extensive in the United States. The native vegetation is forest on some of the soils and grasses and shrubs on others. Slopes range from nearly level to very steep. Most of the soils are used as grazeable forest or rangeland.

Oxyaquic Haploxerolls.—These soils are like Typic Haploxerolls, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils are of small extent in the United States. Slopes are nearly level or gently sloping. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly willow and cottonwood. The soils are used mostly as cropland, hayland, or pasture, much of which is irrigated. Some of the soils are used as pasture, rangeland, or wildlife habitat.

Pachic Haploxerolls.—These soils are similar to Typic Haploxerolls, but they have a thicker mollic epipedon. They are extensive in parts of the Western United States. Slopes are nearly level to very steep. The native vegetation is dominantly grasses and shrubs, but some of the soils support widely spaced trees, mostly oak or juniper. Many of the less sloping soils are used as cropland, some of which is irrigated. The steeper soils and those with many rock fragments are used as rangeland or wildlife habitat.

Pachic Ultic Haploxerolls.—These soils have a mollic epipedon that is thicker than that in soils of the Typic subgroup, and they have a base saturation of 75 percent or less in one or more horizons between an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. Pachic Ultic Haploxerolls are moderately extensive in the Western United States. They range from nearly level to very steep. The native vegetation is grasses and shrubs on some of the soils and forest on others. Many of the less sloping soils are used as cropland, some of which is irrigated. The steeper soils and those with many rock fragments are used mainly as rangeland, forest, or wildlife habitat.

Psammentic Haploxerolls.—These soils have a sandy particle-size class. Because they are sandy, they do not have a cambic horizon. They are of small extent in the United States. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly oak, juniper, and pine species. Slopes generally are moderate or gentle, and most of the soils are used as rangeland. Some nearly level or gently sloping soils are used as irrigated cropland, hayland, or pasture.

Torrertic Haploxerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They also have an aridic moisture regime that borders on xeric. They are not known to occur in the United States.

Torrifluventic Haploxerolls.—These soils have an aridic moisture regime that borders on xeric and formed in alluvium that is recent enough for the content of organic carbon to decrease irregularly with increasing depth or to remain high as depth increases. These soils are of small extent in the Western United States. The native vegetation is dominantly grasses and shrubs, but some of the soils support widely spaced trees. Most of the larger areas are used as irrigated cropland or pasture. Some of the smaller areas and those dissected by stream channels are used as rangeland or wildlife habitat.

Torriorthentic Haploxerolls.—These soils have an aridic moisture regime that borders on xeric and do not have a cambic horizon. They are of small extent in the Western United States. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly juniper and pine species. Slopes are nearly level to very steep. Most of the soils are used as rangeland or grazeable forest.

Torripsammentic Haploxerolls.—These soils have a sandy particle-size class and have an aridic moisture regime that borders on xeric. Because they are sandy, they do not have a cambic horizon. They are of small extent in the Western United States. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly juniper and pine species. Slopes are nearly level to very steep. Most of the soils are used as rangeland or grazeable forest. Some that are nearly level or gently sloping are used as irrigated cropland.

Ultic Haploxerolls.—These soils have a lower degree of base saturation than Typic Haploxerolls. Many Ultic Haploxerolls receive more precipitation than the Typic Haploxerolls. The native vegetation is grasses and shrubs on some of the soils and forest on others. Some of the soils support widely spaced trees, mostly oak or juniper. Ultic Haploxerolls are extensive in the Western United States. Many of the less sloping soils are used as cropland. The steeper soils and those with many rock fragments are used mainly as rangeland, forest, or wildlife habitat.

Vermic Haploxerolls.—These soils have a mollic epipedon that has granular structure. The most common horizon sequence is a mollic epipedon consisting of many wormcasts overlying a horizon containing many worm channels filled with dark soil from the mollic epipedon. These soils have not been identified in the United States. The subgroup is provided for use elsewhere.

Vertic Haploxerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. The native vegetation is mostly grasses and forbs on most of the soils but is forest or widely spaced trees on others. Vertic Haploxerolls are of small extent in the Western United States. Many of the less sloping soils are used as cropland, some of which is irrigated. The steeper soils are used mostly as rangeland, forest, or wildlife habitat.

Vitrandic Haploxerolls.—These soils have a surface mantle or layer in the upper 75 cm that consists of slightly or moderately weathered pyroclastic materials. They are of large extent, mostly in Washington, Oregon, and Idaho in the Western United States. The vegetation is either mostly grass and shrubs or coniferous forest. Some of the soils support widely spaced trees. Slopes range from nearly level to very steep. Many of the less sloping soils are used as cropland. Most of the others are used as rangeland, forest, or wildlife habitat.

Vitritorrandic Haploxerolls.—These soils have an aridic moisture regime that borders on xeric and have a surface mantle or layer in the upper 75 cm that consists of slightly or moderately weathered pyroclastic materials. These soils are moderately extensive, mostly in Oregon, Nevada, and Washington in the Western United States. The vegetation is mostly grass and shrubs, but some of the soils support trees, mostly juniper species. Slopes range from nearly level to very steep. Many of the less sloping soils are used as cropland, much of which is irrigated. The steeper soils and those with many rock fragments are used mainly as rangeland or wildlife habitat.

Natrixerolls

These are the Xerolls that have a natric horizon and do not have a duripan. The natric horizon commonly has either prismatic or columnar structure, and there is a Bk horizon in or below the natric horizon. Some of the soils have a thin albic horizon above the natric horizon. The areas of Natrixerolls are mostly small. These soils formed mostly in mixed sediments of late-Pleistocene age, commonly in depressions, in basins, or on low terraces.

Definition

Natrixerolls are the Xerolls that:

1. Have a natric horizon; *and*

2. Do not have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

IEBA. Natrixerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Natrixerolls

IEBB. Other Natrixerolls that have *both*:

1. In one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Aquic Duric Natrixerolls

IEBC. Other Natrixerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Natrixerolls

IEBD. Other Natrixerolls that have an aridic moisture regime.

Aridic Natrixerolls

IEBE. Other Natrixerolls that have a horizon within 100 cm of the mineral soil surface that is 15 cm or more thick and either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Natrixerolls

IEBF. Other Natrixerolls.

Typic Natrixerolls

Definition of Typic Natrixerolls

Typic Natrixerolls are the Natrixerolls that:

1. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

2. Do not have a horizon within 100 cm of the mineral soil surface that is more than 15 cm thick and that either has at least 20 percent durinodes or is brittle and has a firm rupture-resistance class when moist;

3. Have a xeric moisture regime; *and*

4. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Natrixerolls.—The central concept or Typic subgroup of Natrixerolls is fixed on soils that have a xeric moisture regime, that do not have redox depletions with low chroma in the upper 75 cm accompanied by ground water at a shallow depth, and do not have slickensides, wedge-shaped aggregates, a high linear extensibility, and wide cracks in normal years.

Shallow ground water or artificial drainage and redox depletions with low chroma are properties of Aquolls and are the basis for defining the Aquic subgroup. A brittle horizon and the presence of durinodes indicate an intergrade to Durixerolls and are the basis for defining Duric and combination Duric subgroups. An aridic moisture regime is used, in part, as the basis for defining the Aridic subgroup. A clayey texture, slickensides, wedge-shaped aggregates, a high linear extensibility, and cracks are properties of Vertisols and are the basis for defining the Vertic subgroup.

The Typic subgroup is the most extensive subgroup of Natrixerolls, but it is of small extent in the Western United States. The native vegetation is mostly grasses and shrubs. Slopes generally are gentle but range from nearly level to steep. Most of the less sloping soils are used as irrigated cropland or pasture, and the other soils are used mainly as rangeland or wildlife habitat.

Aquic Duric Natrixerolls.—These soils have redox depletions with low chroma and either are saturated with water at some time of the year or have artificial drainage. In addition, they have a subhorizon within 100 cm of the surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle when wet and has a firm rupture-resistance class when moist. These soils are not known to occur in the United States.

Aquic Natrixerolls.—These soils have redox depletions with low chroma and either are saturated with water at some time of the year or have artificial drainage. They developed mostly on nearly level valley or marine terraces. They are of very small extent in the Western United States. The native vegetation is mostly grasses and shrubs. Most of the soils are used as irrigated cropland or pasture, and the others are used mainly as rangeland or wildlife habitat.

Aridic Natrixerolls.—These soils are like Typic Natrixerolls, but they receive less moisture. They are not known to occur in the United States.

Duric Natrixerolls.—These soils have a subhorizon within 100 cm of the surface that does not meet the requirements for a duripan but is more than 15 cm thick and either has 20 percent or more (by volume) durinodes or is brittle when wet and has a firm rupture-resistance class when moist. These soils are not known to occur in the United States.

Vertic Natrixerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. They occur in California and in other Western States. They commonly are used as rangeland.

Palexerolls

These are the Xerolls that formed on old surfaces, commonly on basalt plains of Miocene or Pliocene age that later, during or after the late Pleistocene, received a thin covering of loess or of mixed loess and ash. Slopes range from nearly level to very steep. The soils commonly have a thick, dark brown or reddish brown, clayey argillic horizon that has an abrupt upper boundary, or they have a petrocalcic horizon. A calcic or Bk horizon is common in the lower part of the argillic horizon or below it. The native vegetation was mainly bunchgrasses and some shrubs. Some of the soils supported a coniferous forest with an understory of grasses and shrubs or supported an open forest or savanna. Palexerolls occur in parts of the Western United States, but they are not extensive.

Definition

Palexerolls are the Xerolls that:

1. Have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface or have an argillic horizon that has *one or both* of the following characteristics:

a. A vertical clay distribution in which the clay content does not decrease by as much as 20 percent from the maximum clay content within a vertical distance of 150 cm below the soil surface and *one or more* of the following:

(1) Hue redder than 10YR and chroma greater than 4 dominant in the matrix of at least the lower part of the argillic horizon; *or*

(2) Common redox concentrations that have hue of 7.5YR or redder or chroma greater than 5, or both; *or*

b. 35 percent or more clay and an increase of at least 20 percent clay (absolute) within a vertical distance of 7.5 cm or of 15 percent clay (absolute) within a distance of 2.5 cm at the upper boundary (and there is no densic, lithic, or paralithic contact within 50 cm of the mineral soil surface);

2. Do not have a natric horizon; *and*

3. Do not have a duripan that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

IECA. Palexerolls that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Palexerolls

IECB. Other Palexerolls that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

1. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

2. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Vitrandic Palexerolls

IECC. Other Palexerolls that have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexerolls

IECD. Other Palexerolls that have a mollic epipedon that is 50 cm or more thick and has a texture finer than loamy fine sand.

Pachic Palexerolls

IECE. Other Palexerolls that have *both*:

1. An aridic moisture regime; *and*

2. A petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcidic Palexerolls

IECF. Other Palexerolls that have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist.

Duric Palexerolls

IECG. Other Palexerolls that have an aridic moisture regime.

Aridic Palexerolls

IECH. Other Palexerolls that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Palexerolls

IECI. Other Palexerolls that have a base saturation of 75 percent or less in one or more subhorizons either within the argillic horizon if more than 50 cm thick or within its upper 50 cm.

Ultic Palexerolls

IECJ. Other Palexerolls that have an argillic horizon that has *either*:

1. Less than 35 percent clay in the upper part; *or*

2. At its upper boundary, a clay increase that is both less than 20 percent (absolute) within a vertical distance of 7.5 cm and less than 15 percent (absolute) within a vertical distance of 2.5 cm, in the fine-earth fraction.

Haplic Palexerolls

IECK. Other Palexerolls.

Typic Palexerolls

Definition of Typic Palexerolls

Typic Palexerolls are the Palexerolls that:

1. Have an argillic horizon that has 35 percent or more clay in the upper part and an increase in clay content of 20 percent (absolute) or more within a vertical distance of 7.5 cm or of 15 percent (absolute) or more within a distance of 2.5 cm at the upper boundary;

2. Do not have, in any horizon within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions;

3. Do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface;

4. Have a mollic epipedon that is less than 50 cm thick or has a texture of loamy fine sand or coarser if it is more than 50 cm thick;

5. Have a base saturation of more than 75 percent throughout the argillic horizon or in the upper 50 cm of the argillic horizon, whichever is thinner;

6. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

7. Do not have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist;

8. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or both* of the following:

a. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

b. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^{1}/_{2}$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more; *and*

9. Have a xeric moisture regime.

Description of Subgroups

Typic Palexerolls.—The central concept or Typic subgroup of Palexerolls is fixed on deep, freely drained soils that have a clayey argillic horizon that has an abrupt upper boundary. These soils have a moderately thick mollic epipedon, a high base saturation, and a xeric moisture regime. They do not have a petrocalcic horizon that has its upper boundary within 150 cm of the soil surface.

A petrocalcic horizon is the basis for defining the Petrocalcic subgroup. A thick mollic epipedon is the basis for defining the Pachic subgroup. A base saturation that is less than normal is the basis for defining the Ultic subgroup.

The Typic subgroup is the most extensive subgroup of Palexerolls. It is moderately extensive in parts of the Western United States. The native vegetation is dominantly grasses and shrubs. Some of the soils support widely spaced trees, mostly oak and juniper species. Most of the soils are used as rangeland. Some that have nearly level to moderate slopes are used as cropland, and some of the nearly level and gently sloping cropland is irrigated. Most of the soils on the steeper slopes are used as rangeland.

Aquic Palexerolls.—These soils have redox depletions with low chroma and either have shallow ground water at some time of the year or are artificially drained. They developed in nearly level or gently sloping areas where they receive more moisture than the amount that falls on the surface. The native vegetation is dominantly grasses and shrubs, but some of the soils support trees, mostly oak species. The soils are of very small extent in the Western United States. They are used mostly as cropland or pasture, some of which is irrigated.

Aridic Palexerolls.—These soils have an aridic moisture regime that borders on xeric, but they otherwise are like Typic Palexerolls in their defined properties. They are of small extent in the Western United States. Slopes are nearly level to very steep. The native vegetation is dominantly grasses and shrubs, and a few of the soils support widely spaced trees, mostly juniper species. Most of the soils are used as rangeland. A few that have nearly level or gentle slopes are used as irrigated cropland or pasture.

Duric Palexerolls.—These soils have a horizon, 15 cm or more thick within 100 cm of the mineral soil surface, that either has 20 percent or more (by volume) durinodes or is brittle and has a firm rupture-resistance class when moist. The soils do not have a high shrink-swell potential; significant amounts of volcanic ash, cinders, or glass near the surface; a thick mollic epipedon; a petrocalcic horizon; or aquic conditions within 75 cm of the mineral soil surface. These soils occur in Oregon and are used for grazing by livestock.

Haplic Palexerolls.—These soils are similar to Typic Palexerolls, but they do not have a clayey argillic horizon that has an abrupt upper boundary. They are not known to occur in the United States.

Pachic Palexerolls.—These soils have a thick mollic epipedon. They are of small extent in the Western United States. Slopes range from nearly level to very steep. The native vegetation is grasses and shrubs on most of the soils, but some of the soils support coniferous forest or savanna with widely spaced trees, mostly juniper. Most of the soils are used as rangeland. Some are used as grazeable woodland, and a few that have nearly level or gentle slopes are used as cropland or pasture, some of which is irrigated.

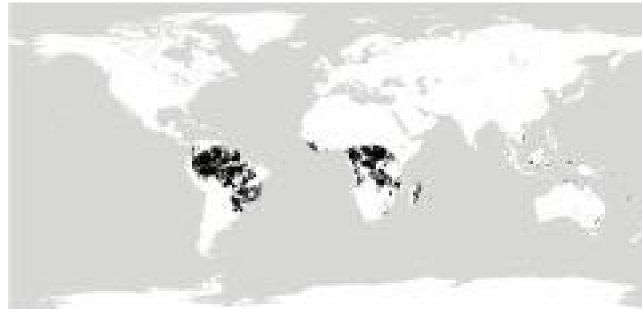
Petrocalcic Palexerolls.—These soils have a petrocalcic horizon that generally has its upper boundary within 150 cm of the soil surface. The argillic horizon that overlies the calcic horizon commonly is calcareous in the lower part. These soils are of small extent in the Western United States. The native vegetation is dominantly a sparse forest of juniper and pine trees interspersed with grasses and shrubs. Slopes are nearly level to steep. Most of the soils are used as rangeland. Some are used as grazeable woodland, and a few that have nearly level or gentle slopes are used as irrigated cropland or pasture.

Petrocalcidic Palexerolls.—These soils have an aridic moisture regime that borders on xeric and have a petrocalcic horizon. The petrocalcic horizon commonly is shallower than 75 cm and, in some of the soils, it is less than 50 cm below the surface. Petrocalcidic Palexerolls are of small extent in the Western United States. The native vegetation is dominantly a sparse forest of juniper and pine trees interspersed with grasses and shrubs. Slopes are nearly level to steep. Most of the soils are used as rangeland. Some are used as grazeable woodland, and a few that have nearly level or gentle slopes are used as irrigated cropland or pasture.

Ultic Palexerolls.—These soils have a lower degree of base saturation than Typic Palexerolls. Many Ultic Palexerolls receive more precipitation than the Typic Palexerolls. The native vegetation is forest on some Ultic Palexerolls and grasses and shrubs on others. Some of the soils support widely spaced trees, mostly oak or juniper. The soils are of small extent in the Western United States. Slopes are nearly level to very steep. Some of the soils in the less sloping areas are used as cropland. The steeper soils and those with many rock fragments are used mainly as forest, rangeland, or wildlife habitat.

Vertic Palexerolls.—These soils have a clayey particle-size class in a significant part, have expanding clays, and in normal years have deep cracks. The native vegetation is mostly grasses, shrubs, and forbs. These soils are of small extent in the Western United States. Most of the soils are used as rangeland. Some of the less sloping soils are used as cropland or pasture, some of which is irrigated.

Vitrandic Palexerolls.—These soils have significant amounts of vocanic ash, cinders, or glass in one or more layers 18 cm or more thick within 75 cm of the mineral soil surface. They do not have a high shrink-swell potential. These soils occur in Oregon. They are used for timber production or for grazing by livestock.



CHAPTER 17

Oxisols[1]

Oxisols are weathered soils that are low in fertility. They are most common on the gentle slopes of geologically old surfaces in tropical and subtropical regions. Their profiles are distinctive because of a lack of obvious horizons. Their surface horizons are normally somewhat darker than the subsoil, but the transition of subsoil features is gradual.

Oxisols consist mainly of quartz, kaolinite, oxides, and organic matter. Both the structure and "feel" of Oxisols are deceptive. Upon first examination, they appear structureless and have the feel of a loamy texture. While some are loamy or even coarser textured, many have a fine or very-fine particle-size class, but the clay is aggregated in a strong grade of fine and very fine granular structure. To obtain a true "feel" of the texture, a wet sample must be worked for several minutes in the hands to break down the aggregates. The strong granular structure apparently causes most Oxisols to have a much more rapid permeability than would be predicted, given the particle-size class. Although compaction and reduction in permeability can be caused by cultivation, the soils are extremely resistant to compaction and are so free draining that cultivation can take place soon after rain without puddling.

Oxisols occur in every soil moisture regime from aridic to perudic and aquic. The natural vegetation ranges from tropical rain forests to desert savannas. The lack of a unifying climatic factor throughout their geographic distribution indicates that climatic changes have taken place since these soils formed or that highly weathered parent material has been transported to areas with a dry climate. As part of the definition, the soils are limited to a very low cation-exchange capacity and very few weatherable minerals. They occur over many kinds of geologic bedrock. Close examination, commonly to a great depth, however, shows evidence that the material in which the soils formed has been transported. Where the material clearly is not transported, formation is most common in mafic rock.

Although many Oxisols are extremely infertile, some have small but adequate supplies of nutrients and are immediately productive when cultivated. The reserves of plant nutrients even in the most fertile Oxisols are not great, and, to sustain high yields, fertilizer and lime are needed after only a few years of cultivation. In most of the Oxisols, fertilizers are needed for the first crop unless the soils are fertile enough for one or two crops because of the ash derived from burning the natural vegetation. Phosphorus generally is the most restricted plant nutrient, mainly because of the tendency of the clay- and oxide-rich surface horizon to fix large amounts of fertilizer phosphorus in an unavailable form. Once this tendency to fix the phosphate has been overcome by an initial application, however, there is no further fixation problem and annual fertilizer rates are no higher than those for other soils. Because of the initial expense of fertilization, Oxisols are cultivated extensively only where modern agronomic techniques are sustainable by an infrastructure of agribusiness. Under primitive, shifting cultivation, the soils are used only if they naturally support a large biomass, which can yield a large volume of ash upon burning.

Road building and other engineering practices are relatively easy in most Oxisols because of the physical stability of the clay. There is little silt in most Oxisols; thus, the soils hold little water that is available to plants. The content of organic matter is commonly much higher than is indicated by the soil color, which may result from red staining of the associated iron oxides. The organic matter is very stable, infertile humus and is slow to decompose in many of these soils.

The most extensive areas of Oxisols are on the interior plateaus of South America, the lower portion of the Amazon basin, significant portions of the central African basin, and important areas in Asia, Australia, and several tropical and subtropical islands. Oxisols are of small extent in the United States, and many of the taxa are not known to occur in the country. Because many of the taxa occur only outside the United States, less is known about the vegetation, extent, and use of these taxa. The descriptions of many of the subgroups in this chapter are necessarily brief.

Definition of Oxisols and Limits Between Oxisols and Soils of Other Orders

Oxisols are mineral soils that:

1. Meet one of these two requirements:

a. Have, within 150 cm of the mineral soil surface, the upper boundary of an oxic horizon and no kandic horizon; *or*

b. Have 40 percent or more (by weight) clay in the fine-

[1] This chapter was rewritten in 1987 following recommendations of the International Committee on the Classification of Oxisols (ICOMOX), chaired by Hari Eswaran from 1978 to 1981 and then by S.W. Buol until completion of the task in 1987.

earth fraction between the mineral soil surface and a depth of 18 cm, after mixing, and a kandic horizon that meets the weatherable mineral requirements of an oxic horizon and that has its upper boundary within 150 cm of the mineral soil surface; *and*

2. Do not have *either* of the following:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface; *and*

3. Do not have, above the oxic or kandic horizon, *one or more* of the following:

a. A spodic horizon and an albic horizon in 50 percent or more of each pedon and a cryic or pergelic soil temperature regime; *or*

b. An Ap horizon containing 85 percent or more spodic materials; *or*

c. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature regime; *or*

(e) A cryic or pergelic temperature regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Any depth above the kandic or oxic horizon if the soil has a sandy particle-size class in at least some part between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface, *or* at the top of a duripan or fragipan, *or* at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth,

1) If the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime; *or*

2) If the soil has a cryic or pergelic temperature regime; *and*

4. Do not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower than 60 cm.

Limits Between Oxisols and the Other Soil Orders

The definition of Oxisols must provide criteria that separate Oxisols from soils of all other orders. The aggregate of these criteria defines the limits of Oxisols in relation to all other known kinds of soil.

1. Unlike Alfisols, Aridisols, Entisols, Inceptisols, Mollisols, Ultisols, and Vertisols, Oxisols must have *one* of the following characteristics:

a. An oxic horizon and no kandic horizon within 150 cm of the mineral soil surface; *or*

b. A kandic horizon that meets the weatherable mineral requirements of an oxic horizon that has its upper boundary within 150 cm of the mineral soil surface; and 40 percent or more (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18 cm after mixing.

2. Unlike Andisols, Oxisols must not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower than 60 cm.

3. Unlike Gelisols, Oxisols do not have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

4. Unlike Histosols, Oxisols do not have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices *and* directly below these materials have a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact *and* have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

5. Unlike Spodosols, Oxisols must not have an Ap horizon consisting of spodic materials or a spodic horizon above a kandic horizon and must not have *one or more* of the following:

a. An albic horizon in 50 percent or more of each pedon and a cryic soil temperature regime; *or*

b. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature regime; *or*

(e) A cryic temperature regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy particle-size class between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface, *or* at the top of a duripan or fragipan, *or* at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth if the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime, or if the soil has a cryic temperature regime.

Representative Pedon and Data

Following is a description of a representative Oxisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Oxisol."

Classification: Fine, kaolinitic, isohyperthermic Aeric Haplaquox
Site identification number: 85P0741
Location: Brazil; main road to CPAC/EMBRAPA, 3 km from Br-41 (1.4 km after headquarters), approximately 300 m to the right
Latitude: 15 degrees 35 minutes 30 seconds S.
Longitude: 47 degrees 43 minutes 10 seconds W.
Slope: 5 percent
Elevation: 950 m above m.s.l.
Soil moisture regime: Aquic
Drainage class: Poorly drained
Diagnostic horizons: An ochric epipedon from a depth of 0 to 30 cm and an oxic horizon from a depth of 30 to 180 cm

In the following pedon description, colors are for moist soil unless otherwise indicated.

Ap—0 to 18 cm; dark gray (10YR 4/1) clay, dark gray (10YR 4/1) dry; common fine redox concentrations; moderate fine and medium granular structure; hard, firm, sticky and plastic; common fine roots; many very fine and fine tubular pores; yellowish red (5YR 5/8) oxides along roots; clear smooth boundary.

A—18 to 30 cm; dark gray (10YR 4/1) clay, gray (10YR 5/1) dry; common fine prominent redox concentrations; weak fine granular structure parting to weak fine subangular blocky; very hard, very firm, sticky and plastic; common fine roots; common very fine and fine tubular pores; abrupt wavy boundary.

BAg—30 to 38 cm; pale yellow (5Y 8/3) clay, light gray (10YR 7/1) dry; common fine prominent redox concentrations; weak fine and medium subangular blocky structure; slightly hard, firm, sticky and plastic; few roots; clear wavy boundary.

Bg1—38 to 70 cm; pale yellow (5Y 8/3) clay, white (10YR 8/1) dry; common fine prominent redox concentrations; weak fine and medium subangular blocky structure; slightly hard, friable, sticky and plastic; few roots; gradual wavy boundary.

Bg2—70 to 110 cm; white (5Y 8/2) clay, white (10YR 8/1) dry; few fine and medium prominent redox concentrations; weak fine and medium subangular blocky structure; hard, firm, sticky and plastic; clear wavy boundary.

BCg—110 to 180 cm; pinkish white (5YR 8/2) clay, white (10YR 8/2) dry; common medium and coarse prominent redox concentrations; moderate medium and thick platy structure parting to weak fine and medium angular and subangular blocky; hard, firm, sticky and plastic; gradual wavy boundary.

Cg—180 to 220 cm; pale yellow (5Y 7/4 and 2.5Y 7/4) clay; white (5Y 8/1) to reddish yellow (7.5YR 6/8) redox depletions and concentrations; wet soil compacted by auger.

Characterization Data for an Oxisol

SITE IDENTIFICATION NO.: 85P0741
CLASSIFICATION: FINE, KAOLINITIC, ISOHYPERTHERMIC AERIC HAPLAQUOX
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	CLAY LT .002	SILT .002 -.05	SAND .05 -2	FINE CLAY LT .0002	CO_3 CLAY LT .002	FINE SILT .002 -.02	COARSE SILT .02 -.05	VF SAND .05 -.10	F SAND .10 -.25	M SAND .25 -.50	C SAND .5 -1	VC SAND 1 -2	COARSE FRACTIONS WEIGHT 2 -5	5 -20	20 -75	.1- 75	WT PCT OF WHOLE SOIL (>2mm)
	-1-	-2-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-	-19-	-20-
			<- Pct of <2mm (3A1)											->	<- Pct of <75mm(3B1)->				
85P3892	0- 18	Ap	53.9	21.1	25.0	40.5		10.1	11.0	6.9	11.3	6.3	0.4	0.1	--	--	--	18	--
85P3893	18- 30	A	53.8	20.4	25.8	40.9		9.4	11.0	6.3	12.2	6.9	0.4	--	--	--	--	19	--
85P3894	30- 38	BAg	56.9	19.6	23.5	43.0		9.6	10.0	6.4	10.8	5.8	0.5	--	--	--	--	17	--
85P3895	38- 70	Bg1	60.0	20.3	19.7	45.0		9.5	10.8	5.7	8.9	4.5	0.3	0.3	--	--	--	14	--
85P3896	70-110	Bg2	59.7	20.6	19.7	42.0		10.5	10.1	5.7	9.2	4.5	0.3	--	TR	--	--	14	--
85P3897	110-180	BCg	60.7	20.4	18.9	40.6		10.3	10.1	5.5	8.8	4.3	0.3	--	TR	TR	--	13	--

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	(BULK DENSITY) FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1 cm/cm	(WATER CONTENT) FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1 cm/cm
					<- Percent of <2mm -->					Pct <0.4mm		<- - g/cc - - ->				<- - -Pct of <2mm - ->				
0- 18	2.12	0.139			0.7	0.3	--	0.19	0.39	41	18		1.28	1.35	0.018		27.4	25.1	18.2	0.05
18- 30	1.59	0.098			0.3	0.2	--	0.17	0.40	41	19		1.25	1.41	0.041		32.8	30.2	17.8	0.11
30- 38	1.00	0.084			0.1	0.2	--	0.12	0.38	41	19		1.23	1.35	0.032		31.4	28.4	18.3	0.08
38- 70	0.48	0.028			0.1	0.1	--	0.11	0.39	45	20		1.09	1.20	0.033		33.9	29.7	19.7	0.07
70-110	0.26	0.027			0.2	0.1	--	0.11	0.43	47	21		1.16	1.26	0.028		33.2	29.5	21.0	0.04
110-180	0.18	0.013			0.4	0.1	--	0.09	0.43	48	18		1.24	1.32	0.021		30.1	28.2	22.1	0.03

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9a	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8b	BASES + Al 5A3b	Al SAT 5G1	(BASE SAT) SUM 5C3	NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	(PH) KCl IN 8C1g	NaF 8C1d	$CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- -meq / 100 g									->	<- - - - -Pct - - - ->								
0- 18	0.2	0.4	TR	--	0.6	14.5	2.3	15.1	10.4	2.9	79	4	6			3.7	9.1	3.9	4.1
18- 30	--	0.1	TR	--	0.1	12.8	2.9	12.9	9.1	3.0	97	1	1			3.7	9.4	3.9	4.3
30- 38	--	TR	TR	--	TR	10.6	2.8	10.6	7.1	2.8	100	TR	TR			3.8		4.0	4.4
38- 70	--	--	TR	--	TR	9.2	1.8	9.2	6.3	1.8	100	TR	TR			3.9	9.9	4.2	5.0
70-110	--	--	TR	--	TR	8.1	1.9	8.1	6.5	1.9	100	TR	TR			4.0		4.2	5.1
110-180	--	--	TR	--	TR	7.1	1.6	7.1	5.4	1.6	100	TR	TR			4.0	9.8	4.3	5.3

SAMPLE NO.	HZ NO	(ACID OXALATE EXTRACTION) OPT DEN 8J	Fe 6C9a	Si 6V2	Al 6G12	PHOSPHOUS RET 6S4	CIT-ACID 6S5	KCl Mn 6D3	TOTAL C 6A2d	(WATER CONTENT) 0.06 BAR 4B1c	1- BAR 4B1a	2- BAR 4B1a	15 BAR 4B2b	(WATER DISPERSIBLE) PIPETTE CLAY 3A1c	SILT	SAND	HYDROMETER CLAY SML	SILT	SAND	MIN SOIL CONT 8F1	AGGRT STABL <5mm 4G1
			<- P c t o f < 2 m m ->			<- p p m ->			<- P e r c e n t o f < 2 m m											->	Pct>
85P3892	1	0.13	0.42	0.02	0.38				1.94				21.0								
85P3893	2	0.08	0.19	0.01	0.38				1.45				21.7								
85P3894	3	0.05	0.11		0.39				0.87				21.5								
85P3895	4	0.04	0.05	0.08	0.39				0.46				23.2								
85P3896	5	0.02	0.02	0.08	0.32				0.24				25.8								
85P3897	6	0.02	0.03	0.09	0.28				0.16				25.8								

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRAC-TION	X-RAY 7A2i (Peak size)				THERMAL DTA 7A6 (Percent)	TGA 7A4b	ELEMENTAL 7C3 (Percent) SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 (mg/g)	INTER-PRETA-TION
85P3892	TCLY	KK 5	GI 2	VR 2		KK70	GI 4			2.3			0.1			
85P3896	TCLY	KK 5	GI 2	VR 2		KK80	GI 5			1.1						
85P3897	TCLY	KK 5	GI 2	VR 2	GE 1	KK76	GI 5			1.3						

SAND - SILT MINERALOGY (2.0-0.002mm)

SAMPLE NUMBER	FRACTION	OPTICAL GRAIN COUNT PERCENT TOTAL RESISTANT 7B1a				
85P3896	VFS	100	QZ88	PO12	OPtr	MItr

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm; VFS, very fine sand, 0.05-0.10 mm.
Mineral interpretation: KK, kaolinite; GI, gibbsite; VR, vermiculite; QZ, quartz; PO, plant opal; OP, opaques; MI, mica; GE, goethite.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.
Pedon mineralogy based on clay: Kaolinitic.
Family mineralogy: Kaolinitic.

Key to Suborders

EA. Oxisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or more* of the following:

1. A histic epipedon; *or*

2. An epipedon with a color value, moist, of 3 or less and, directly below it, a horizon with chroma of 2 or less; *or*

3. Distinct or prominent redox concentrations within 50 cm of the mineral soil surface, an epipedon, and, directly below it, a horizon with *one or both* of the following:

  a. 50 percent or more hue of 2.5Y or yellower; *or*

  b. Chroma of 3 or less; *or*

4. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquox, p. 659

EB. Other Oxisols that have an aridic moisture regime.

Torrox, p. 671

EC. Other Oxisols that have an ustic or xeric moisture regime.

Ustox, p. 683

ED. Other Oxisols that have a perudic moisture regime.

Perox, p. 662

EE. Other Oxisols.

Udox, p. 673

Aquox

These are wet Oxisols in shallow depressions and in seepage areas at the base of slopes. Because the water table may fluctuate seasonally in the soils, there is a tendency to accumulate iron in the form of secondary nodules, concretions, and plinthite. Most areas of these soils are small.

Definition

Aquox are the Oxisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or more* of the following:

1. A histic epipedon; *or*

2. An epipedon directly above a horizon with 50 percent or more hue of 2.5Y or yellower or chroma of 3 or less and distinct or prominent redox concentrations within 50 cm of the mineral soil surface; *or*

3. An epipedon with a color value, moist, of 3 or less directly above a horizon with chroma of 2 or less; *or*

4. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

EAA. Aquox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (in 1N KCl) of 5.0 or more.

Acraquox, p. 659

EAB. Other Aquox that have plinthite forming a continuous phase within 125 cm of the mineral soil surface.

Plinthaquox, p. 661

EAC. Other Aquox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutraquox, p. 660

EAD. Other Aquox.

Haplaquox, p. 661

Acraquox

This great group is provided for those Aquox with extremely low cation-exchange capacities. Few examples have been made available for study.

Definition

Acraquox are the Aquox that have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EAAA. Acraquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acraquox

EAAB. Other Acraquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Acraquox

EAAC. Other Acraquox.

Typic Acraquox

Definition of Typic Acraquox

Typic Acraquox are the Acraquox that:

1. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume); *and*

2. Do not have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Description of Subgroups

Typic Acraquox.—The central concept or Typic subgroup of Acraquox is fixed on soils that have dominantly low chroma in a layer 10 cm or more thick that is directly below an epipedon. These soils also have less than 5 percent plinthite in all horizons within a depth of 125 cm. They are not known to occur in the United States.

Aeric Acraquox.—These soils are like Typic Acraquox, but they have chroma dominantly of 3 or more in a layer 10 cm or more thick that is directly below an epipedon. Aeric Acraquox are considered intergrades between Acraquox and Acrudox or Acroperox. They are not known to occur in the United States.

Plinthic Acraquox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Eutraquox

These Aquox have a base saturation (pH 7) of more than 35 percent in all horizons to a depth of 125 cm. They do not have plinthite that forms a continuous phase within 125 cm of the mineral soil surface and do not have both a very low apparent ECEC and a pH value (1N KCl) of 5.0 or more in some part of the oxic or kandic horizon.

Definition

Eutraquox are the Aquox that:

1. Have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface;

2. Do not have plinthite that forms a continuous phase within 125 cm of the mineral soil surface; *and*

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EACA. Eutraquox that have a histic epipedon.

Histic Eutraquox

EACB. Other Eutraquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutraquox

EACC. Other Eutraquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Eutraquox

EACD. Other Eutraquox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutraquox

EACE. Other Eutraquox.

Typic Eutraquox

Definition of Typic Eutraquox

Typic Eutraquox are the Eutraquox that:

1. Do not have a histic epipedon;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more; *and*

4. Have less than 16 kg of organic carbon per m^2 to a depth of 100 cm, exclusive of surface litter.

Description of Subgroups

Typic Eutraquox.—The central concept or Typic subgroup of Acraquox is fixed on soils that do not have a histic epipedon and have dominantly low chroma in a layer 10 cm or more thick that is directly below an epipedon. These soils also have less than 16 kg/m^2 organic carbon to a depth of 100 cm and less than 5 percent plinthite in all horizons within a depth of 125 cm. They are not known to occur in the United States.

Aeric Eutraquox.—These soils have chroma dominantly of 3 or more in a layer 10 cm or more thick that is directly below an epipedon. Aeric Eutraquox are considered intergrades between Eutraquox and Eutrudox or Eutroperox. They are not known to occur in the United States.

Histic Eutraquox.—These soils have a histic epipedon. They commonly are wet much of the year and are among the wettest of the soils in this great group. Histic Eutraquox are not known to occur in the United States.

Humic Eutraquox.—These soils are like Typic Eutraquox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Plinthic Eutraquox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Haplaquox

These are the Aquox that have low base status in one or more subhorizons of the oxic or kandic horizon. They do not have plinthite that forms a continuous phase within 125 cm of the mineral soil surface and do not have both a very low apparent ECEC and a pH value (1N KCl) of 5.0 or more in some part of the oxic or kandic horizon.

Definition

Haplaquox are the Aquox that:

1. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

2. Do not have plinthite that forms a continuous phase within 125 cm of the mineral soil surface; *and*

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EADA. Haplaquox that have a histic epipedon.

Histic Haplaquox

EADB. Other Haplaquox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haplaquox

EADC. Other Haplaquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Haplaquox

EADD. Other Haplaquox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haplaquox

EADE. Other Haplaquox.

Typic Haplaquox

Definition of Typic Haplaquox

Typic Haplaquox are the Haplaquox that:

1. Do not have a histic epipedon;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more; *and*

4. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter.

Description of Subgroups

Typic Haplaquox.—The central concept or Typic subgroup of Haplaquox is fixed on soils that do not have a histic epipedon and have dominantly low chroma in a layer 10 cm or more thick that is directly below an epipedon. These soils also have less than 16 kg/m^2 organic carbon to a depth of 100 cm and less than 5 percent plinthite in all horizons within a depth of 125 cm. They are not known to occur in the United States.

Aeric Haplaquox.—These soils have chroma dominantly of 3 or more in a layer 10 cm or more thick that is directly below an epipedon. Aeric Haplaquox are considered intergrades between Haplaquox and Hapludox or Haploperox. They are not known to occur in the United States.

Histic Haplaquox.—These soils have a histic epipedon. They commonly are wet much of the year and are among the wettest of the soils in this great group. Histic Haplaquox are not known to occur in the United States.

Humic Haplaquox.—These soils are like Typic Haplaquox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are of very small extent in Puerto Rico and generally are forested.

Plinthic Haplaquox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquox

This great group is provided for pedons of Aquox that have continuous plinthite within 125 cm of the mineral soil surface and an apparent ECEC of more than 1.50 cmol(+) per kg clay or a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface. Only small areas of Plinthaquox have been observed, and no data have been made available for study.

Definition

Plinthaquox are the Aquox that:

1. Have plinthite that forms a continuous phase within 125 cm of the mineral soil surface; *and*

2. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EABA. Plintaquox that have, directly below an epipedon, a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Aeric Plinthaquox

EABB. Other Plinthaquox.

Typic Plinthaquox

Definition of Typic Plinthaquox

Typic Plinthaquox are the Plinthaquox that, directly below an epipedon, do not have a horizon 10 cm or more thick that has 50 percent or more chroma of 3 or more.

Description of Subgroups

Typic Plinthaquox.—The central concept or Typic subgroup of Haplaquox is fixed on soils that have dominantly low chroma in a layer 10 cm or more thick that is directly below an epipedon. These soils are not known to occur in the United States.

Aeric Plinthaquox.—These soils have chroma dominantly of 3 or more in a layer 10 cm or more thick that is directly below an epipedon. They are not known to occur in the United States.

Perox

Perox are well drained Oxisols with a perudic soil moisture regime. Clearing and burning are difficult because of atmospheric wetness. Curing many seed crops and storing produce also are difficult. There are no large areas of the perudic soil moisture regime, but areas of this regime appear distinctive enough to show and identify on some small-scale soil maps.

Definition

Perox are the Oxisols that have a perudic soil moisture regime.

Key to Great Groups

EDA. Perox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriperox, p. 671

EDB. Other Perox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acroperox, p. 662

EDC. Other Perox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutroperox, p. 664

EDD. Other Perox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiperox, p. 668

EDE. Other Perox.

Haploperox, p. 666

Acroperox

These are the Perox that do not have a sombric horizon within 150 cm of the mineral soil surface and have, in all subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, a very low effective cation-exchange value and a pH value (1N KCl) of 5.0 or more.

Definition

Acroperox are the Perox that:

1. Have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface; *and*

2. Do not have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EDBA. Acroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acroperox

EDBB. Other Acroperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acroperox

EDBC. Other Acroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acroperox

EDBD. Other Acroperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acroperox

EDBE. Other Acroperox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acroperox

EDBF. Other Acroperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acroperox

EDBG. Other Acroperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acroperox

EDBH. Other Acroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Acroperox

EDBI. Other Acroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acroperox

EDBJ. Other Acroperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acroperox

EDBK. Other Acroperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acroperox

EDBL. Other Acroperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acroperox

EDBM. Other Acroperox.

Typic Acroperox

Definition of Typic Acroperox

Typic Acroperox are the Acroperox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Have a delta pH (KCl pH minus 1:1 water pH) with a net negative charge in all parts within 125 cm of the mineral soil surface;

3. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

4. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

5. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

6. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Acroperox.—The central concept or Typic subgroup of Acroperox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are not known to occur in the United States.

Anionic Acroperox.—These soils have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface. The soils are of very small extent and are known to occur only in Hawaii in the United States.

Aquic Acroperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Acroperox are considered intergrades between Acroperox and Acraquox. They are not known to occur in the United States.

Aquic Lithic Acroperox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Acroperox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Acroperox.—These soils are like Typic Acroperox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Acroperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Acroperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Acroperox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Acroperox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthic Acroperox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Rhodic Acroperox.—These soils are like Typic Acroperox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Acroperox.—These soils are like Typic Acroperox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Eutroperox

These are the Perox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface. They do not have a sombric horizon within 150 cm of the mineral soil surface and have, in all subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0.

Definition

Eutroperox are the Perox that:

1. Have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EDCA. Eutroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutroperox

EDCB. Other Eutroperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutroperox

EDCC. Other Eutroperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutroperox

EDCD. Other Eutroperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutroperox

EDCE. Other Eutroperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutroperox

EDCF. Other Eutroperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutroperox

EDCG. Other Eutroperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutroperox

EDCH. Other Eutroperox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiudalfic Eutroperox

EDCI. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutroperox

EDCJ. Other Eutroperox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutroperox

EDCK. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Eutroperox

EDCL. Other Eutroperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutroperox

EDCM. Other Eutroperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutroperox

EDCN. Other Eutroperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutroperox

EDCO. Other Eutroperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutroperox

EDCP. Other Eutroperox.

Typic Eutroperox

Definition of Typic Eutroperox

Typic Eutroperox are the Eutroperox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have a kandic horizon with its upper boundary within 150 cm of the mineral soil surface;

5. Have an oxic horizon with a lower boundary 125 cm or more from the mineral soil surface;

6. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Eutroperox.—The central concept or Typic subgroup of Eutroperox is fixed on soils that have a thick oxic horizon. These soils do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. The soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are not known to occur in the United States.

Aquic Eutroperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Eutroperox are considered intergrades between Eutroperox and Eutraquox. They are not known to occur in the United States.

Aquic Lithic Eutroperox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Eutroperox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Eutroperox.—These soils are like Typic Eutroperox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Inceptic Eutroperox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Rhodic Eutroperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Eutroperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Inceptic Eutroperox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Kandiudalfic Eutroperox.—These soils have a kandic horizon that has its upper boundary within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Eutroperox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Eutroperox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Eutroperox.—These soils have, within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Plinthic Eutroperox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Rhodic Eutroperox.—These soils are like Typic Eutroperox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. These soils are not known to occur in the United States.

Xanthic Eutroperox.—These soils are like Typic Eutroperox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Haploperox

These are the Perox that have, in all subhorizons of an oxic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They also have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface and do not have a kandic or sombric horizon that has its upper boundary within 150 cm of the mineral soil surface. The subsoil has granular structure, and the epipedons may be either dark or light colored.

Definition

Haploperox are the Perox that:

1. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface;

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic horizon within 150 cm of the mineral soil surface; *and*

4. Do not have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Key to Subgroups

EDEA. Haploperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more

and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Haploperox

EDEB. Other Haploperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haploperox

EDEC. Other Haploperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Haploperox

EDED. Other Haploperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haploperox

EDEE. Other Haploperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Haploperox

EDEF. Other Haploperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haploperox

EDEG. Other Haploperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploperox

EDEH. Other Haploperox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploperox

EDEI. Other Haploperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Haploperox

EDEJ. Other Haploperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Haploperox

EDEK. Other Haploperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haploperox

EDEL. Other Haploperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Haploperox

EDEM. Other Haploperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Haploperox

EDEN. Other Haploperox.

Typic Haploperox

Definition of Typic Haploperox

Typic Haploperox are the Haploperox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-

extractable aluminum plus ½ acid-oxalate-extractable iron of more than 1.0 percent;

5. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

6. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Haploperox.—The central concept or Typic subgroup of Haploperox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. They do not have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. These soils are not known to occur in the United States.

Andic Haploperox.—These soils have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. The soils are not known to occur in the United States.

Aquic Haploperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Haploperox are considered intergrades between Haploperox and Haplaquox. They are not known to occur in the United States.

Aquic Lithic Haploperox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Haploperox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). These soils are not known to occur in the United States.

Humic Haploperox.—These soils are like Typic Haploperox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Haploperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Haploperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Haploperox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Haploperox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Haploperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Haploperox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Rhodic Haploperox.—These soils are like Typic Haploperox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Haploperox.—These soils are like Typic Haploperox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. These soils are not known to occur in the United States.

Kandiperox

These are the clayey Perox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface. They do not have a sombric horizon within 150 cm of the mineral soil surface, but they have, in all subhorizons of a kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They also have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface. The subsoil has granular structure, and the epipedons may be either dark or light colored.

Definition

Kandiperox are the Perox that:

1. Have the upper boundary of a kandic horizon within 150 cm of the mineral soil surface;

2. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

3. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

4. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of a kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EDDA. Kandiperox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiperox

EDDB. Other Kandiperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiperox

EDDC. Other Kandiperox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiperox

EDDD. Other Kandiperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiperox

EDDE. Other Kandiperox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiperox

EDDF. Other Kandiperox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiperox

EDDG. Other Kandiperox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiperox

EDDH. Other Kandiperox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiperox

EDDI. Other Kandiperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Kandiperox

EDDJ. Other Kandiperox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiperox

EDDK. Other Kandiperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiperox

EDDL. Other Kandiperox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiperox

EDDM. Other Kandiperox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiperox

EDDN. Other Kandiperox.

Typic Kandiperox

Definition of Typic Kandiperox

Typic Kandiperox are the Kandiperox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

5. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

6. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Kandiperox.—The central concept or Typic subgroup of Kandiperox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. They do not have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. These soils are not known to occur in the United States.

Andic Kandiperox.—These soils have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. The soils are not known to occur in the United States.

Aquic Kandiperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Kandiperox are considered intergrades between Kandiperox and Aquox. They are not known to occur in the United States.

Aquic Lithic Kandiperox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Kandiperox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Kandiperox.—These soils are like Typic Kandiperox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Kandiperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Kandiperox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Kandiperox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Kandiperox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Kandiperox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Kandiperox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Rhodic Kandiperox.—These soils are like Typic Kandiperox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Kandiperox.—These soils are like Typic Kandiperox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Sombriperox

These are the Perox that have a sombric horizon. They are not known to occur in the United States at this time but are expected to occur in other parts of the world.

Definition

Sombriperox are the Perox that have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EDAA. Sombriperox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriperox

EDAB. Other Sombriperox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriperox

EDAC. Other Sombriperox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriperox

EDAD. Other Sombriperox.

Typic Sombriperox

Definition of Typic Sombriperox

Typic Sombriperox are the Sombriperox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface; *and*

2. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter.

Description of Subgroups

Typic Sombriperox.—The central concept or Typic subgroup of Sombriperox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils also have less than 16 kg/m^2 organic carbon to a depth of 100 cm. They are not known to occur in the United States.

Humic Sombriperox.—These soils are like Typic Sombriperox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Sombriperox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Sombriperox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Torrox

These are Oxisols of arid regions. They have an aridic moisture regime, and many of them have a higher base saturation than other Oxisols. Torrox are excellent soils for a variety of crops if irrigation water and fertilizer are applied. These soils are known to occur only Hawaii in the United States and perhaps in some areas in Australia.

Definition

Torrox are the Oxisols that have an aridic (torric) moisture regime.

Key to Great Groups

EBA. Torrox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrotorrox, p. 671

EBB. Other Torrox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrotorrox, p. 672

EBC. Other Torrox.

Haplotorrox, p. 672

Acrotorrox

These are the Torrox that have, in all subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, a very low effective cation-exchange value and a pH value (1N KCl) of 5.0 or more.

Definition

Acrotorrox are the Torrox that have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EBAA. Acrotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrotorrox

EBAB. Other Acrotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrotorrox

EBAC. Other Acrotorrox.

Typic Acrotorrox

Definition of Typic Acrotorrox

Typic Acrotorrox are the Acrotorrox that have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface.

Description of Subgroups

Typic Acrotorrox.—The central concept or Typic subgroup of Acrotorrox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Acrotorrox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Acrotorrox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Eutrotorrox

These are the Torrox that have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface. They also have, in some subhorizon of an oxic or kandic horizon within 150 cm of the mineral soil surface, an effective cation-exchange value higher than very low or a pH value (1N KCl) of less than 5.0. These soils occur mainly in Hawaii, where they are used for irrigated crops.

Definition

Eutrotorrox are the Torrox that:

1. Have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface; *and*

2. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EBBA. Eutrotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrotorrox

EBBB. Other Eutrotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrotorrox

EBBC. Other Eutrotorrox.

Typic Eutrotorrox

Definition of Typic Eutrotorrox

Typic Eutrotorrox are the Eutrotorrox that have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface.

Description of Subgroups

Typic Eutrotorrox.—The central concept or Typic subgroup of Eutrotorrox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Eutrotorrox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Eutrotorrox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Haplotorrox

These are the Torrox that have 35 percent or less base saturation (by NH_4OAc) in some part within 125 cm of the mineral soil surface. They also have, in some subhorizon of an oxic or kandic horizon within 150 cm of the mineral soil surface, an effective cation-exchange value higher than very low or a pH value (1N KCl) of less than 5.0.

Definition

Haplotorrox are the Torrox that:

1. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface; *and*

2. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EBCA. Haplotorrox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haplotorrox

EBCB. Other Haplotorrox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haplotorrox

EBCC. Other Haplotorrox.

Typic Haplotorrox

Definition of Typic Haplotorrox

Typic Haplotorrox are the Haplotorrox that have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface.

Description of Subgroups

Typic Haplotorrox.—The central concept or Typic subgroup of Haplotorrox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Haplotorrox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Haplotorrox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Udox

Udox are well drained Oxisols with a udic soil moisture regime. They are moist because of natural rainfall in normal years and are dry in some parts for less than 90 days, a period that is short enough for rain-fed crops to be grown continuously in normal years. There are fewer than 90 days during which crops are not planted. In local terms there are 1 to 3 months that considered "dry" in normal years. Udox are an extensive suborder, occurring mostly in South America and in parts of Africa and Asia.

Definition

Udox are the Oxisols that have a udic moisture regime.

Key to Great Groups

EEA. Udox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriudox, p. 682

EEB. Other Udox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrudox, p. 673

EEC. Other Udox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrudox, p. 675

EED. Other Udox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiudox, p. 680

EEE. Other Udox.

Hapludox, p. 678

Acrudox

These are Udox that have very low CEC values in the subsoil and that do not have a sombric horizon within 150 cm of the mineral soil surface. Frequent but small applications of fertilizer and lime are required. Because the CEC is low, the amount of exchangeable aluminum in the subsoil is low. This deficiency can be corrected by leaching basic cations from lime and fertilizer.

Definition

Acrudox are the Udox that:

1. Have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface; *and*

2. Do not have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EEBA. Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acrudox

EEBB. Other Acrudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrudox

EEBC. Other Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acrudox

EEBD. Other Acrudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrudox

EEBE. Other Acrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Anionic Aquic Acrudox

EEBF. Other Acrudox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acrudox

EEBG. Other Acrudox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acrudox

EEBH. Other Acrudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acrudox

EEBI. Other Acrudox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutric Acrudox

EEBJ. Other Acrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Acrudox

EEBK. Other Acrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acrudox

EEBL. Other Acrudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acrudox

EEBM. Other Acrudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acrudox

EEBN. Other Acrudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acrudox

EEBO. Other Acrudox.

Typic Acrudox

Definition of Typic Acrudox

Typic Acrudox are the Acrudox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Have a delta pH (KCl pH minus 1:1 water pH) with a net negative charge in all parts within 125 cm of the mineral soil surface;

3. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

4. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

5. Have 35 percent or less base saturation (by NH_4OAc) in some subhorizon within 125 cm of the mineral soil surface;

6. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

   a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

   b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Acrudox.—The central concept or Typic subgroup of Acrudox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are of small extent in Hawaii.

Anionic Acrudox.—These soils have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface. They are of small extent and are known to occur only in Hawaii and Puerto Rico in the United States.

Anionic Aquic Acrudox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Aquic Acrudox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Acrudox are considered intergrades between Acrudox and Acraquox. They are not known to occur in the United States.

Aquic Lithic Acrudox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Acrudox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Eutric Acrudox.—These soils have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Humic Acrudox.—These soils are like Typic Acrudox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Acrudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Acrudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Acrudox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Acrudox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthic Acrudox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. They are of small extent in Hawaii.

Rhodic Acrudox.—These soils are like Typic Acrudox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Acrudox.—These soils are like Typic Acrudox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Eutrudox

These are the Udox with high base saturation throughout the profile. They do not have a sombric horizon within 150 cm of the mineral soil surface. They have, in all subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 cmol(+) per kg clay or more or a pH value (1N KCl) of less than 5.0. These soils are highly valued by shifting cultivators and are most common in areas near basic geologic rock.

Definition

Eutrudox are the Udox that:

1. Have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EECA. Eutrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutrudox

EECB. Other Eutrudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrudox

EECC. Other Eutrudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutrudox

EECD. Other Eutrudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrudox

EECE. Other Eutrudox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutrudox

EECF. Other Eutrudox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutrudox

EECG. Other Eutrudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrudox

EECH. Other Eutrudox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiudalfic Eutrudox

EECI. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutrudox

EECJ. Other Eutrudox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutrudox

EECK. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Eutrudox

EECL. Other Eutrudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutrudox

EECM. Other Eutrudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutrudox

EECN. Other Eutrudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutrudox

EECO. Other Eutrudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutrudox

EECP. Other Eutrudox.

Typic Eutrudox

Definition of Typic Eutrudox

Typic Eutrudox are the Eutrudox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have a kandic horizon with its upper boundary within 150 cm of the mineral soil surface;

5. Have an oxic horizon with a lower boundary 125 cm or more from the mineral soil surface;

6. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Eutrudox.—The central concept or Typic subgroup of Eutrudox is fixed on soils that have a thick oxic horizon. These soils do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. They have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are of small extent in Hawaii.

Aquic Eutrudox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Eutrudox are considered intergrades between Eutrudox and Eutraquox. They are not known to occur in the United States.

Aquic Lithic Eutrudox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Eutrudox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Eutrudox.—These soils are like Typic Eutrudox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Inceptic Eutrudox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Rhodic Eutrudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Eutrudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Inceptic Eutrudox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They are of small extent in Hawaii.

Kandiudalfic Eutrudox.—These soils have a kandic horizon that has its upper boundary within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Eutrudox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are of very small extent, mostly in Puerto Rico.

Petroferric Eutrudox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Eutrudox.—These soils have, within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Plinthic Eutrudox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Eutrudox.—These soils are like Typic Eutrudox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Eutrudox.—These soils are like Typic Eutrudox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Hapludox

These are the Udox that do not have a sombric horizon within 150 cm of the mineral soil surface and have, in all subhorizons of an oxic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They also have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface and do not have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface. The subsoil has granular structure, and the epipedons may be either dark or light colored. Hapludox commonly are acid, and the subsoil ranges from dark red to pale yellow. These soils are common in the uplands of Africa, the central part of Indonesia, and many other areas.

Definition

Hapludox are the Udox that:

1. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface;

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic horizon within 150 cm of the mineral soil surface; *and*

4. Do not have the upper boundary of a kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EEEA. Hapludox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Hapludox

EEEB. Other Hapludox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Hapludox

EEEC. Other Hapludox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Hapludox

EEED. Other Hapludox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Hapludox

EEEE. Other Hapludox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Hapludox

EEEF. Other Hapludox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Hapludox

EEEG. Other Hapludox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Hapludox

EEEH. Other Hapludox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Hapludox

EEEI. Other Hapludox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Hapludox

EEEJ. Other Hapludox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Hapludox

EEEK. Other Hapludox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Hapludox

EEEL. Other Hapludox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Hapludox

EEEM. Other Hapludox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Hapludox

EEEN. Other Hapludox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Hapludox

EEEO. Other Hapludox.

Typic Hapludox

Definition of Typic Hapludox

Typic Hapludox are the Hapludox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

3. Have an oxic horizon with a lower boundary 125 cm or more from the mineral soil surface;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

5. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

6. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, less than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Hapludox.—The central concept or Typic subgroup of Hapludox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. They do not have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. These soils are of small extent, mostly in Puerto Rico and Hawaii.

Andic Hapludox.—These soils have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. The soils are not known to occur in the United States.

Aquic Hapludox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Hapludox are considered intergrades between Hapludox and Haplaquox. They are not known to occur in the United States.

Aquic Lithic Hapludox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Hapludox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Hapludox.—These soils are like Typic Hapludox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are of very small extent, mostly in Puerto Rico.

Humic Rhodic Hapludox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Xanthic Hapludox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Inceptic Hapludox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They are of small extent, mostly in Puerto Rico and Hawaii.

Lithic Hapludox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are of very small extent, mostly in Puerto Rico.

Petroferric Hapludox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Hapludox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Hapludox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Hapludox.—These soils are like Typic Hapludox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are of very small extent, mostly in Puerto Rico.

Xanthic Hapludox.—These soils are like Typic Hapludox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Kandiudox

These are the clayey Udox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface. They do not have a sombric horizon within 150 cm of the mineral soil surface, but they have, in all subhorizons of a kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They also have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface. The subsoil has a moderate grade of blocky structure in most pedons. The epipedons are either dark or light colored.

Definition

Kandiudox are the Udox that:

1. Have the upper boundary of a kandic horizon within 150 cm of the mineral soil surface;

2. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

3. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

4. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of a kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EEDA. Kandiudox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiudox

EEDB. Other Kandiudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiudox

EEDC. Other Kandiudox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiudox

EEDD. Other Kandiudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiudox

EEDE. Other Kandiudox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiudox

EEDF. Other Kandiudox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiudox

EEDG. Other Kandiudox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudox

EEDH. Other Kandiudox that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiudox

EEDI. Other Kandiudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Kandiudox

EEDJ. Other Kandiudox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiudox

EEDK. Other Kandiudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiudox

EEDL. Other Kandiudox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiudox

EEDM. Other Kandiudox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiudox

EEDN. Other Kandiudox.

Typic Kandiudox

Definition of Typic Kandiudox

Typic Kandiudox are the Kandiudox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

5. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

6. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, less than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

   b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Kandiudox.—The central concept or Typic subgroup of Kandiudox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. They do not have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. These soils are of small extent, mostly in Puerto Rico.

Andic Kandiudox.—These soils have a surface mantle or layer in the upper 75 cm with both a low bulk density and a high content of weakly crystalline minerals. The soils are not known to occur in the United States.

Aquic Kandiudox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Kandiudox are considered intergrades between Kandiudox and Aquox. They are not known to occur in the United States.

Aquic Lithic Kandiudox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Kandiudox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Kandiudox.—These soils are like Typic Kandiudox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Kandiudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Kandiudox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Kandiudox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Kandiudox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Kandiudox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Kandiudox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Kandiudox.—These soils are like Typic Kandiudox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Kandiudox.—These soils are like Typic Kandiudox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Sombriudox

These are the Udox that have a sombric horizon. These soils are poorly understood. They have an increase in content of organic carbon in the subsoil. The only known pedons are near the Rift Valley in Africa.

Definition

Sombriudox are the Udox that have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

EEAA. Sombriudox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriudox

EEAB. Other Sombriudox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriudox

EEAC. Other Sombriudox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriudox

EEAD. Other Sombriudox.

Typic Sombriudox

Definition of Typic Sombriudox

Typic Sombriudox are the Sombriudox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface; *and*

2. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter.

Description of Subgroups

Typic Sombriudox.—The central concept or Typic subgroup of Sombriudox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm. They are not known to occur in the United States.

Humic Sombriudox.—These soils are like Typic Sombriudox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Sombriudox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Sombriudox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Ustox

These are the Oxisols that have an ustic moisture regime. Because of natural rainfall, they are moist in normal years for at least 90 days (a period that usually is long enough for one rain-fed crop) but not for more than 270 days. Crops are not grown continuously because there is inadequate moisture for at least 90 days in normal years. Ustox may be the most extensive suborder, occurring over a large portion of the interior of South America and in extensive areas of Africa. A few Ustox are in areas of the xeric soil moisture regime, for example, in Australia. The range of natural rainfall within the Ustox provides that two crops can be grown on some Ustox but only one crop can be grown on others unless supplemental irrigation is available.

Definition

Ustox are the Oxisols that have an ustic moisture regime.

Key to Great Groups

ECA. Ustox that have a sombric horizon within 150 cm of the mineral soil surface.

Sombriustox, p. 692

ECB. Other Ustox that have, in one or more subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more.

Acrustox, p. 683

ECC. Other Ustox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutrustox, p. 685

ECD. Other Ustox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiustox, p. 690

ECE. Other Ustox.

Haplustox, p. 688

Acrustox

These are the Ustox with very low cation-exchange values. They do not have a sombric horizon within 150 cm of the mineral soil surface. They can easily have their chemical environment altered by applications of fertilizer and lime. Because of a low buffering capacity, small but frequent applications of fertilizer and lime are desirable. A low content of exchangeable aluminum in the subsoil can be corrected by leaching basic cations from lime and fertilizer.

Definition

Acrustox are the Ustox that:

1. Have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface; *and*

2. Do not have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

ECBA. Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Acrustox

ECBB. Other Acrustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Acrustox

ECBC. Other Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Acrustox

ECBD. Other Acrustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Acrustox

ECBE. Other Acrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Anionic Aquic Acrustox

ECBF. Other Acrustox that have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface.

Anionic Acrustox

ECBG. Other Acrustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Acrustox

ECBH. Other Acrustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Acrustox

ECBI. Other Acrustox that have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface.

Eutric Acrustox

ECBJ. Other Acrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Acrustox

ECBK. Other Acrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Acrustox

ECBL. Other Acrustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Acrustox

ECBM. Other Acrustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Acrustox

ECBN. Other Acrustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Acrustox

ECBO. Other Acrustox.

Typic Acrustox

Definition of Typic Acrustox

Typic Acrustox are the Acrustox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Have a delta pH (KCl pH minus 1:1 water pH) with a net negative charge in all parts within 125 cm of the mineral soil surface;

3. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

4. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

5. Have 35 percent or less base saturation (by NH_4OAc) in some subhorizon within 125 cm of the mineral soil surface;

6. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Acrustox.—The central concept or Typic subgroup of Acrustox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm.

Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are not known to occur in the United States.

Anionic Acrustox.—These soils have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface. They are of very small extent and are known to occur only in Hawaii in the United States.

Anionic Aquic Acrustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have a delta pH (KCl pH minus 1:1 water pH) with a 0 or net positive charge in a layer 18 cm or more thick within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Aquic Acrustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Acrustox are considered intergrades between Acrustox and Acraquox. They are not known to occur in the United States.

Aquic Lithic Acrustox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Acrustox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Eutric Acrustox.—These soils have a base saturation (by NH_4OAc) of 35 percent or more in all horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States

Humic Acrustox.—These soils are like Typic Acrustox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Acrustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Acrustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Acrustox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Acrustox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthic Acrustox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Acrustox.—These soils are like Typic Acrustox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Acrustox.—These soils are like Typic Acrustox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Eutrustox

These are the Ustox with high base saturation throughout the profile. They do not have a sombric horizon within 150 cm of the mineral soil surface. They have, in all subhorizons of an oxic or kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 cmol(+) per kg clay or more or a pH value (1N KCl) of less than 5.0. These soils are well known by local farmers because of their relatively high natural fertility. Commonly, they supported natural forests while the surrounding areas of like rainfall but low base status supported savannas. Currently, forest vegetation is rare because the forests have been completely cut by native farmers. Why these Ustox have high saturation throughout their profile is not known, but they tend to occur over or near basic rocks, such as limestone and basalt.

Definition

Eutrustox are the Ustox that:

1. Have more than 35 percent base saturation (by NH_4OAc) in all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic or kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

ECCA. Eutrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Eutrustox

ECCB. Other Eutrustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Eutrustox

ECCC. Other Eutrustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Eutrustox

ECCD. Other Eutrustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Eutrustox

ECCE. Other Eutrustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Eutrustox

ECCF. Other Eutrustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Eutrustox

ECCG. Other Eutrustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Eutrustox

ECCH. Other Eutrustox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Kandiustalfic Eutrustox

ECCI. Other Eutrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. An oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Humic Inceptic Eutrustox

ECCJ. Other Eutrustox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Eutrustox

ECCK. Other Eutrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Eutrustox

ECCL. Other Eutrustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Eutrustox

ECCM. Other Eutrustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Eutrustox

ECCN. Other Eutrustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Eutrustox

ECCO. Other Eutrustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Eutrustox

ECCP. Other Eutrustox.

Typic Eutrustox

Definition of Typic Eutrustox

Typic Eutrustox are the Eutrustox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Do not have a kandic horizon with its upper boundary within 150 cm of the mineral soil surface;

5. Have an oxic horizon with a lower boundary 125 cm or more from the mineral soil surface;

6. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

   a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

   b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Eutrustox.—The central concept or Typic subgroup of Eutrustox is fixed on soils that have a thick oxic horizon. These soils do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. The soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are not known to occur in the United States.

Aquic Eutrustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Eutrustox are considered intergrades between Eutrustox and Eutraquox. They are not known to occur in the United States.

Aquic Lithic Eutrustox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Eutrustox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Eutrustox.—These soils are like Typic Eutrustox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Inceptic Eutrustox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Rhodic Eutrustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Eutrustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Inceptic Eutrustox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They are of very small extent, mostly in Hawaii and Guam.

Kandiustalfic Eutrustox.—These soils have a kandic horizon that has its upper boundary within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Eutrustox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are of small extent, mostly in Puerto Rico and Hawaii.

Petroferric Eutrustox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Eutrustox.—These soils have, within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. These soils are not known to occur in the United States.

Plinthic Eutrustox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Eutrustox.—These soils are like Typic Eutrustox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are of small extent, mostly in Hawaii.

Xanthic Eutrustox.—These soils are like Typic Eutrustox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Haplustox

These are the Ustox that do not have a sombric horizon within 150 cm of the mineral soil surface but that have, in all subhorizons of an oxic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface and do not have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface. The subsoil has granular structure, and the epipedons may be either dark or light colored. Haplustox are dark red to yellow and all intervening colors in the subsoil. They occur in vast areas in central South America and Africa.

Definition

Haplustox are the Ustox that:

1. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

2. Do not have a sombric horizon within 150 cm of the mineral soil surface;

3. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of an oxic horizon within 150 cm of the mineral soil surface; *and*

4. Do not have the upper boundary of an oxic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

ECEA. Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Haplustox

ECEB. Other Haplustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Haplustox

ECEC. Other Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Haplustox

ECED. Other Haplustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Haplustox

ECEE. Other Haplustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Haplustox

ECEF. Other Haplustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Haplustox

ECEG. Other Haplustox that have, within 125 cm of the mineral soil surface, *both*:

1. The lower boundary of the oxic horizon; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aqueptic Haplustox

ECEH. Other Haplustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustox

ECEI. Other Haplustox that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplustox

ECEJ. Other Haplustox that have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface.

Inceptic Haplustox

ECEK. Other Haplustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less.

Humic Rhodic Haplustox

ECEL. Other Haplustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Haplustox

ECEM. Other Haplustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Haplustox

ECEN. Other Haplustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Haplustox

ECEO. Other Haplustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Haplustox

ECEP. Other Haplustox.

Typic Haplustox

Definition of Typic Haplustox

Typic Haplustox are the Haplustox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

5. Have an oxic horizon with a lower boundary 125 cm or more from the mineral soil surface;

6. Do not have mottles with a color value, moist, of 4 or more and chroma of 2 or less within 25 cm of the mineral soil surface; *and*

7. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Haplustox.—The central concept or Typic subgroup of Haplustox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and 125 cm. These soils are not known to occur in the United States.

Aqueptic Haplustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. Aqueptic Haplustox are considered intergrades between Haplustox and Aquepts. They are not known to occur in the United States.

Aquic Haplustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Haplustox are considered intergrades between Haplustox and Haplaquox. They are not known to occur in the United States.

Aquic Lithic Haplustox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Haplustox.—These soils have, within

125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Haplustox.—These soils are like Typic Haplustox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Haplustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Haplustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Inceptic Haplustox.—These soils have an oxic horizon that has its lower boundary within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Haplustox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Oxyaquic Haplustox.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. They are not known to occur in the United States.

Petroferric Haplustox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Haplustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Haplustox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Haplustox.—These soils are like Typic Haplustox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are of very small extent, mostly in Puerto Rico.

Xanthic Haplustox.—These soils are like Typic Haplustox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Kandiustox

These are the clayey Ustox that have a kandic horizon that has its upper boundary within 150 cm of the mineral soil surface. They do not have a sombric horizon within 150 cm of the mineral soil surface, but they have, in all subhorizons of a kandic horizon within 150 cm of the mineral soil surface, an apparent ECEC of 1.50 or more cmol(+) per kg clay or a pH value (1N KCl) of less than 5.0. They also have a base saturation (by NH_4OAc) of less than 35 percent in some horizon within 125 cm of the mineral soil surface. The subsoil has a moderate grade of blocky structure in most pedons. The epipedons are either dark or light colored. The subsoil shows evidence of translocated clay only in a few areas. In some pedons it tends to have a weak or moderate grade of blocky structure. In most of the soils, however, there is a strong secondary structure that is fine granular.

Definition

Kandiustox are the Ustox that:

1. Have the upper boundary of a kandic horizon within 150 cm of the mineral soil surface;

2. Have 35 percent or less base saturation (by NH_4OAc) in some or all parts within 125 cm of the mineral soil surface;

3. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

4. Do not have an apparent ECEC of less than 1.50 cmol(+) per kg clay and a pH value (1N KCl) of 5.0 or more in some part of a kandic horizon within 150 cm of the mineral soil surface.

Key to Subgroups

ECDA. Kandiustox that have, within 125 cm of the mineral soil surface, *both*:

1. A petroferric contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Petroferric Kandiustox

ECDB. Other Kandiustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Kandiustox

ECDC. Other Kandiustox that have, within 125 cm of the mineral soil surface, *both*:

1. A lithic contact; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Lithic Kandiustox

ECDD. Other Kandiustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Kandiustox

ECDE. Other Kandiustox that have, in one or more horizons within 125 cm of the mineral soil surface, *both*:

1. 5 percent or more (by volume) plinthite; *and*

2. Redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiustox

ECDF. Other Kandiustox that have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface.

Plinthic Kandiustox

ECDG. Other Kandiustox that have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustox

ECDH. Other Kandiustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. In all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less.

Humic Rhodic Kandiustox

ECDI. Other Kandiustox that have *both*:

1. 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm; *and*

2. 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Humic Xanthic Kandiustox

ECDJ. Other Kandiustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Kandiustox

ECDK. Other Kandiustox that have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have *both* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less.

Rhodic Kandiustox

ECDL. Other Kandiustox that have 50 percent or more hue of 7.5YR or yellower and a color value, moist, of 6 or more at a depth between 25 and 125 cm from the mineral soil surface.

Xanthic Kandiustox

ECDM. Other Kandiustox.

Typic Kandiustox

Definition of Typic Kandiustox

Typic Kandiustox are the Kandiustox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface;

2. Do not have, within 125 cm of the mineral soil surface, a horizon that has more than 5 percent plinthite (by volume);

3. Do not have, in any horizon within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions;

4. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter; *and*

5. Have, in some horizon at a depth between 25 and 125 cm from the mineral soil surface, 50 percent or less colors that have *both* of the following:

   a. Hue of 2.5YR or redder and a color value, moist, of 3 or less; *and*

   b. Hue of 7.5YR or yellower and a color value, moist, of 6 or more.

Description of Subgroups

Typic Kandiustox.—The central concept or Typic subgroup of Kandiustox is fixed on soils that do not have a petroferric contact, a lithic contact, or redox depletions with a color value, moist, of 4 or more and chroma of 2 or less within 125 cm of the mineral soil surface and also do not have aquic conditions for some time in normal years. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm and have less than 5 percent plinthite in all horizons within a depth of 125 cm. Their colors are reddish, but the soils do not have very dark reddish colors throughout the layers between depths of 25 and

125 cm. These soils are not known to occur in the United States.

Aquic Kandiustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). Aquic Kandiustox are considered intergrades between Kandiustox and Aquox. They are not known to occur in the United States.

Aquic Lithic Kandiustox.—These soils have, within 125 cm of the mineral soil surface, both a lithic contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Aquic Petroferric Kandiustox.—These soils have, within 125 cm of the mineral soil surface, both a petroferric contact and redox depletions with a color value, moist, of 4 or more and chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Humic Kandiustox.—These soils are like Typic Kandiustox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Humic Rhodic Kandiustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Humic Xanthic Kandiustox.—These soils have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 7.5YR or yellower and value, moist, of 6 or more. They also have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. These soils are not known to occur in the United States.

Lithic Kandiustox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Kandiustox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Plinthaquic Kandiustox.—These soils have, in one or more horizons within 125 cm of the mineral soil surface, 5 percent or more (by volume) plinthite, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, and aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States.

Plinthic Kandiustox.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 125 cm of the mineral soil surface. The soils are not known to occur in the United States.

Rhodic Kandiustox.—These soils are like Typic Kandiustox, but they have, in all horizons at a depth between 25 and 125 cm from the mineral soil surface, more than 50 percent colors that have hue of 2.5YR or redder and a value, moist, of 3 or less. The soils are not known to occur in the United States.

Xanthic Kandiustox.—These soils are like Typic Kandiustox, but they have hue of 7.5YR or yellower and a color value, moist, of 6 or more in all horizons at a depth between 25 and 125 cm from the mineral soil surface. The soils are not known to occur in the United States.

Sombriustox

These are the Ustox that have a sombric horizon. They are poorly understood. They have an increase in content of organic carbon in the subsoil. Commonly, this layer has andic soil properties or some properties of spodic materials. The only known pedons are near the Rift Valley in Africa.

Definition

Sombriustox are the Ustox that have a sombric horizon within 150 cm of the mineral soil surface.

Key to Subgroups

ECAA. Sombriustox that have a petroferric contact within 125 cm of the mineral soil surface.

Petroferric Sombriustox

ECAB. Other Sombriustox that have a lithic contact within 125 cm of the mineral soil surface.

Lithic Sombriustox

ECAC. Other Sombriustox that have 16 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humic Sombriustox

ECAD. Other Sombriustox.

Typic Sombriustox

Definition of Typic Sombriustox

Typic Sombriustox are the Sombriustox that:

1. Have neither a petroferric nor a lithic contact within 125 cm of the mineral soil surface; *and*

2. Have less than 16 kg of organic carbon per m^2 to a depth of 1 m, exclusive of surface litter.

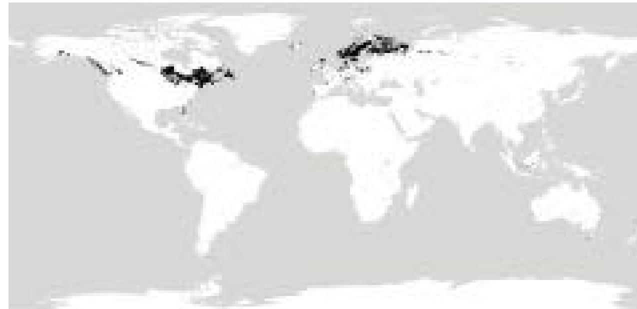
Description of Subgroups

Typic Sombriustox.—The central concept or Typic subgroup of Sombriustox is fixed on soils that do not have a petroferric or lithic contact within 125 cm of the mineral soil surface. These soils have less than 16 kg/m^2 organic carbon to a depth of 100 cm. They are not known to occur in the United States.

Humic Sombriustox.—These soils are like Typic Sombriustox, but they have 16 kg or more organic carbon per m^2 within 100 cm of the mineral soil surface. They are not known to occur in the United States.

Lithic Sombriustox.—These soils have a lithic contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.

Petroferric Sombriustox.—These soils have a petroferric contact within 125 cm of the mineral soil surface. They are not known to occur in the United States.



CHAPTER 18
Spodosols[1]

The feature that is common to most Spodosols is the presence of a spodic horizon, in which amorphous mixtures of organic matter and aluminum, with or without iron, have accumulated. The spodic horizon may be destroyed by cultivation, yet spodic materials may still be present. In undisturbed soils there commonly is an overlying eluvial horizon, generally with a gray or light gray color similar to that of uncoated quartz. In some Spodosols this horizon is too thin to be preserved after cultivation, while in others it is very thick. Below the spodic horizon, there may be a fragipan or another sequum that has an argillic horizon. A few Spodosols have a placic horizon either on or within a spodic horizon or on a fragipan. Some Spodosols have layers thicker than a placic horizon that are cemented by spodic materials and organic matter (ortstein).

Most Spodosols have few clay-sized phyllosilicates. The particle-size class is mostly sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty. In a few of the soils, it is fine-loamy.

Spodosols are most extensive in areas of cool, humid or perhumid climates. They also formed, however, in hot, humid tropical regions and in warm, humid regions, where they occur mostly in areas of quartz-rich sands that have a fluctuating level of ground water. In many of the latter soils, the silt and sand fractions contain very few weatherable minerals and the albic horizons tend to be thick. Soils with an albic horizon 200 cm or more thick, however, are excluded from Spodosols and are grouped with Entisols. Some of the very deep spodic horizons may be buried, but it seems likely that others have formed at great depths because the overlying soil materials have very little iron and aluminum that could precipitate the organic carbon. In some areas the source of aluminum may be the ground water. Exclusion of a soil from Spodosols if the albic horizon is very thick is largely pragmatic. The chemical and physical properties of many Spodosols and Andisols are very similar. The definition of spodic materials, however, is based on the concept of organic matter and aluminum, with or without iron, accumulating by illuviation.

The Spodosols in the United States occur mainly in areas of late-Pleistocene or Holocene deposits. They are common in Alaska, in the higher mountains of the West, in the Great Lakes States, in the Northeast, and along the Atlantic coast of both the United States and Canada. They also occur in Northern Europe and northwestern Asia as well as New Zealand and southern Australia. Most are covered with coniferous or, less commonly, hardwood forests if they are not cultivated or grazed. In tropical areas the vegetation may be rain forest, palms, or a savanna that probably is anthropic.

The moisture regime of Spodosols is mostly udic, but a few of the soils have a xeric regime. Some have aquic conditions. Spodosols may have any soil temperature regime.

Spodosols are naturally infertile, but they can be highly responsive to good management. Under cultivation, the spodic horizon may be biologically destroyed, particularly if lime and nitrogen are applied.

Definition of Sposols and Limits Between Spodosols and Soils of Other Orders

Spodosols are mineral soils that do not have a plaggen epipedon or an argillic or kandic horizon above a spodic horizon and have *one or more* of the following:

1. A spodic horizon, an albic horizon in 50 percent or more of each pedon, and a cryic soil temperature regime; *or*

2. An Ap horizon containing 85 percent or more spodic materials; *or*

3. A spodic horizon that has *all* of the following properties:

a. *One or more* of the following:

(1) A thickness of 10 cm or more; *or*

(2) An overlying Ap horizon; *or*

(3) Cementation in 50 percent or more of each pedon; *or*

(4) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid temperature regime; *or*

(5) A cryic temperature regime; *and*

b. An upper boundary within the following depths from the mineral soil surface: *either*

(1) Less than 50 cm; *or*

(2) Less than 200 cm if the soil has a sandy or sandy-

[1] This chapter was rewritten in 1992 following recommendations of the International Committee on the Classification of Spodosols (ICOMOD), chaired initially by F. Ted Miller, then by Robert V. Rourke (since 1986).

skeletal particle-size class between the mineral soil surface and the spodic horizon; *and*

c. A lower boundary as follows:

(1) Either at a depth of 25 cm or more below the mineral soil surface, at the top of a duripan or fragipan, or at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(2) At any depth,

(a) If the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime; *or*

(b) If the soil has a cryic temperature regime; *and*

d. *Either*:

(1) A directly overlying albic horizon in 50 percent or more of each pedon; *or*

(2) No andic soil properties in 60 percent or more of the thickness *either*:

(a) Within 60 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower, if there is no densic, lithic, or paralithic contact, duripan, or petrocalcic horizon within that depth; *or*

(b) Between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon.

Limits Between Spodosols and the Other Soil Orders

The definition of Spodosols must provide criteria that separate Spodosols from all other soil orders. These criteria define the limits of Spodosols in relation to all other known kinds of soil.

1. Unlike Alfisols and Ultisols, Spodosols do not have an argillic or kandic horizon above a spodic horizon.

2. Unlike Andisols, Aridisols, Entisols, Inceptisols, Oxisols, Mollisols, and Vertisols, Spodosols have a spodic horizon or an Ap horizon with 85 percent or more spodic materials.

4. Unlike Gelisols, Spodosols do not have permafrost within 100 cm of the soil surface or both permafrost within 200 cm of the soil surface and gelic materials within 100 cm of the soil surface.

5. Unlike Histosols, Spodosols must meet the definition of mineral soils.

Representative Pedon and Data

Following is a description of a representative Spodosol. Data for the pedon identified in this description are given in the table "Characterization Data for a Spodosol."

Classification: Coarse-loamy, isotic Typic Haplocryod
Site identification number: 95P0037
Location: Kuopio County, Finland; about 20 m east-southeast of a gravel road; close to the village of Haapapuro
Finnish coordinates: X—6974.300 & Y—3522.920
Quadrangle name: Finnish Quad 4 Kainuu, Yleiskartta Generalkarta
Latitude: 62 degrees 52 minutes 17 seconds N.
Longitude: 27 degrees 27 minutes 1 seconds E.
Slope: 7 percent
Aspect: 100 degrees
Horizontal shape: Plane
Vertical shape: Plane
Microrelief: Kind—mound; elevation—40 cm; pattern—reticulate (net)
Elevation: 120 m
Landscape: Plateaus
Landform: Till plain
Parent material: Basal till
Annual precipitation: 510 mm
Average annual air temperature: 3 °C
Average annual soil temperature: 5 °C
Weather station name: Kuopio, Finland
Boulders and stones: Covering 2 percent of the surface
Natural drainage class: Well drained
Permeability class: Moderate
Land use: Mixed coniferous and hardwood forest (not grazed)
Plant association: Taiga forest
Soil moisture regime: Udic
Soil temperature regime: Cryic
Particle-size control section: 33 to 108 cm
Diagnostic horizons: An albic horizon from a depth of 8 to 25 cm and a spodic horizon at a depth of 25 to 48 cm
Described by: D.L. Newton, S.E. Lee, Dr. M. Raisanen, and H.R. Mount

In the following pedon description, colors are for moist soil unless otherwise indicated.

Oi—0 to 3 cm; dark reddish brown (5YR 3/2) fibric material; weak very fine granular structure; very friable, nonsticky and nonplastic; many fine and medium roots throughout; many fine to coarse interstitial pores; 80 percent fiber unrubbed, 75 percent rubbed; 5 percent subangular gravel; extremely acid; abrupt smooth boundary.

Oe—3 to 8 cm; black (5YR 2/1) extremely cobbly hemic material; weak very fine granular structure; very friable, nonsticky and nonplastic; many fine and medium roots throughout; many fine and medium interstitial pores; 60 percent fiber unrubbed, 20 percent rubbed; 10 percent subangular gravel,

Characterization Data for a Spodosol

SITE IDENTIFICATION NO.: 95P0037
CLASSIFICATION: COARSE-LOAMY, ISOTIC TYPIC HAPLOCRYOD
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	-1- DEPTH (cm)	-2- HORIZON	-3-	-4- TOTAL CLAY LT .002	-5- TOTAL SILT .002 -.05	-6- TOTAL SAND .05 -2	-7- CLAY FINE LT .0002	-8- CLAY CO_3 LT .002	-9- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS (mm) WEIGHT 2 -5	-17- WEIGHT 5 -20	-18- WEIGHT 20 -75	-19- WEIGHT .1- 75	-20- (>2mm) WT PCT OF WHOLE SOIL
				<- Pct of <2mm (3A1) ->												<- Pct of <75mm(3B1)->				
95P 312	0- 3	Oi														--	--	--		--
95P 313	3- 8	Oe														--	--	--		81
95P 314	8- 25	E		1.8	19.9	78.3			10.3	9.6	12.7	25.1	23.0	13.1	4.4	4	8	2	70	83
95P 315	25- 48	Bs		3.3	24.5	72.2			14.2	10.3	12.8	20.6	17.1	13.5	8.2	9	16	4	71	45
95P 316	48- 64	BC		1.9	34.7	63.4			21.6	13.1	11.5	18.1	16.6	11.4	5.8	8	14	5	65	27
95P 317	64-100	C		1.9	32.6	65.5			20.4	12.2	12.7	20.5	15.6	10.3	6.4	6	15	1	63	22

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B4a <2mm	EXTR P 6S3b ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	(BULK DENSITY) FIELD MOIST 4A5	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	(WATER CONTENT) FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 3	52.5	1.679																	82.8	
3- 8	50.9	1.279																	83.3	
8- 25	0.76	0.073			0.1	TR	--	2.56	1.33										2.4	
25- 48	2.32	0.204			1.6	0.9	--	4.39	4.48										8.6	
48- 64	0.33	0.031			0.5	0.2	--	1.58	2.53										2.5	
64-100	0.12	0.015			0.3	0.1	--	0.95	1.21										1.3	

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9d	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8c	BASES + Al 5A3b	Al SAT 5G1	(BASE SAT) SUM 5C3	NH_4 OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1		COND. mmhos /cm 8I	(PH) NaF 8C1d	$CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- -meq / 100 g ->										<- - - - -Pct - - - ->									
0- 3	25.4	7.7	0.3	5.2	38.6	73.7		112.3	84.4			34	46					6.1	3.8	4.3
3- 8	5.9	4.7	0.3	2.5	13.4	99.3		112.7	101.2			12	13					6.0	2.7	3.3
8- 25	0.2	0.2	0.1	0.1	0.6	3.8	1.5	4.4	4.6	2.1	71	14	13					7.1	3.4	3.9
25- 48	0.5	0.2	0.1	0.1	0.9	20.9	1.6	21.8	14.5	2.5	64	4	6					10.9	4.4	4.5
48- 64	0.1	0.1	TR	--	0.2	4.0	0.1	4.2	3.0	0.3	33	5	7					10.3	5.0	4.9
64-100	0.1	0.1	TR	TR	0.2	2.0	TR	2.2	1.8			9	11					9.9	4.9	5.3

SAMPLE NO.	HZ NO	ACID OXALATE EXTRACTION OPT DEN 8J	Fe 6C9a	Si 6V2b	Al 6G12b	PHOSPHORUS RET 6S4b	CIT-ACID 6S5	KCl Mn 6D3b	TOTAL C 6A2e	(WATER CONTENT) 0.06 BAR 4B1c	1-BAR 4B1a	2-BAR 4B1a	15 BAR 4B2b	(WATER DISPERSIBLE) PIPETTE CLAY 3A1c	SILT	SAND	HYDROMETER CLAY SML	SILT	SAND	MIN SOIL CONT 8F1	AGGRT STABL <5mm 4G1
			<- P c t o f < 2 m m ->			<- p p m ->		<- Percent of < 2 m m ->													Pct
95P 312	1								47.75				152.8							13	
95P 313	2	0.06	0.13	0.02	0.11				45.15				84.6							13	
95P 314	3	0.05	0.11	0.01	0.04			TR	1.40			4.3	2.4								
95P 315	4	0.34	0.93	0.42	1.51			TR	3.77			13.9	14.8								
95P 316	5	0.03	0.29	0.18	0.53			--	0.43			5.7	4.8								
95P 317	6	0.02	0.17	0.07	0.21			--	0.16			4.1	2.3								

SAND - SILT MINERALOGY (2.0-0.002mm)

SAMPLE NUMBER	FRAC-TION	X-RAY 7A2i (Peak Size)	THERMAL DTA 7A3c (Percent)	THERMAL TGA 7A4c (Percent)	OPTICAL TOT RE (Percent)	OPTICAL GRAIN COUNT 7B1a (Percent)						INTER-PRETA-TION
95P 314	FS				46	QZ45	FP23	FK18	BT 4	HN 4	PR 3	
95P 314	FS					MS 3	GN 1	OPtr	TMtr	CAtr		
95P 315	FS				56	QZ51	BT17	FK12	PR 7	FP 5	FE 3	
95P 315	FS					HN 2	GN 1	MS 1	OP 1	RAtr	MZtr	
95P 315	FS					TMtr						
95P 316	FS				54	QZ49	FK24	BT12	FP 6	PR 4	CD 3	
95P 316	FS					HN 1	OP 1	FE 1	MStr	TMtr	GNtr	
95P 317	FS				62	QZ57	FK23	BT 8	PR 4	FP 3	HN 2	
95P 317	FS					CD 2	TM 1	OP 1	GN 1	MStr		

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: FS, fine sand, 0.1-0.25 mm.
Mineral interpretation: QZ, quartz; FP, plagioclase feldspar; FK, potassium feldspar; BT, biotite; HN, hornblende; PR, pyroxene; MS, muscovite; GN, garnet; OP, opaques; TM, tourmaline; CA, calcite; FE, iron oxides; RA, resistant aggregate; MZ, monazite; CD, chalcedony.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.

60 percent subangular cobbles, and 10 percent subangular stones; extremely acid; abrupt smooth boundary.

E—8 to 25 cm; gray (10YR 5/1) extremely cobbly loamy sand, light gray (10YR 7/1) dry; weak fine granular structure; very friable, nonsticky and nonplastic; common fine and medium roots throughout; many fine to coarse interstitial pores; estimated bulk density of 1.5 g cm^{-3}; 10 percent subangular gravel, 60 percent subangular cobbles, and 10 percent subangular stones; very strongly acid; abrupt smooth boundary.

Bs—25 to 48 cm; dark brown (7.5YR 3/4) very cobbly fine sandy loam; weak fine granular structure; very friable, moderately smeary, nonsticky and nonplastic; common fine and medium roots throughout; many fine interstitial pores; estimated bulk density of 1.2 g cm^{-3}; 20 percent subangular gravel and 15 percent subangular cobbles; strongly acid; gradual smooth boundary.

BC—48 to 64 cm; light olive brown (2.5Y 5/4) gravelly fine sandy loam; weak fine granular structure; very friable, nonsticky and nonplastic; few fine roots throughout; many fine interstitial pores; estimated bulk density of 1.5 g cm^{-3}; 15 percent subangular gravel; moderately acid; gradual smooth boundary.

C—64 to 100 cm; 60 percent olive (5Y 5/3) and 40 percent olive gray (5Y 5/2) gravelly sandy loam; friable, nonsticky and nonplastic; few very fine interstitial pores; estimated bulk density of 1.5 g cm^{-3}; 15 percent subangular gravel; slightly acid.

Key to Suborders

CA. Spodosols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or both* of the following:

1. A histic epipedon; *or*

2. Within 50 cm of the mineral soil surface, redoximorphic features in an albic or a spodic horizon.

Aquods, p. 698

CB. Other Spodosols that have a cryic soil temperature regime.

Cryods, p. 705

CC. Other Spodosols that have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon.

Humods, p. 709

CD. Other Spodosols.

Orthods, p. 712

Aquods

Aquods are the Spodosols of wet regions. They are characterized either by a shallow fluctuating water table or an extremely humid climate. If the soil temperature regime is mesic, isomesic, or warmer, most of the soils have a nearly white albic horizon thick enough to persist under cultivation or, in the wettest Aquods, a black surface horizon resting on a dark reddish brown spodic horizon that is virtually free of iron. Other Aquods have a placic horizon or a duripan or are cemented by an amorphous mixture of sesquioxides and organic matter.

The Aquods that do not have a placic horizon normally have a transitional horizon between the albic horizon and the spodic horizon, a feature virtually unique to these soils.

Aquods formed mainly in sandy materials of Pleistocene age. They may have any temperature regime. Water-loving plants of a very wide variety, ranging from sphagnum in cold areas to palms in the tropics, grow on these soils. In the United States, relatively few Aquods are cultivated, except in New Jersey and Florida.

Definition

Aquods are the Spodosols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and have *one or both* of the following:

1. A histic epipedon; *or*

2. Within 50 cm of the mineral soil surface, redoximorphic features in an albic or spodic horizon.

Key to Great Groups

CAA. Aquods that have a cryic soil temperature regime.

Cryaquods, p. 700

CAB. Other Aquods that have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon.

Alaquods, p. 699

CAC. Other Aquods that have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Fragiaquods, p. 704

CAD. Other Aquods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placaquods, p. 704

CAE. Other Aquods that have, in 90 percent or more of each pedon, a cemented soil layer that has its upper boundary within 100 cm of the mineral soil surface.

Duraquods, p. 701

CAF. Other Aquods that have episaturation.

Epiaquods, p. 703

CAG. Other Aquods.

Endoaquods, p. 702

Alaquods

These soils occur primarily in the southeastern part of the United States. Their water table generally fluctuates and in the process reduces iron and moves it out of the soils. The spodic horizon consists mostly of an accumulation of organic matter and aluminum and commonly has few or no redoximorphic features. The albic horizon in the drier Alaquods is normally thick. The wettest Alaquods have no albic horizon but generally have uncoated sand grains above the spodic horizon. Alaquods normally have a sandy particle-size class. Because of their high humus content, however, some of them feel and behave like loamy soils.

Definition

Alaquods are the Aquods that:

1. Have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon; *and*

2. Do not have a cryic soil temperature regime.

Key to Subgroups

CABA. Alaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Alaquods

CABB. Other Alaquods that have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Duric Alaquods

CABC. Other Alaquods that have a histic epipedon.

Histic Alaquods

CABD. Other Alaquods that have *both*:

1. Within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part; *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Alfic Arenic Alaquods

CABE. Other Alaquods that have *both*:

1. An argillic or kandic horizon within 200 cm of the mineral soil surface; *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Ultic Alaquods

CABF. Other Alaquods that have *both*:

1. An umbric epipedon; *and*

2. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm or more.

Arenic Umbric Alaquods

CABG. Other Alaquods that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Alaquods

CABH. Other Alaquods that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more.

Grossarenic Alaquods

CABI. Other Alaquods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Alfic Alaquods

CABJ. Other Alaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Alaquods

CABK. Other Alaquods that have an ochric epipedon.

Aeric Alaquods

CABL. Other Alaquods.

Typic Alaquods

Definition of Typic Alaquods

Typic Alaquods are the Alaquods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have, in 90 percent or more of each pedon, any cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface;

3. Do not have a histic or ochric epipedon;

4. Do not have an argillic or kandic horizon; *and*

5. Do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm or more.

Description of Subgroups

Typic Alaquods.—The Typic subgroup of Alaquods is centered on soils that have an umbric epipedon but do not have a lithic contact within 50 cm of the soil surface, an argillic or kandic horizon within 200 cm, a histic or ochric epipedon, a cemented layer, or a sandy or sandy-skeletal particle-size class from the soil surface to the top of a spodic horizon at a depth of 75 cm or more. Typic Alaquods commonly are saturated for shorter periods than the Histic subgroups and for longer periods than the Aeric subgroups. They occur in the southeastern part of the United States as well as along the Atlantic coast as far north as New Jersey. Typic Alaquods are used as woodland, as grazing land, or for cultivated crops, when water is controlled.

Aeric Alaquods.—These are the Alaquods that have an ochric epipedon. The presence of the ochric epipedon is indicative of Alaquods that are saturated for shorter periods than the Typic subgroup. These soils do not have a lithic contact within 50 cm of the soil surface, an argillic or kandic horizon within 200 cm, a histic epipedon, a cemented layer, or a sandy or sandy-skeletal particle-size class from the soil surface to the top of a spodic horizon at a depth of 75 cm or more. Commonly, the soils are forested. They occur along the Atlantic coast from Florida to Virginia.

Alfic Alaquods.—These are the Alaquods that have an argillic or kandic horizon with a base saturation of 35 percent or more in some part. These soils do not have a lithic contact within 50 cm of the soil surface, a histic epipedon, a cemented soil layer, or a sandy or sandy-skeletal particle-size class from the surface to the top of a spodic horizon at a depth of 75 cm or more. The soils are mostly in wooded areas in Florida. Some have been planted to pine or citrus trees.

Alfic Arenic Alaquods.—These are the Alaquods that have a thick sandy E horizon above the spodic horizon and an argillic or kandic horizon with a base saturation of at least 35 percent in at least some part. These soils most commonly occur in Florida and are used as grazing land or for citrus.

Arenic Alaquods.—These are the Alaquods that have a sandy E horizon 75 to 125 cm above the spodic horizon. These soils do not have an argillic or kandic horizon, a lithic contact within 50 cm of the soil surface, a cemented layer, or a histic epipedon. They occur in Florida and North Carolina and are used as woodland, as grazing land, or for citrus production.

Arenic Ultic Alaquods.—These are the Alaquods that have an argillic or kandic horizon and sandy E horizons 75 to 125 cm thick above the spodic horizon. These soils do not have a lithic contact within 50 cm of the soil surface, a cemented layer, or a histic epipedon. They occur in Florida and commonly have been planted to pine trees.

Arenic Umbric Alaquods.—These soils have an umbric epipedon and sandy E horizons at least 75 cm thick above the spodic horizon. These soils do not have a lithic contact within 50 cm of the soil surface, a cemented layer, a histic epipedon, or an argillic or kandic horizon. They occur in Florida.

Duric Alaquods.—These are the Alaquods that have a cemented soil layer but do not have a lithic contact within 50 cm of the soil surface. The cemented soil layer commonly is ortstein, but it could also be cemented by silica. These soils are rare in the United States.

Grossarenic Alaquods.—These are the Alaquods that have sandy E horizons 125 cm or more thick above the spodic horizon. These soils do not have an argillic or kandic horizon, a histic epipedon, a cemented layer, or a lithic contact within 50 cm of the soil surface. They occur in Florida and the Carolinas and commonly are used for pulp production.

Histic Alaquods.—These are the Alaquods that have a histic epipedon. Typically, these soils are saturated close to the surface. They do not have a lithic contact within 50 cm of the soil surface or a cemented layer. They occur in Florida and are used as woodland.

Lithic Alaquods.—These are the Alaquods that have a lithic contact within 50 cm of the soil surface. These soils are rare in the world.

Ultic Alaquods.—These are the Alaquods that have an argillic or kandic horizon that has less than 35 percent base saturation in all parts. These soils do not have a lithic contact within 50 cm of the soil surface, a cemented layer, a histic epipedon, or thick sandy E horizons above the spodic horizon. They occur in Florida, the Carolinas, and Georgia. Some of these soils have been planted to pine, and some are used as grazing land or for the production of truck crops.

Cryaquods

These Aquods occur in areas of cold climates, mainly at high latitudes. Because they are both cold and wet, Cryaquods have been given low priority for study. Most are covered with coniferous forest or tundra vegetation. Aquic conditions persist during much of the growing season. In the United States, these soils occur in Alaska.

Definition

Cryaquods are the Aquods that have a cryic soil temperature regime.

Key to Subgroups

CAAA. Cryaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Cryaquods

CAAB. Other Cryaquods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placic Cryaquods

CAAC. Other Cryaquods that have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Duric Cryaquods

CAAD. Other Cryaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Cryaquods

CAAE. Other Cryaquods that have a spodic horizon less than 10 cm thick in 50 percent or more of each pedon.

Entic Cryaquods

CAAF. Other Cryaquods.

Typic Cryaquods

Definition of Typic Cryaquods

Typic Cryaquods are the Cryaquods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface;

4. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface; *and*

5. Have a spodic horizon 10 cm or more thick in 50 percent or more of each pedon.

Description of Subgroups

Typic Cryaquods.—The Typic subgroup of Cryaquods is centered on soils that have a spodic horizon 10 cm or more thick. Typic Cryaquods do not have a lithic contact within 50 cm of the soil surface, a placic horizon, a cemented soil layer, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Andic Cryaquods.—These are the Cryaquods that have andic soil properties throughout horizons with a total thickness of 25 cm or more within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface, a placic horizon, or a cemented soil layer.

Duric Cryaquods.—These are the Cryaquods that have a cemented soil layer. The cemented layer commonly is ortstein, but in some soils the cementing agents are not well understood. These soils do not have a lithic contact within 50 cm of the soil surface or a placic horizon.

Entic Cryaquods.—These are the Cryaquods that have a spodic horizon that is less than 10 cm thick. These soils do not have a lithic contact within 50 cm of the soil surface, a placic horizon, a cemented layer, or andic soil properties in one-third or more of the upper 75 cm.

Lithic Cryaquods.—These are the Cryaquods that have a lithic contact within 50 cm of the mineral soil surface. These soils are relatively rare in the world. They commonly are forested.

Placic Cryaquods.—These are the Cryaquods that have a placic horizon. The placic horizon commonly is convoluted. These soils do not have a lithic contact within 50 cm of the soil surface.

Duraquods

These Aquods have a cemented soil layer that in many areas is a combination of iron and/or aluminum and organic matter. In some of these soils, silica also is a cementing agent. Duraquods are seasonally saturated above the cemented soil layer but not necessarily below it. In the United States, these soils occur mostly in the Northwest and in Michigan. They also are known to occur in New Zealand, under kauri pine. The cemented soil layer in Duraquods severely restricts plant rooting. Currently, few of these soils are recognized.

Definition

Duraquods are the Aquods that:

1. Have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface;

2. Have 0.10 percent or more iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

3. Do not have a cryic temperature regime;

4. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Key to Subgroups

CAEA. Duraquods that have a histic epipedon.

Histic Duraquods

CAEB. Other Duraquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Duraquods

CAEC. Other Duraquods.

Typic Duraquods

Definition of Typic Duraquods

Typic Duraquods are the Duraquods that:

1. Do not have a histic epipedon; *and*

2. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Duraquods.—The Typic subgroup of Duraquods is centered on soils that do not have a histic epipedon and do not have andic soil properties in one-third or more of the upper 75 cm. Typic Duraquods are the most common subgroup of Duraquods and occur on the west coast, in New England, and in Indiana and Michigan in the United States.

Andic Duraquods.—These soils have a cemented layer that commonly is ortstein but is not limited to ortstein. These soils do not have a histic epipedon. They occur in the State of Washington.

Histic Duraquods.—These soils have a histic epipedon. They are rare in the world.

Endoaquods

These Aquods do not have a perched water table. They have a considerable accumulation of iron in addition to aluminum and organic carbon in the spodic horizon. The spodic horizon has few to many redoximorphic features and commonly is brown to dark reddish brown. Most Endoaquods have an albic horizon. Some of the wettest do not have an albic horizon but normally have uncoated sand grains above the spodic horizon.

Definition

Endoaquods are the Aquods that:

1. Have endosaturation;

2. Have 0.10 percent or more iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

3. Do not have a cryic temperature regime;

4. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

5. Do not have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon; *and*

6. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CAGA. Endoaquods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Endoaquods

CAGB. Other Endoaquods that have a histic epipedon.

Histic Endoaquods

CAGC. Other Endoaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Endoaquods

CAGD. Other Endoaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Argic Endoaquods

CAGE. Other Endoaquods that have an umbric epipedon.

Umbric Endoaquods

CAGF. Other Endoaquods.

Typic Endoaquods

Definition of Typic Endoaquods

Typic Endoaquods are the Endoaquods that:

1. Do not have a histic or umbric epipedon;

2. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have an argillic or kandic horizon underlying the spodic horizon; *and*

4. Do not have a lithic contact within 50 cm of the mineral soil surface.

Description of Subgroups

Typic Endoaquods.—The Typic subgroup of Endoaquods is centered on soils that have an ochric epipedon. These soils do not have a lithic contact within 50 cm of the soil surface, an argillic or kandic horizon, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. The soils occur in both the western and northeastern parts of the United States and in Michigan, Wisconsin, and Indiana.

Andic Endoaquods.—These are the Endoaquods that have andic soil properties throughout horizons totaling 25 cm or more thick from the soil surface to a depth of 75 cm. These soils do not have a histic epipedon or a lithic contact within 50 cm of the soil surface.

Argic Endoaquods.—These are the Endoaquods that have an argillic or kandic horizon below the spodic horizon. These soils do not have a lithic contact within 50 cm of the soil surface, a histic epipedon, or andic soil properties in a layer 25 cm or more thick from the soil surface to a depth of 75 cm. The soils occur in Michigan and Wisconsin.

Histic Endoaquods.—These are the Endoaquods that have a histic epipedon. Commonly, these soils are saturated throughout most of the year. They do not have a lithic contact within 50 cm of the soil surface.

Lithic Endoaquods.—These are the Endoaquods that have a lithic contact within 50 cm of the soil surface. These soils are rare in the world.

Umbric Endoaquods.—These are the Endoaquods that have an umbric epipedon. These soils do not have a lithic contact within 50 cm of the soil surface, a histic epipedon, an argillic or kandic horizon, or andic soil properties in a layer 25 cm or more thick from the soil surface to a depth of 75 cm. The soils occur in North Carolina and Florida.

Epiaquods

These Aquods have a perched water table above one or more relatively impermeable layers. Epiaquods normally have a considerable accumulation of iron in addition to aluminum and organic matter. The relatively impermeable layers commonly are argillic horizons or dense till.

Definition

Epiaquods are the Aquods that:

1. Have episaturation;

2. Have 0.10 percent or more iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

3. Do not have a cryic temperature regime;

4. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

5. Do not have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon; *and*

6. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CAFA. Epiaquods that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Epiaquods

CAFB. Other Epiaquods that have a histic epipedon.
Histic Epiaquods

CAFC. Other Epiaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.
Andic Epiaquods

CAFD. Other Epiaquods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.
Alfic Epiaquods

CAFE. Other Epiaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.
Ultic Epiaquods

CAFF. Other Epiaquods that have an umbric epipedon.
Umbric Epiaquods

CAFG. Other Epiaquods.
Typic Epiaquods

Definition of Typic Epiaquods

Typic Epiaquods are the Epiaquods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a histic or umbric epipedon;

3. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

4. Do not have an argillic or kandic horizon underlying the spodic horizon.

Description of Subgroups

Typic Epiaquods.—The Typic subgroup of Epiaquods is centered on soils that have an ochric epipedon. These soils do not have an argillic or kandic horizon, a lithic contact within 50 cm of the soil surface, or andic soil properties in a layer 25 cm or more thick from the surface to a depth of 75 cm. These soils occur in the northeastern part of the United States and in Michigan and Wisconsin.

Alfic Epiaquods.—These soils have an argillic or kandic horizon that has a base saturation of 35 percent or more in at least some part. They do not have a lithic contact within 50 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils occur in Michigan, Minnesota, and Wisconsin.

Andic Epiaquods.—These soils have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. They do not have a lithic contact within 50 cm of the soil surface or a histic epipedon.

Histic Epiaquods.—These soils have a histic epipedon. They tend to be saturated during most of the growing season. They do not have a lithic contact within 50 cm of the soil surface. These soils occur in Michigan.

Lithic Epiaquods.—These soils have a lithic contact within 50 cm of the soil surface. They are rare in the world.

Ultic Epiaquods.—These soils have an argillic horizon that has a base saturation of less than 35 percent in all parts. They do not have a lithic contact within a depth of 50 cm, a histic epipedon, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils occur in Michigan, Minnesota, and Wisconsin.

Umbric Epiaquods.—These are the Epiaquods that have an umbric horizon. These soils do not have a lithic contact within 50 cm of the soil surface, a histic epipedon, an argillic or kandic horizon, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Fragiaquods

These are the Aquods that have a fragipan below the spodic horizon, normally at a depth of 40 to 75 cm below the mineral soil surface. Plant roots are shallow, and the soil clinging to the roots of falling trees has in many areas developed a microrelief of 20 to 50 cm. The soil temperature regime is normally frigid. These soils are nearly level, but few of them are cultivated, except for those used for the production of hay. Most of the soils are forested. Fragiaquods are not extensive in the United States.

Definition

Fragiaquods are the Aquods that:

1. Have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

2. Have 0.10 percent or more iron (by ammonium oxalate) in 75 percent or more of the spodic horizon; *and*

3. Do not have a cryic temperature regime.

Key to Subgroups

CACA. Fragiaquods that have a histic epipedon.
Histic Fragiaquods

CACB. Other Fragiaquods that have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness.
Plagganthreptic Fragiaquods

CACC. Other Fragiaquods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.
Argic Fragiaquods

CACD. Other Fragiaquods.
Typic Fragiaquods

Definition of Typic Fragiaquods

Typic Fragiaquods are the Fragiaquods that:

1. Do not have a histic epipedon;

2. Do not have a surface horizon more than 30 cm thick that meets all of the requirements for a plaggen epipedon except thickness; *and*

3. Do not have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in any part.

Description of Subgroups

Typic Fragiaquods.—The Typic subgroup of Fragiaquods is centered on soils that do not have a histic epipedon, an argillic or kandic horizon, or a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness. These soils generally support forest vegetation, but some have been cleared and are used as pasture. Typic Fragiaquods occur in Michigan, New York, and Vermont.

Argic Fragiaquods.—These soils have an argillic or kandic horizon. Commonly, the argillic or kandic horizon is within the fragipan. These soils do not have a histic epipedon or a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness. They are known to occur in Michigan.

Histic Fragiaquods.—These soils have a histic epipedon. Commonly, they are saturated throughout most of the growing season. They are rare in the world.

Plagganthreptic Fragiaquods.—These are the Fragiaquods that have a surface horizon 30 cm or more thick that has all of the properties of a plaggen epipedon except thickness. These soils are rare in the world, but they do occur in Europe.

Placaquods

These are the Aquods that have an involute placic horizon. The horizons above the placic horizon have low-contrast mottles that are probably caused by organic matter. Placaquods are known to occur only in areas of perhumid oceanic climates. Many have, or used to have, sphagnum and heath vegetation.

Definition

Placaquods are the Aquods that:

1. Have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon;

2. Have 0.10 percent or more iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

3. Do not have a cryic temperature regime; *and*

4. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CADA. Placaquods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Placaquods

CADB. Other Placaquods.

Typic Placaquods

Definition of Typic Placaquods

Typic Placaquods are the Placaquods that do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Placaquods.—The Typic subgroup of Placaquods is centered on soils that do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils occur in Great Britain and in Western Europe.

Andic Placaquods.—These are the Placaquods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the surface. These soils are rare in the world.

Cryods

Cryods are the Spodosols of high latitudes and/or high elevations. In the United States, they occur mostly in southeast Alaska and in the mountains of Washington and Oregon. Some of these soils are in the mountains of New York and northern New England. Many Cryods formed in volcanic ash or glacial drift, and some formed in residuum or colluvium on mountain slopes. Cryods commonly have an O horizon over a very thin or intermittent albic horizon, which overlies a well-developed spodic horizon. Some of the soils have a placic horizon, ortstein, or another cemented soil layer within 100 cm of the mineral soil surface. In many Cryods the content of organic carbon in the upper part of the spodic horizon is relatively high. The vegetation is mostly a coniferous forest or alpine tundra.

Definition

Cryods are the Spodosols that:

1. Have a cryic temperature regime; *and*

2. Do not have both aquic conditions within 50 cm of the mineral soil surface and *either* of the following:

a. A histic epipedon; *or*

b. Within 50 cm of the mineral soil surface, redoximorphic features in an albic or spodic horizon.

Key to Great Groups

CBA. Cryods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placocryods, p. 709

CBB. Other Cryods that have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Duricryods, p. 705

CBC. Other Cryods that have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon.

Humicryods, p. 708

CBD. Other Cryods.

Haplocryods, p. 706

Duricryods

These are the Cryods that have, either within or below the spodic horizon, a cemented horizon that is considered ortstein if it is more than 2.5 cm thick and part of the spodic horizon. In the United States, these soils are known to occur in the State of Washington. They probably also occur in other cold regions of the world.

Definition

Duricryods are the Cryods that:

1. Have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Key to Subgroups

CBBA. Duricryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic

conditions for some time in normal years (or artificial drainage); *and*

2. Andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Duricryods

CBBB. Other Duricryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Duricryods

CBBC. Other Duricryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Duricryods

CBBD. Other Duricryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Duricryods

CBBE. Other Duricryods that have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon.

Humic Duricryods

CBBF. Other Duricryods.

Typic Duricryods

Definition of Typic Duricryods

Typic Duricryods are the Duricryods that:

1. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

2. Do not have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon;

3. Do not have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years; *and*

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for either or both 20 or more consecutive days or 30 or more cumulative days.

Description of Subgroups

Typic Duricryods.—The Typic subgroup of Duricryods is centered on soils that are not saturated with water within 100 cm of the soil surface and soils that do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils also do not have thick Bh or Bhs horizons. They are wooded and occur in Alaska.

Andic Duricryods.—These are the Duricryods that are intergrades to the Andisols. They have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. They do not have aquic conditions and redox features within 75 cm of the soil surface. They are wooded and occur in the State of Washington.

Aquandic Duricryods.—These are the Duricryods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface and have aquic conditions accompanied by redoximorphic features within 75 cm of the soil surface. These soils are rare in the world.

Aquic Duricryods.—These are the Duricryods that have aquic conditions accompanied by redoximorphic features within 75 cm of the soil surface. These soils do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. They are rare in the world.

Humic Duricryods.—These are the Duricryods that have a thick Bh or Bhs horizon. These soils are not saturated within 100 cm of the soil surface and do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Oxyaquic Duricryods.—These are the Duricryods that are saturated within 100 cm of the soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. Commonly, these soils are saturated by snowmelt during the spring. They do not have either redoximorphic features within 75 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Haplocryods

These are the Cryods of high latitudes or high elevations that do not have a fragipan, a placic horizon, or other cemented soil layers and do not have a very high content of organic matter in the spodic horizon. The horizons are mostly thin but may be strongly contrasting. The base of the spodic horizon is generally less than 50 cm below the mineral soil surface. Some Haplocryods have permafrost at varying depths below the spodic horizon. Others have, below the spodic horizon, another sequum with an argillic or kandic horizon. In the United States, these soils occur mostly in Alaska and in the higher mountains of the West and Northeast.

Definition

Haplocryods are the Cryods that:

1. Do not have 6.0 percent or more organic carbon

throughout a layer 10 cm or more thick within the spodic horizon;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface; *and*

3. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CBDA. Haplocryods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplocryods

CBDB. Other Haplocryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Haplocryods

CBDC. Other Haplocryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplocryods

CBDD. Other Haplocryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplocryods

CBDE. Other Haplocryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplocryods

CBDF. Other Haplocryods that have 1.1 percent or less organic carbon in the upper 10 cm of the spodic horizon.

Entic Haplocryods

CBDG. Other Haplocryods.

Typic Haplocryods

Definition of Typic Haplocryods

Typic Haplocryods are the Haplocryods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

3. Do not have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years;

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years; *and*

5. Have 1.2 percent or more organic carbon in the upper 10 cm of the spodic horizon.

Description of Subgroups

Typic Haplocryods.—The Typic subgroup of Haplocryods is centered on soils that have more than 1.1 percent organic carbon in the upper 10 cm of the spodic horizon. These soils do not have a lithic contact within 50 cm of the soil surface, andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface, or a saturated layer within 100 cm of the soil surface. They commonly are forested, and some are used for timber production. A few have been cleared and are used for hay. Typic Haplocryods occur in Oregon and Alaska.

Andic Haplocryods.—These are the Haplocryods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface and do not have aquic conditions and redoximorphic features within 75 cm of the soil surface. They occur in Washington and Alaska, where they are used for timber production and wildlife habitat. A few areas have been cleared for crop production.

Aquandic Haplocryods.—These are the Haplocryods that have both andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface and aquic conditions and redoximorphic features within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface. They are rare in the world.

Aquic Haplocryods.—These are the Haplocryods that have aquic conditions and redoximorphic features within 75 cm of the soil surface. These soils do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface or a lithic contact within 50 cm of the soil surface. The soils support forest vegetation and occur in New Hampshire, Maine, and New York.

Entic Haplocryods.—These are the Haplocryods that have 1.1 percent or less organic carbon in the upper 10 cm of the spodic horizon. These soils do not have a lithic contact within

50 cm of the soil surface, andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface, or a saturated layer within 100 cm of the soil surface. The soils occur in Alaska and commonly are forested.

Lithic Haplocryods.—These are the Haplocryods that have a lithic contact within 50 cm of the soil surface. These soils occur under forest vegetation in Washington and in an alpine environment in Alaska.

Oxyaquic Haplocryods.—These are the Haplocryods that are saturated with water within 100 cm of the soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils do not have redoximorphic features within 75 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Humicryods

Humicryods are the Cryods of high latitudes or high elevations. In the United States, they occur mostly in southeast Alaska and in the mountains of Washington and Oregon. Some are in the higher mountains of the Northeast. Humicryods commonly have a thick O horizon over a very thin or intermittent albic horizon, which overlies a dark colored spodic horizon. They have a high content of organic carbon in the upper part of the spodic horizon. The vegetation commonly is a coniferous forest or alpine tundra.

Definition

Humicryods are the Cryods that:

1. Have 6.0 percent or more organic carbon throughout a layer 10 cm or more thick within the spodic horizon;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface; *and*

3. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CBCA. Humicryods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Humicryods

CBCB. Other Humicryods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Aquandic Humicryods

CBCC. Other Humicryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Humicryods

CBCD. Other Humicryods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Humicryods

CBCE. Other Humicryods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Humicryods

CBCF. Other Humicryods.

Typic Humicryods

Definition of Typic Humicryods

Typic Humicryods are the Humicryods that:

1. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for either or both 20 or more consecutive days or 30 or more cumulative days;

2. Do not have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years;

3. Do not have a lithic contact within 50 cm of the mineral soil surface; *and*

4. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Humicryods.—The Typic subgroup of Humicryods is centered on soils that do not have a lithic contact within 50 cm of the soil surface, saturation with water within 100 cm of the soil surface, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils commonly are forested and are used for timber production and wildlife habitat. They occur in the northeastern part of the United States and in Oregon and Alaska.

Andic Humicryods.—These are the Humicryods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or aquic conditions and redoximorphic features within 75 cm of the soil surface. They occur in the States of Alaska and Washington. In Alaska the soils occur under alpine tundra, and in Washington they are under forest vegetation.

Aquandic Humicryods.—These are the Humicryods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface and have aquic conditions and redoximorphic features within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in the State of Washington. They are used for woodland and wildlife habitat.

Aquic Humicryods.—These are the Humicryods that have aquic conditions and redoximorphic features within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. The soils occur in the Northeastern United States and support forest vegetation.

Lithic Humicryods.—These are the Humicryods that have a lithic contact within 50 cm of the soil surface. These soils occur in Alaska, Maine, Vermont, New Hampshire, and New York and are used for wildlife habitat and woodland.

Oxyaquic Humicryods.—These are the Humicryods that are saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils do not have a lithic contact within 50 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. The soils formed under forest vegetation in Maine, New Hampshire, New York, and Vermont.

Placocryods

These Cryods have a placic horizon, normally within the spodic horizon. In the United States, they are known to occur only in Alaska. They are thought to be rare elsewhere in the world.

Definition

Placocryods are the Cryods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Key to Subgroups

CBAA. Placocryods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Placocryods

CBAB. Other Placocryods that have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon.

Humic Placocryods

CBAC. Other Placocryods.

Typic Placocryods

Definition of Typic Placocryods

Typic Placocryods are the Placocryods that:

1. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

2. Do not have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon.

Description of Subgroups

Typic Placocryods.—The Typic subgroup of Placocryods is centered on soils that do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface or 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon. These soils are rare in the world.

Andic Placocryods.—These are the Placocryods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils are rare in the world.

Humic Placocryods.—These are the Placocryods that have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon. These soils do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface.

Humods

Humods are the relatively freely drained Spodosols that have a large accumulation of organic carbon in the spodic horizon. Undisturbed Humods may have either a thin, intermittent or a distinct, continuous albic horizon over a spodic horizon, which in its upper part is nearly black and has reddish hue. The hue normally becomes yellower with increasing depth.

Humods formed predominantly in Pleistocene or Holocene deposits. In the United States, they developed mainly under a coniferous forest. In Western Europe they are common in areas of sandy materials where heather (*Calluna vulgaris*) is, or used to be, a dominant plant. In tropical regions most Humods have supported a rain forest.

Humods are not extensive in the United States. They are known to occur in Maine and in the Pacific Northwest, mostly in small areas, and may occur in the Southeast.

Definition

Humods are the Spodosols that:

1. Have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon;

2. Do not have a cryic temperature regime; *and*

3. Do not have both aquic conditions within 50 cm of the mineral soil surface and *either* of the following:

a. A histic epipedon; *or*

b. Within 50 cm of the mineral soil surface, redoximorphic features in an albic or spodic horizon.

Key to Great Groups

CCA. Humods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Placohumods, p. 711

CCB. Other Humods that have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Durihumods, p. 710

CCC. Other Humods that have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Fragihumods, p. 710

CCD. Other Humods.

Haplohumods, p. 710

Durihumods

These are the Humods with a layer that is cemented, commonly with sesquioxides and organic matter but in some areas also with silica. These soils are not common in the United States but occur in some areas in the Pacific Northwest and the Southeast.

Definition

Durihumods are the Humods that:

1. Have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface.

Key to Subgroups

CCBA. Durihumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Durihumods

CCBB. Other Durihumods.

Typic Durihumods

Definition of Typic Durihumods

Typic Durihumods are the Durihumods that do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Durihumods.—The Typic subgroup of Durihumods is centered on soils that do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils are rare in the world.

Andic Durihumods.—These are the Durihumods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils are rare in the United States.

Fragihumods

These Humods have a fragipan below the spodic horizon and do not have a placic horizon. They are not known to occur in the United States, and a classification of subgroups has not been developed.

Definition

Fragihumods are the Humods that:

1. Have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface; *and*

3. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CCCA. All Fragihumods (provisionally).

Typic Fragihumods

Haplohumods

Haplohumods are the Humods commonly in cool to warm, moist coastal regions, although some are in inland areas at higher elevations. These soils occur in the Northeast and the Pacific Northwest; in the Southeastern United States, particularly in areas of sandy deposits; and in Western Europe, where most of them at some time supported heather (*Calluna* *vulgaris*). If undisturbed, these soils generally have an umbric epipedon and an albic horizon overlying a spodic horizon with reddish hue and a black upper subhorizon rich in organic carbon. Some of the soils, however, have an ochric epipedon.

Definition

Haplohumods are the Humods that:

1. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface; *and*

3. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CCDA. Haplohumods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplohumods

CCDB. Other Haplohumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplohumods

CCDC. Other Haplohumods that have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness.

Plagganthreptic Haplohumods

CCDD. Other Haplohumods.

Typic Haplohumods

Definition of Typic Haplohumods

Typic Haplohumods are the Haplohumods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower; *and*

3. Do not have a surface horizon more than 30 cm thick that meets all of the requirements for a plaggen epipedon except thickness.

Description of Subgroups

Typic Haplohumods.—The Typic subgroup of Haplohumods is centered on soils that do not have a lithic contact within 50 cm of the soil surface, andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface, or a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness.

Andic Haplohumods.—These soils have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. They do not have a lithic contact within 50 cm of the soil surface.

Lithic Haplohumods.—These soils have a lithic contact within 50 cm of the soil surface.

Plagganthreptic Haplohumods.—These soils have a surface horizon 30 cm or more thick that has all of the attributes of a plaggen epipedon except thickness. They do not have a lithic contact within 50 cm of the soil surface or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. They occur in Europe.

Placohumods

These are the Humods that have a placic horizon within the spodic horizon. They are probably rare in the world but are known to occur in eastern Canada and in parts of Western Europe, where their vegetation is, or used to be, heather.

Definition

Placohumods are the Humods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Key to Subgroups

CCAA. Placohumods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Placohumods

CCAB. Other Placohumods.

Typic Placohumods

Definition of Typic Placohumods

Typic Placohumods are the Placohumods that do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Placohumods.—The Typic subgroup of Placohumods is centered on soils that do not have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils are rare in the world.

Andic Placohumods.—These are the Placohumods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils are rare in the world.

Orthods

Orthods are the relatively freely drained Spodosols that have a horizon of accumulation containing aluminum, or aluminum and iron, and organic carbon. These are the most common Spodosols in the northern parts of Europe and in the United States. They formed predominantly in coarse, acid Pleistocene or Holocene deposits under a mostly coniferous forest vegetation. If undisturbed, Orthods normally have an O horizon, an albic horizon, and a spodic horizon and may have a fragipan. Some of these soils, however, have been mixed by the roots of falling trees or by animals and have a very thin albic horizon or no albic horizon. In cultivated areas the albic horizon is very commonly mixed with part of the spodic horizon. In the United States, the moisture regime of Orthods is predominantly udic, but a few have a xeric regime. The soil temperature regimes range from frigid to hyperthermic. Orthods are extensive in the southeastern part of the United States, the Northeast, the Great Lakes States, and the mountains of the West.

Definition

Orthods are the Spodosols that:

1. Do not have 6.0 percent or more organic carbon in a layer 10 cm or more thick within the spodic horizon;

2. Do not have a cryic temperature regime; *and*

3. Do not have both aquic conditions within 50 cm of the mineral soil surface and *either* of the following:

   a. A histic epipedon; *or*

   b. Within 50 cm of the mineral soil surface, redoximorphic features in an albic or spodic horizon.

Key to Great Groups

CDA. Orthods that have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface.

Placorthods, p. 720

CDB. Other Orthods that have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Durorthods, p. 714

CDC. Other Orthods that have a fragipan with its upper boundary within 100 cm of the mineral soil surface.

Fragiorthods, p. 714

CDD. Other Orthods that have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon.

Alorthods, p. 712

CDE. Other Orthods.

Haplorthods, p. 716

Alorthods

These are the Orthods that have accumulations of aluminum that are relatively high compared to the accumulations of iron. These soils formed predominantly in sandy deposits. The soils have low accumulations of iron either because of intensive leaching or because of parent materials that are low in iron. Alorthods normally have a thick albic horizon and an ochric epipedon. They are more common in areas of warm climates than in cool environments. In the United States, they occur mainly in the Southeast.

Definition

Alorthods are the Orthods that:

1. Have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface;

3. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CDDA. Alorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

   1. 20 or more consecutive days; *or*

   2. 30 or more cumulative days.

Oxyaquic Alorthods

CDDB. Other Alorthods that have *both*:

   1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm; *and*

   2. An argillic or kandic horizon below the spodic horizon.

Arenic Ultic Alorthods

CDDC. Other Alorthods that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm.

Arenic Alorthods

CDDD. Other Alorthods that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more; *and*

2. In 10 percent or more of each pedon, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon.

Entic Grossarenic Alorthods

CDDE. Other Alorthods that have, in 10 percent or more of each pedon, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon.

Entic Alorthods

CDDF. Other Alorthods that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more.

Grossarenic Alorthods

CDDG. Other Alorthods that have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness.

Plagganthreptic Alorthods

CDDH. Other Alorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Alfic Alorthods

CDDI. Other Alorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Alorthods

CDDJ. Other Alorthods.

Typic Alorthods

Definition of Typic Alorthods

Typic Alorthods are the Alorthods that:

1. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for either or both 20 or more consecutive days or 30 or more cumulative days;

2. Do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm;

3. Do not have an argillic or kandic horizon;

4. Do not have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness;

5. Do not have an argillic or kandic horizon within 200 cm of the mineral soil surface; *and*

6. Have, in 10 percent or more of each pedon, 3.0 percent or more organic carbon in the upper 2 cm of the spodic horizon.

Description of Subgroups

Typic Alorthods.—The Typic subgroup of Alorthods is centered on soils that are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have an argillic or kandic horizon, a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon, or a surface horizon 30 cm or more thick that has all of the attributes of a plaggen epipedon except thickness. These soils have not been recognized in the United States.

Alfic Alorthods.—These are the Alorthods that have an argillic or kandic horizon with 35 percent or more base saturation in at least some part. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm or more, less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon, or a surface horizon 30 cm or more thick that has all of the attributes of a plaggen epipedon except thickness. Alfic Alorthods are rare in the world.

Arenic Alorthods.—These are the Alorthods that have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm. These soils do not have an argillic or kandic horizon and are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years. They occur in Florida. They generally support woodland vegetation, but some have been cleared for community development.

Arenic Ultic Alorthods.—These are the Alorthods that have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm and have an argillic or kandic horizon. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years. They occur in Europe.

Entic Alorthods.—These are the Alorthods that have less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have an argillic or kandic horizon or a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 to 125 cm. The soils occur in Puerto Rico and Florida. Among the uses of these soils are native pasture and coconut production.

Entic Grossarenic Alorthods.—These are the Alorthods that have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more and have less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have an argillic or kandic horizon. They are common in the southeastern part of the United States. Most do or did support hardwood vegetation, but some have been cleared for crop production.

Grossarenic Alorthods.—These are the Alorthods that have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 125 cm or more and have 3.0 percent or more organic carbon in the upper 2 cm of the spodic horizon. These soils do not have an argillic or kandic horizon and are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years. They are rare in the world.

Oxyaquic Alorthods.—These are the Alorthods that are saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years. These soils occur in many States in the southeastern part of the United States. They have a variety of uses, including tame pasture, woodland, and the production of citrus and other crops.

Plagganthreptic Alorthods.—These are the Alorthods that have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have an argillic or kandic horizon, a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm or more, or less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon. The soils are rare but are known to occur in Europe.

Ultic Alorthods.—These are the Alorthods that have an argillic or kandic horizon with a base saturation of less than 35 percent in all parts. These soils are not saturated with water for 20 or more consecutive days or 30 or more cumulative days in normal years and do not have a sandy or sandy-skeletal particle-size class from the mineral soil surface to the top of a spodic horizon at a depth of 75 cm or more or less than 3.0 percent organic carbon in the upper 2 cm of the spodic horizon. The soils are rare in the United States.

Durorthods

These are the Orthods that have a cemented soil layer. These soils formed in sandy and loamy deposits. The cemented soil layer commonly is composed of spodic materials and in many areas is within 50 cm of the mineral soil surface. The cementing agents commonly are combinations of iron, aluminum, and organic matter, but silica may be an important cementing agent in some of these soils.

Definition

Durorthods are the Orthods that:

1. Have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface.

Key to Subgroups

CDBA. Durorthods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Durorthods

CDBB. Other Durorthods.

Typic Durorthods

Definition of Typic Durorthods

Typic Durorthods are the Durorthods that do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Description of Subgroups

Typic Durorthods.—The Typic subgroup of Durorthods is centered on soils without andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. The cemented layer in these soils commonly is ortstein. The soils occur in Michigan and New York. Most are forested, but some areas have been cleared and are used for hay and pasture.

Andic Durorthods.—These are the Durorthods that have andic soil properties in a layer 25 cm or more thick in the upper 75 cm. These soils occur in the State of Washington and support forest vegetation.

Fragiorthods

Fragiorthods are the Orthods that have a fragipan below the spodic horizon. They formed mainly in loamy deposits, but some formed in sandy deposits containing a considerable amount of fine and very fine sand. The fragipan may be thick, or it may have formed in the eluvial (E´) horizon of a lower sequum that overlies an argillic horizon. Generally, a lighter colored eluvial horizon has developed above the fragipan, presumably because of the lateral movement of ground water. Trees growing on Fragiorthods are normally shallow rooted and are sometimes blown down. When the trees are blown down, there is a mixing of soil horizons above the fragipan. As a consequence, many of these soils have a weakly expressed albic horizon or no albic horizon or have a thin, intermittent albic horizon below part of the spodic horizon. A distinct microrelief is a normal feature, unless the soils have been smoothed by cultivation. In the United States, the soil temperature regimes of Fragiorthods are mostly frigid, but some are mesic bordering on frigid.

Definition

Fragiorthods are the Orthods that:

1. Have a fragipan with its upper boundary within 100 cm of the mineral soil surface;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface; *and*

3. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CDCA. Fragiorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiorthods

CDCB. Other Fragiorthods that:

1. Are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

2. Have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Alfic Oxyaquic Fragiorthods

CDCC. Other Fragiorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Fragiorthods

CDCD. Other Fragiorthods that have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness.

Plagganthreptic Fragiorthods

CDCE. Other Fragiorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Alfic Fragiorthods

CDCF. Other Fragiorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Fragiorthods

CDCG. Other Fragiorthods that have a spodic horizon that has *one* of the following:

1. A texture of very fine sand, loamy very fine sand, or finer; *and*

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A texture of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Fragiorthods

CDCH. Other Fragiorthods.

Typic Fragiorthods

Definition of Typic Fragiorthods

Typic Fragiorthods are the Fragiorthods that:

1. Do not have redoximorphic features in any horizon within 75 cm of the mineral soil surface and also aquic conditions;

2. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for either or both 20 or more consecutive days or 30 or more cumulative days;

3. Do not have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness;

4. Do not have an argillic or kandic horizon within 200 cm of the mineral soil surface; *and*

5. Have a spodic horizon with *one or more* of the following:

a. A texture of very fine sand, loamy very fine sand, or finer; *and*

(1) A thickness of more than 10 cm; *or*

(2) A weighted average of 1.2 percent or more organic carbon in the upper 10 cm; *or*

(3) Within the upper 7.5 cm, *either or both* a moist color value or chroma of 3 or less (crushed and smoothed sample); *or*

b. A texture of loamy fine sand, fine sand, or coarser and a color value, moist, and chroma of 3 or less (crushed and smoothed sample) in the upper 2.5 cm.

Description of Subgroups

Typic Fragiorthods.—The Typic subgroup of Fragiorthods is centered on properties that are not evident. Typic Fragiorthods are not saturated within 100 cm of the soil surface and do not have an argillic or kandic horizon, a surface horizon 30 cm or more thick that has all of the attributes of a plaggen epipedon except thickness, or a moist value and chroma of 4 or more. These soils are forested and occur in Michigan, New York, and Pennsylvania.

Alfic Fragiorthods.—These are the Fragiorthods that have an argillic horizon that has a base saturation of 35 percent or more in at least some part. These soils are not saturated for extended periods within 100 cm of the soil surface. They do not have a surface layer 30 cm or more thick that has all of the attributes of a plaggen epipedon except thickness. They are wooded and occur in Wisconsin and Michigan.

Alfic Oxyaquic Fragiorthods.—These are the Fragiorthods that have an argillic horizon with a base saturation of 35 percent or more in some part and are saturated with water for extended periods within 100 cm of the soil surface. These soils do not have redoximorphic features within 75 cm of the soil surface. They occur in Michigan and Wisconsin. They commonly are wooded, but some have been cleared and are used for small grain or hay.

Aquic Fragiorthods.—These are the Fragiorthods that have aquic conditions and redoximorphic features within 75 cm of the soil surface. These soils commonly occur in New York and Pennsylvania. They generally support forest vegetation, but some areas have been cleared for crop production.

Entic Fragiorthods.—These are the Fragiorthods that have a value and chroma, moist, of 4 or more. These soils are not saturated for extended periods within 100 cm of the surface, do not have an argillic or kandic horizon, and do not have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness. The soils support forest vegetation and occur in New York, New Hampshire, and Vermont.

Oxyaquic Fragiorthods.—These are the Fragiorthods that are saturated for extended periods within 100 cm of the soil surface. These soils do not have redoximorphic features within 75 cm of the soil surface or an argillic or kandic horizon with a base saturation of 35 percent or more in at least some part. Oxyaquic Fragiorthods occur in Wisconsin and Michigan and support northern hardwoods.

Plagganthreptic Fragiorthods.—These are the Fragiorthods that have a surface layer 30 cm or more thick that has all of the properties of a plaggen epipedon except thickness. These soils do not have an argillic or kandic horizon with a base saturation of 35 percent or more in at least some part and are not saturated with water for extended periods within 100 cm of the soil surface. The soils are rare. They occur in small areas of Europe.

Ultic Fragiorthods.—These are the Fragiorthods that have an argillic or kandic horizon with a base saturation of less than 35 percent in all parts. These soils are not saturated with water for extended periods within 100 cm of the soil surface and do not have a surface horizon 30 cm or more thick that meets all of the requirements for a plaggen epipedon except thickness. The soils are rare in the world.

Haplorthods

These are the relatively freely drained Orthods that either have an albic horizon and a spodic horizon or, under cultivation, commonly have only a spodic horizon below an Ap horizon. The spodic horizon may rest on a lower sequum with an argillic or kandic horizon, on relatively unaltered unconsolidated materials, or on rock. The soil temperature regime is frigid or warmer, and the moisture regime is predominantly udic. Most Haplorthods have, or used to have, forest vegetation, mainly conifers but also hardwoods in some areas. A majority of these soils formed in sandy deposits or in materials weathered from sandstone or quartzite.

Definition

Haplorthods are the Orthods that:

1. Do not have less than 0.10 percent iron (by ammonium oxalate) in 75 percent or more of the spodic horizon;

2. Do not have, in 50 percent or more of each pedon, a placic horizon within 100 cm of the mineral soil surface;

3. Do not have a fragipan with its upper boundary within 100 cm of the mineral soil surface; *and*

4. Do not have, in 90 percent or more of each pedon, a cemented soil layer that does not slake in water after air drying and has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

CDEA. Haplorthods that have a lithic contact within 50 cm of the mineral soil surface; *and either*

1. A spodic horizon with a texture of very fine sand, loamy very fine sand, or finer; *and*

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A spodic horizon with a texture of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Lithic Haplorthods

CDEB. Other Haplorthods that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplorthods

CDEC. Other Haplorthods that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Haplorthods

CDED. Other Haplorthods that have *both*:

1. Redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Aqualfic Haplorthods

CDEE. Other Haplorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage); *and either*

1. A spodic horizon with a texture of very fine sand, loamy very fine sand, or finer; *and*

a. A thickness of 10 cm or less; *and*

b. A weighted average of less than 1.2 percent organic carbon; *and*

c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A spodic horizon with a texture of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Aquentic Haplorthods

CDEF. Other Haplorthods that have redoximorphic features in one or more horizons within 75 cm of the mineral soil surface and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplorthods

CDEG. Other Haplorthods that have:

1. Within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Alfic Oxyaquic Haplorthods

CDEH. Other Haplorthods that have:

1. Within 200 cm of the mineral soil surface, an argillic or kandic horizon; *and*

2. Saturation with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Oxyaquic Ultic Haplorthods

CDEI. Other Haplorthods that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Haplorthods

CDEJ. Other Haplorthods that, below the spodic horizon but not below an argillic horizon, have lamellae (two or more) within 200 cm of the mineral soil surface.

Lamellic Haplorthods

CDEK. Other Haplorthods that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplorthods

CDEL. Other Haplorthods that have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower.

Andic Haplorthods

CDEM. Other Haplorthods that have, within 200 cm of the mineral soil surface, an argillic or kandic horizon that has a base saturation of 35 percent or more (by sum of cations) in some part.

Alfic Haplorthods

CDEN. Other Haplorthods that have an argillic or kandic horizon within 200 cm of the mineral soil surface.

Ultic Haplorthods

CDEO. Other Haplorthods that have a spodic horizon that has *one* of the following:

1. A texture of very fine sand, loamy very fine sand, or finer; *and*

   a. A thickness of 10 cm or less; *and*

   b. A weighted average of less than 1.2 percent organic carbon; *and*

   c. Within the upper 7.5 cm, *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample); *or*

2. A texture of loamy fine sand, fine sand, or coarser and *either or both* a moist color value or chroma of 4 or more (crushed and smoothed sample) in the upper 2.5 cm.

Entic Haplorthods

CDEP. Other Haplorthods.

Typic Haplorthods

Definition of Typic Haplorthods

Typic Haplorthods are the Haplorthods that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have redoximorphic features in any horizon within 75 cm of the mineral soil surface and also aquic conditions;

3. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for either or both 20 or more consecutive days or 30 or more cumulative days;

4. Do not have an argillic or kandic horizon within 200 cm of the mineral soil surface;

5. Do not have andic soil properties throughout horizons that have a total thickness of 25 cm or more within 75 cm either of the mineral soil surface or of the top of an organic layer with andic soil properties, whichever is shallower;

6. Have a spodic horizon with *one or more* of the following:

   a. A texture of very fine sand, loamy very fine sand, or finer; *and*

      (1) A thickness of more than 10 cm; *or*

      (2) A weighted average of 1.2 percent or more organic carbon in the upper 10 cm; *or*

      (3) Within the upper 7.5 cm, *either or both* a moist color value or chroma of 3 or less (crushed and smoothed sample); *or*

   b. A texture of loamy fine sand, fine sand, or coarser and a color value, moist, and chroma of 3 or less (crushed and smoothed sample) in the upper 2.5 cm;

7. Do not have lamellae (two or more) within 200 cm of the soil surface; *and*

8. Have fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick.

Description of Subgroups

Typic Haplorthods.—The Typic subgroup of Haplorthods is centered on soils that do not have an argillic or kandic horizon, a lithic contact within 50 cm of the mineral soil surface, saturation with water for extended periods within 100 cm of the mineral soil surface, andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface, fragic properties, lamellae, or both a chroma and value, moist, of 4 or more. These soils occur in the northeastern and northwestern parts of the United States as well as Michigan, Wisconsin, Minnesota, West Virginia, and Maryland. They generally support forest vegetation, but some have been cleared for pasture or crop production. The most common crops are small grain, corn for silage, and in Maine potatoes.

Alfic Haplorthods.—These are the Haplorthods that have an argillic or kandic horizon that has a base saturation of 35 percent or more in at least some part. These soils do not have a lithic contact within 50 cm of the soil surface, saturation with water for extended periods within 100 cm of the mineral soil surface, fragic properties, lamellae, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. The soils occur in Michigan, Wisconsin, and New York. They generally are forested, but some of the less sloping areas are used for small grain or hay.

Alfic Oxyaquic Haplorthods.—These are the Haplorthods that have an argillic or kandic horizon with a base saturation of 35 percent or more in at least some part and are saturated with water for extended periods within 100 cm of the mineral soil surface. These soils do not have aquic conditions and redoximorphic features within 75 cm of the mineral soil surface or a lithic contact within 50 cm of the soil surface. They occur in Wisconsin and Michigan. Most of the soils are forested, but some have been cleared and are used for small grain or hay.

Andic Haplorthods.—These are the Haplorthods that have andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface, fragic soil properties, saturation with water for extended periods within 100 cm of the soil surface, or lamellae. They occur in Washington and are wooded.

Aqualfic Haplorthods.—These are the Haplorthods that have an argillic or kandic horizon with a base saturation of 35 percent or more in at least some part and aquic conditions and redoximorphic features within 75 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or fragic soil properties. They occur in Washington, Michigan, and Wisconsin. Most of the soils are forested, but some have been cleared for crop production.

Aquentic Haplorthods.—These are the Haplorthods that have aquic conditions and redoximorphic features within 75 cm of the soil surface and have a value and chroma, moist, of 4 or more. These soils do not have an argillic or kandic horizon, fragic soil properties, or a lithic contact within 50 cm of the mineral soil surface. They occur in Oregon, Washington, Minnesota, Michigan, Wisconsin, and New York. They formed under forest vegetation. Some areas have been cleared and are used for hay or pasture.

Aquic Haplorthods.—These are the Haplorthods that have aquic conditions and redoximorphic features within 75 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm of the soil surface, an argillic or kandic horizon, fragic soil properties, or a value and chroma, moist, of 4 or more. They occur in New England and the Lake States. Most are forested.

Entic Haplorthods.—These are the Haplorthods that have both a value and chroma, moist, of 4 or more. These soils do not have an argillic or kandic horizon, a lithic contact within 50 cm of the mineral soil surface, saturation with water for extended periods within 100 cm of the mineral soil surface, andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface, fragic properties, or lamellae. The soils occur in the Pacific Northwest, in the Northeast, and in Michigan, Wisconsin, Virginia, Pennsylvania, Maryland, and West Virginia. Commonly, these soils are wooded, but some have been cleared and are used for hay, corn, oats, potatoes, or fruit crops.

Entic Lithic Haplorthods.—These are the Haplorthods that have both a value and chroma, moist, of 4 or more and have a lithic contact within 50 cm of the mineral soil surface. These soils are wooded and occur in Wisconsin.

Fragiaquic Haplorthods.—These are the Haplorthods that have aquic conditions and redoximorphic features within 75 cm of the mineral soil surface and have fragic properties or a fragipan between depths of 100 and 200 cm. These soils do not have a lithic contact within 50 cm of the mineral soil surface. They are rare in the world.

Fragic Haplorthods.—These are the Haplorthods that have fragic properties or a fragipan between depths of 100 and 200 cm. These soils do not have a lithic contact within 50 cm of the soil surface and are not saturated with water for extended periods within 100 cm of the mineral soil surface. They are rare in the world.

Lamellic Haplorthods.—These are the Haplorthods that have lamellae. These soils do not have a lithic contact within 50 cm of the soil surface, saturation with water for extended periods within 100 cm of the mineral soil surface, or fragic properties. They occur in Michigan. In some areas they are forested. In other areas they have been cleared and are used for small grain, hay, or potatoes.

Lithic Haplorthods.—These are the Haplorthods that have a lithic contact within 50 cm of the soil surface but do not have both a value and chroma, moist, of 4 or more. These soils occur in the Northeast as well as Michigan. Most support forest vegetation, but some areas have been cleared and are used for hay or pasture.

Oxyaquic Haplorthods.—These are the Haplorthods that are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 cumulative days in normal years. These soils do not have a lithic contact within 50 cm of the mineral soil surface, aquic conditions and redoximorphic features within 75 cm of the mineral soil surface, fragic properties, or lamellae. The soils occur in Washington, Michigan, Wisconsin, and the northeastern part of the United States. In most areas these soils are wooded, but some areas have been cleared and are used for hay and pasture.

Oxyaquic Ultic Haplorthods.—These are the Haplorthods that have an argillic or kandic horizon with a base saturation of less than 35 percent in all parts and in normal years are saturated with water for 20 or more consecutive days or 30 or more cumulative days within 100 cm of the mineral soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or aquic conditions and redoximorphic features within 75 cm of the mineral soil surface. Oxyaquic Ultic Haplorthods occur in Wisconsin. They generally are wooded, but some have been cleared and are used for corn, hay, or pasture.

Ultic Haplorthods.—These are the Haplorthods that have an argillic horizon that has a base saturation of less than 35 percent in all parts. These soils do not have a lithic contact within 50 cm of the mineral soil surface, fragic soil properties, lamellae, or andic soil properties in a layer 25 cm or more thick within 75 cm of the soil surface and are not saturated with water for extended periods within 100 cm of the mineral soil surface. The soils are rare in the world.

Placorthods

These are the Orthods that have a placic horizon within 100 cm of the mineral soil surface. These soils are not known to occur in the continental United States and are thought to be rare elsewhere in the world.

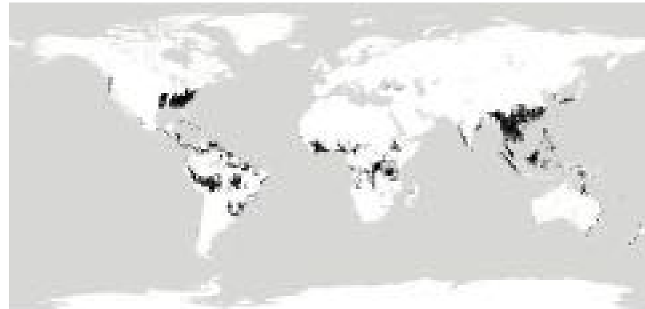
Definition

Placorthods are the Orthods that have a placic horizon within 100 cm of the mineral soil surface in 50 percent or more of each pedon.

Key to Subgroups

CDAA. All Placorthods (provisionally).

Typic Placorthods



CHAPTER 19

Ultisols

Ultisols are soils that have an argillic or kandic horizon with low base saturation. They may have any soil temperature regime and any soil moisture regime except aridic. There is more precipitation than evapotranspiration at some season, and some water moves through the soils and into a moist or wet substratum. The release of bases by weathering usually is equal to or less than the removal by leaching, and most of the bases commonly are held in the vegetation and the upper few centimeters of the soils. Base saturation in most Ultisols decreases with increasing depth because the vegetation has concentrated the bases at a shallow depth. Cultivation, therefore, is a shifting cultivation unless soil amendments are applied.

Ultisols are most extensive in warm, humid climates that have a seasonal deficit of precipitation. They are mainly on Pleistocene or older surfaces. They formed in a very wide variety of parent materials, but very few have many primary minerals that contain bases other than some micas. Some of the few that have a supply of bases are intensively cultivated. Kaolin, gibbsite, and aluminum-interlayered clays are common in the clay fraction. Smectites also may be present if they are in the parent materials. Extractable aluminum normally is high except in the Paleudults and other pale-groups. A calcium-deficient argillic horizon is common in the Ultisols in the United States.

Most of the Ultisols in the United States had a vegetation of coniferous or hardwood forests at the time of settlement. Savannas are present in other parts of the world, but they may be anthropic.

Definition of Ultisols and Limits Between Ultisols and Soils of Other Orders

Ultisols are the mineral soils that:

1. Have *either*:

a. An argillic or kandic horizon, but no fragipan, and a base saturation (by sum of cations) of less than 35 percent at one of the following depths:

(1) If the epipedon has a sandy or sandy-skeletal particle-size class throughout, *either*:

(a) 125 cm below the upper boundary of the argillic or kandic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(b) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

(2) The shallowest of the following depths:

(a) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(b) 180 cm below the mineral soil surface; *or*

(c) At a densic, lithic, paralithic, or petroferric contact; *or*

b. A fragipan and *both* of the following:

(1) Either an argillic or kandic horizon above, within, or below it or clay films 1 mm or more thick in one or more of its subhorizons; *and*

(2) A base saturation (by sum of cations) of less than 35 percent at the shallowest of the following depths:

(a) 75 cm below the upper boundary of the fragipan; *or*

(b) 200 cm below the mineral soil surface; *or*

(c) At a densic, lithic, paralithic, or petroferric contact;

2. Do not have *either* of the following:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface;

3. Do not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower than 60 cm;

4. Do not have an Ap horizon containing 85 percent or more spodic materials;

5. Have an argillic or kandic horizon above any spodic horizon that has *either* of the following:

a. An overlying albic horizon in 50 percent or more of each pedon and a cryic soil temperature regime; *or*

b. *All* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid soil temperature regime; *or*

(e) A cryic soil temperature regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy particle-size class in at least some part between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface, *or* at the top of a duripan or fragipan, *or* at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth,

1) If the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime; *or*

2) If the soil has a cryic temperature regime;

6. Do not have an oxic horizon that has its upper boundary within 150 cm of the mineral soil surface unless there is a kandic horizon above the oxic horizon;

7. Have less than 40 percent (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18 cm (after mixing) if the kandic horizon has the weatherable-mineral properties of an oxic horizon and has its upper boundary within 150 cm of the mineral soil surface;

8. Do not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically;

9. Do not have an aridic moisture regime; *and*

10. Do not have a salic horizon and meet *all* of the following criteria:

a. Are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

b. Do not have a moisture control section that is dry in at least some part in normal years; *and*

c. Have a sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface.

Limits Between Ultisols and the Other Soil Orders

The definition of Ultisols must provide criteria that separate Ultisols from soils of all other orders. The aggregate of these criteria defines the limits of Ultisols in relation to all other known kinds of soil.

1. Unlike Alfisols, Ultisols must have *one* of the following characteristics:

a. No fragipan and a base saturation (by sum of cations) of less than 35 percent at *one* of the following depths:

(1) If there is an epipedon that has a sandy or sandy-skeletal particle-size class throughout, *either*:

(a) 125 cm below the upper boundary of the argillic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(b) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

(2) If the epipedon does not have a sandy or sandy-skeletal particle-size class throughout, the shallowest of the following depths:

(a) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(b) 180 cm below the mineral soil surface; *or*

(c) At a densic, lithic, paralithic, or petroferric contact; *or*

b. A fragipan and a base saturation (by sum of cations) of less than 35 percent at the shallowest of the following depths:

(1) 75 cm below the upper boundary of the fragipan; *or*

(2) 200 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact.

2. Unlike Andisols, Ultisols must not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and either a depth of 60 cm from the shallower of the above or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower than 60 cm.

3. Unlike Aridisols, Ultisols must not:

a. Have an aridic soil moisture regime; *and*

b. Have a salic horizon and meet *all* of the following criteria:

(1) Are not saturated with water in one or more layers within 100 cm of the soil surface for 1 month or more in normal years; *and*

(2) Do not have a moisture control section that is dry in at least some part in normal years; *and*

(3) Have a sulfuric horizon that has its upper boundary within 150 cm of the mineral soil surface.

4. Unlike Entisols and Inceptisols, Ultisols must have *one* of the following:

a. An argillic or kandic horizon; *or*

b. A fragipan that meets all of the requirements for an argillic or kandic horizon or that has clay films more than 1 mm thick in some part.

5. Unlike Gelisols, Ultisols do not have:

a. Permafrost within 100 cm of the soil surface; *or*

b. Gelic materials within 100 cm of the soil surface and permafrost within 200 cm of the soil surface.

6. Unlike Histosols, Ultisols do not have organic soil materials that meet *one or more* of the following:

a. Overlie cindery, fragmental, or pumiceous materials and/or fill their interstices[1] *and* directly below these materials have either a densic, lithic, or paralithic contact; *or*

b. When added with the underlying cindery, fragmental, or pumiceous materials, total 40 cm or more between the soil surface and a depth of 50 cm; *or*

c. Constitute two-thirds or more of the total thickness of the soil to a densic, lithic, or paralithic contact and have no mineral horizons or have mineral horizons with a total thickness of 10 cm or less; *or*

d. Are saturated with water for 30 days or more in normal years (or are artificially drained), have an upper boundary within 40 cm of the soil surface, and have a total thickness of *either*:

(1) 60 cm or more if three-fourths or more of their volume consists of moss fibers or if their bulk density, moist, is less than 0.1 g/cm^3; *or*

(2) 40 cm or more if they consist either of sapric or hemic materials, or of fibric materials with less than three-fourths (by volume) moss fibers and a bulk density, moist, of 0.1 g/cm^3 or more.

7. Unlike Mollisols, Ultisols must have *one* of the following:

a. An argillic or kandic horizon, but no fragipan, and a base saturation (by sum of cations) of less than 35 percent at *one* of the following depths:

(1) If there is an epipedon that has a sandy or sandy-skeletal particle-size class throughout, *either*:

(a) 125 cm below the upper boundary of the argillic horizon (but no deeper than 200 cm below the mineral soil surface) or 180 cm below the mineral soil surface, whichever is deeper; *or*

(b) At a densic, lithic, paralithic, or petroferric contact if shallower; *or*

(2) If the epipedon does not have a sandy or sandy-skeletal particle-size class throughout, the shallowest of the following depths:

(a) 125 cm below the upper boundary of the argillic or kandic horizon; *or*

(b) 180 cm below the mineral soil surface; *or*

(c) At a densic, lithic, paralithic, or petroferric contact; *or*

b. A fragipan and a base saturation (by sum of cations) of less than 35 percent at the shallowest of the following depths:

(1) 75 cm below the upper boundary of the fragipan; *or*

(2) 200 cm below the mineral soil surface; *or*

(3) At a densic, lithic, paralithic, or petroferric contact.

8. Unlike Oxisols, Ultisols must not have *either*:

a. An oxic horizon that has its upper boundary within 150 cm of the mineral soil surface; *or*

b. 40 percent or more (by weight) clay in the fine-earth fraction between the mineral soil surface and a depth of 18

[1] Materials that meet the definition of cindery, fragmental, or pumiceous but have more than 10 percent (by volume) voids that are filled with organic soil materials are considered to be organic soil materials.

cm (after mixing) and a kandic horizon that has less than 10 percent weatherable minerals and has its upper boundary within 150 cm of the mineral soil surface.

9. Unlike Spodosols, Ultisols must not have an Ap horizon consisting of spodic materials or a spodic horizon above the argillic, kandic, or natric horizon and must not have have *one or more* of the following:

a. An albic horizon in 50 percent or more of each pedon and a cryic soil temperature regime; *or*

b. A spodic horizon with *all* of the following characteristics:

(1) *One or more* of the following:

(a) A thickness of 10 cm or more; *or*

(b) An overlying Ap horizon; *or*

(c) Cementation in 50 percent or more of each pedon; *or*

(d) A coarse-loamy, loamy-skeletal, or finer particle-size class and a frigid soil temperature regime; *or*

(e) A cryic soil temperature regime; *and*

(2) An upper boundary within the following depths from the mineral soil surface: *either*

(a) Less than 50 cm; *or*

(b) Less than 200 cm if the soil has a sandy particle-size class between the mineral soil surface and the spodic horizon; *and*

(3) A lower boundary as follows:

(a) *Either* at a depth of 25 cm or more below the mineral soil surface, *or* at the top of a duripan or fragipan, *or* at a densic, lithic, paralithic, or petroferric contact, whichever is shallowest; *or*

(b) At any depth if the spodic horizon has a coarse-loamy, loamy-skeletal, or finer particle-size class and the soil has a frigid temperature regime *or* if the soil has a cryic temperature regime.

10. Unlike Vertisols, Ultisols must not have *all* of the following:

a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped aggregates that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

c. Cracks that open and close periodically.

Representative Pedon and Data

Following is a description of a representative Ultisol. Data for the pedon identified in this description are given in the table "Characterization Data for an Ultisol."

Classification: Fine, kaolinitic, thermic Typic Kandiudult
Site identification number: 82P0398
Location: Autauga County, Alabama; SW1/4SW1/4SW1/4 sec. 33, T. 18 N., R. 16 E.
Latitude: 32 degrees 29 minutes 19 seconds N.
Longitude: 86 degrees 28 minutes 10 seconds W.
Slope: 1 percent
Elevation: 122 m
Landform: Terrace
Parent material: Fluvial or marine sediments
Soil moisture regime: Udic
Permeability class: Moderate
Drainage class: Well drained
Water table: None observed within a depth of 9 m
Land use: Forest land (not grazed)
Vegetation: Native hardwoods and pine
Particle-size control section: 12 to 62 cm
Diagnostic features: An ochric epipedon from a depth of 0 to 12 cm, a kandic from a depth of 12 to more than 200 cm, and an argillic horizon from a depth of 12 to more than 200 cm
Described by: Brown and Stubbs

In the following pedon description, colors are for moist soil unless otherwise indicated. Texture terms are for field textures.

Ap—0 to 12 cm; dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; very friable; many fine and medium roots; common organic coatings; few wormcasts; abundant active fire ant cavities; strongly acid; clear smooth boundary.

Bt1—12 to 40 cm; red (2.5YR 4/6) clay loam; moderate medium subangular blocky structure; friable; common fine and medium roots; many tubular pores (abandoned root channels); few distinct clay films on faces of peds; common active fire ant cavities; very strongly acid; clear wavy boundary.

Bt2—40 to 86 cm; red (2.5YR 4/6) clay loam; moderate medium subangular blocky structure; firm; common distinct clay films on faces of peds; very strongly acid; clear wavy boundary.

Bt3—86 to 140 cm; red (2.5YR 4/6) clay loam; common medium prominent yellowish brown (10YR 5/4) redox depletions; weak medium and coarse prismatic structure

Characterization Data for an Ultisol

SITE IDENTIFICATION NO.: 82P0398
CLASSIFICATION: FINE, KAOLINITIC, THERMIC TYPIC KANDIUDULT
GENERAL METHODS: 1B1A, 2A1, 2B

SAMPLE NO.	DEPTH (cm)	HORIZON	-4- TOTAL CLAY LT .002	-5- TOTAL SILT .002 -.05	-6- TOTAL SAND .05 -2	-7- CLAY FINE LT .0002	-8- CLAY CO_3 LT .002	-9- SILT FINE .002 -.02	-10- SILT COARSE .02 -.05	-11- SAND VF .05 -.10	-12- SAND F .10 -.25	-13- SAND M .25 -.50	-14- SAND C .5 -1	-15- SAND VC 1 -2	-16- COARSE FRACTIONS (mm) WEIGHT 2 -5	-17- WEIGHT 5 -20	-18- WEIGHT 20 -75	-19- WEIGHT .1- 75	-20- (>2mm) WT PCT OF WHOLE SOIL
			<- - - - - - - - - - - - - Pct of <2mm (3A1)											- - - - - - - - - - - - ->	<- Pct of <75mm(3B1)->				SOIL
82P2043	0- 12	Ap	12.3	15.3	72.4	9.9		8.6	6.7	12.2	33.6	22.5	3.4	0.7	1	1	--	61	2
82P2044	12- 40	Bt1	35.0	18.4	46.6	26.5		13.4	5.0	7.6	21.4	14.8	2.3	0.5	TR	TR	--	39	TR
82P2045	40- 86	Bt2	35.3	17.7	47.0	27.6		12.2	5.5	7.6	21.2	14.8	2.4	1.0	TR	TR	--	39	TR
82P2046	86-140	Bt3	40.9	12.3	46.8	29.6		8.5	3.8	7.0	21.3	15.3	2.4	0.8	TR	TR	--	40	TR
82P2047	140-280	Bt4	44.6	9.3	46.1	28.0		5.3	4.0	6.9	20.7	15.2	2.4	0.9	TR	TR	--	39	TR

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a <- Percent	DITH-CIT EXTRACTABLE Fe 6C2b of	Al 6G7a <2mm	Mn 6D2a -->	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1 Pct <0.4mm	PI 4F	(BULK DENSITY) FIELD MOIST 4A3a <- - g/cc	1/3 BAR 4A1d	OVEN DRY 4A1h - - ->	COLE WHOLE SOIL 4D1 cm/cm	(WATER CONTENT) FIELD MOIST 4B4 <- - -Pct of <2mm	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a - ->	WRD WHOLE SOIL 4C1 cm/cm
0- 12	1.25	0.057			0.3	0.1	TR	0.34	0.36				1.46	1.50	0.009			9.6	4.4	0.08
12- 40	0.51	0.037			1.3	0.2	--	0.16	0.34				1.55	1.60	0.011			15.1	11.8	0.05
40- 86	0.32	0.019			1.4	0.2	--	0.15	0.36				1.51	1.58	0.015			18.1	12.7	0.08
86-140	0.20				1.7	TR	--	0.14	0.34				1.75	1.80	0.009			16.0	14.0	0.04
140-280	0.19				1.8	0.2	--	0.12	0.33				1.72	1.75	0.006			17.2	14.8	0.04

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACID-ITY 6H5a	EXTR Al 6G9a	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8b	BASES + Al 5A3b	Al SAT 5G1	(BASE SAT) SUM 5C3	NH_4OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	COND. mmhos /cm 8I	(PH) KCl IN 8C1g	$CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- - - - - - - - - - - - -meq / 100 g									- - - - - - - - - - - ->	<- - - - -Pct		- - - ->						
0- 12	1.3	0.4	--	0.1	1.8	4.5	0.4	6.3	4.2	2.2	18	29	43				4.1	4.9	5.1
12- 40	1.5	0.7	0.2	0.1	2.5	6.1	1.0	8.6	5.7	3.5	29	29	44				3.9	4.7	5.0
40- 86	0.9	0.8	0.2	0.1	2.0	6.4	1.4	8.4	5.3	3.4	41	24	38				3.8	4.7	5.0
86-140	0.1	0.3	0.1	0.1	0.6	7.0	2.7	7.6	5.6	3.3	82	8	11				3.7	4.6	5.0
140-280	0.2	0.3	0.2	0.1	0.8	13.0	2.9	13.8	5.3	3.7	78	6	15				3.7	4.5	4.9

CLAY MINERALOGY (<.002mm)

SAMPLE NUMBER	FRACTION	X-RAY 7A2i Peak size				THERMAL - DTA - 7A6 - TGA - 7A4b Percent	ELEMENTAL 7C3 Percent SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 mg/g	INTER-PRETATION
82P2044	TCLY	KK 4	VR 3	MI 1	GI 1	KK49 GI 4			8.7			0.5			
82P2047	TCLY	KK 5	VR 3	GI 1	GE 1	KK61 GI 1			8.6			0.4			

SAND - SILT MINERALOGY (2.0-0.002mm)

SAMPLE	FRACTION	OPTICAL TOTAL RESISTANT	GRAIN COUNT							
82P2044	VFS	99	QZ98	OP 1	TMtr	ZRtr	BTtr	FKtr	MStr	EPtr
82P2047	VFS	99	QZ96	KK 3	MStr	BTtr	OPtr	HNtr	ZRtr	TMtr

The chemical data are based on the fraction less than 2 mm in size.

parting to moderate medium subangular blocky; very firm; few tubular pores (abandoned root channels); many distinct clay films on faces of peds; few highly weathered quartz pebbles less than 3 cm in diameter; very strongly acid; gradual wavy boundary.

Bt4—140 to 280 cm; red (2.5YR 4/6) clay; common medium prominent light brownish gray (10YR 6/2) and common medium prominent brownish yellow (10YR 6/6) redox depletions; weak medium and coarse prismatic structure parting to weak medium subangular blocky; very firm;

common tubular pores (abandoned root channels); common faint clay films on faces of peds; few black stains on faces of peds; strongly acid; gradual wavy boundary.

Bt5—280 to 430 cm; yellowish red (5YR 4/6) clay; common medium prominent gray (10YR 6/1) and common medium prominent red (2.5YR 4/6) redox depletions and concentrations; weak medium and coarse prismatic structure parting to moderate medium subangular blocky; very firm; few faint clay films on faces of peds; 5 percent rounded quartzite gravel; very strongly acid; clear wavy boundary.

2C1—430 to 530 cm; stratified yellow (10YR 8/6), red (2.5YR 5/6), and gray (N 6/0) loamy sand; firm; few mica flakes; very strongly acid; abrupt wavy boundary.

3C2—530 to 900 cm; stratified red (2.5YR 5/6) and yellowish brown (10YR 5/6) very gravelly sandy loam; very firm; 60 percent rounded quartzite gravel; few highly weathered, gray and light gray pebbles; very strongly acid.

Key to Suborders

HA. Ultisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and *one or both* of the following:

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 40 cm and *one* of the following within the upper 12.5 cm of the argillic or kandic horizon:

a. Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less either on faces of peds or in the matrix; *or*

b. 50 percent or more redox depletions with chroma of 1 or less either on faces of peds or in the matrix; *or*

c. Distinct or prominent redox concentrations and 50 percent or more hue of 2.5Y or 5Y in the matrix and also a thermic, isothermic, or warmer soil temperature regime; *or*

2. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquults, p. 726

HB. Other Ultisols that have *one or both* of the following:

1. 0.9 percent (by weighted average) or more organic carbon in the upper 15 cm of the argillic or kandic horizon; *or*

2. 12 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 100 cm.

Humults, p. 738

HC. Other Ultisols that have a udic moisture regime.

Udults, p. 747

HD. Other Ultisols that have an ustic moisture regime.

Ustults, p. 767

HE. Other Ultisols.

Xerults, p. 778

Aquults

These are the Ultisols in wet areas where ground water is very close to the surface during part of each year, usually in winter and spring in middle latitudes, and is deep at another time. These soils are mostly grayish or olive in the subsoil and formed mainly in alluvium and marine deposits that are of Pleistocene age or older.

Aquults are extensive on the coastal plains in the United States, particularly along the Atlantic Ocean and the Gulf of Mexico. Their slopes are gentle. Most of the soils had and many still have a forest vegetation.

Aquults have an ochric or umbric epipedon and an argillic or kandic horizon. Some have a fragipan, and others have plinthite in or below the argillic or kandic horizon.

Definition

Aquults are the Ultisols that have aquic conditions for some time in normal years (or artificial drainage) in one or more horizons within 50 cm of the mineral soil surface and *one or both* of the following:

1. Redoximorphic features in all layers between either the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and a depth of 40 cm or more and *one* of the following within the upper 12.5 cm of the argillic or kandic horizon:

a. Redox concentrations and 50 percent or more redox depletions with chroma of 2 or less either on faces of peds or in the matrix; *or*

b. 50 percent or more redox depletions with chroma of 1 or less either on faces of peds or in the matrix; *or*

c. Distinct or prominent redox concentrations and 50 percent or more hue of 2.5Y or 5Y in the matrix and also a thermic, isothermic, or warmer soil temperature regime; *or*

2. Within 50 cm of the mineral soil surface, enough active ferrous iron to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

HAA. Aquults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthaquults, p. 737

HAB. Other Aquults that have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Fragiaquults, p. 731

HAC. Other Aquults that have an abrupt textural change between the ochric epipedon or albic horizon and the argillic or kandic horizon *and* have 0.4 cm/hr or slower (moderately low or lower) saturated hydraulic conductivity in the argillic or kandic horizon.

Albaquults, p. 727

HAD. Other Aquults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandiaquults, p. 732

HAE. Other Aquults that have a kandic horizon.

Kanhaplaquults, p. 734

HAF. Other Aquults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Paleaquults, p. 735

HAG. Other Aquults that have an umbric or mollic epipedon.

Umbraquults, p. 738

HAH. Other Aquults that have episaturation.

Epiaquults, p. 729

HAI. Other Aquults.

Endoaquults, p. 728

Albaquults

These are the Aquults that have a marked increase in percentage of clay at an abrupt boundary at the top of the argillic or kandic horizon. The argillic or kandic horizon generally is clayey and has moderately low or lower hydraulic conductivity. In normal years water is perched for a while above the argillic or kandic horizon when the soils are rewetting and later saturates the whole soil. Slopes are nearly level, and draining the soils is difficult. In the Southeastern United States, these soils formed mostly in acid, late-Pleistocene sediments and are on low marine or stream terraces. Most of them have a season when the upper horizons are dry. Some of the Albaquults in the United States have been cleared for grazing or cropping, but many are still in forests.

Definition

Albaquults are the Aquults that:

1. Have an abrupt textural change between the ochric epipedon or the albic horizon and the argillic or kandic horizon and have saturated hydraulic conductivity in the argillic horizon of 0.4 cm/hr or slower;

2. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have plinthite that forms a continuous phase or constitutes half or more of the matrix of any subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HACA. Albaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Albaquults

HACB. Other Albaquults that have a kandic horizon.

Kandic Albaquults

HACC. Other Albaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Albaquults

HACD. Other Albaquults.

Typic Albaquults

Definition of Typic Albaquults

Typic Albaquults are the Albaquults that:

1. Have more than 50 percent chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm; *and*

2. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower; *and*

3. Do not have a kandic horizon.

Description of Subgroups

Typic Albaquults.—These are the Albaquults that have 50 percent or more chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to the Vertic subgroup because these properties are shared with Vertisols.

Typic Albaquults are nearly level and are difficult to drain. Some are cultivated, but many are used as pasture or are in forests. The soils occur mostly on the coastal plain of the Southeastern United States and are of moderately small extent.

Aeric Albaquults.—Chroma in these soils is 3 or more in more than 50 percent of some horizon between the bottom of the A or Ap horizon and a depth of 75 cm. The period of saturation with water in these soils is shorter than the one characteristic of Typic Albaquults. Aeric Albaquults are of very small extent in the United States and occur mostly in California. They generally are either cultivated or used as pasture.

Kandic Albaquults.—These soils are like Typic Albaquults, but they have a kandic horizon. Kandic Albaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Vertic Albaquults.—These soils are like Typic Albaquults, but they are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils are considered intergrades between Albaquults and Aquerts. Vertic Albaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Endoaquults

Endoaquults are the Aquults that have endoaquic saturation and do not have a mollic or umbric epipedon. The ground water fluctuates from a level near the soil surface to below the argillic horizon and is sometimes below a depth of 200 cm. These soils have an epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has moderately low or lower saturated hydraulic conductivity. They do not have a kandic horizon. They have no fragipan or horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface.

Before cultivation, most Endoaquults supported either deciduous broadleaf or coniferous forest plants. Generally, the soils are nearly level.

Definition

Endoaquults are the Aquults that:

1. Have endosaturation;

2. Do not have a kandic horizon;

3. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

4. Do not have an abrupt textural change at the upper boundary of the argillic horizon if the hydraulic conductivity of that horizon is 0.4 cm/hr or slower;

5. Do not have plinthite that either forms a continuous phase or constitutes more than half the matrix (by volume) in any horizon within 150 cm of the mineral soil surface;

6. Do not have a mollic or umbric epipedon; *and*

7. Have, with increasing depth within 150 cm of the mineral soil surface, a decrease of 20 percent or more (relative) from the maximum clay content and either less than 5 percent (by volume) clay depletions on faces of peds in the layer that has the 20 percent lower clay content or, below that layer, no clay increase or an increase of less than 3 percent (absolute).

Key to Subgroups

HAIA. Endoaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Endoaquults

HAIB. Other Endoaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Endoaquults

HAIC. Other Endoaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Endoaquults

HAID. Other Endoaquults.

Typic Endoaquults

Definition of Typic Endoaquults

Typic Endoaquults are the Endoaquults that:

1. Do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

2. Have more than 50 percent chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Description of Subgroups

Typic Endoaquults.—These are the Endoaquults that have 50 percent or more chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. These soils do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of the argillic horizon if the argillic horizon is at a depth of 50 cm or more. Slopes generally are nearly level. The natural vegetation consisted of forest plants. Some of the soils are cultivated, but many are used as pasture or are in forests. The soils occur mostly on the coastal plain of the Southeastern United States and are of moderate extent.

Aeric Endoaquults.—Chroma in these soils is 3 or more in more than 50 percent of some horizon between the bottom of the A or Ap horizon and a depth of 75 cm. The period of saturation with water in these soils is shorter than the one characteristic of Typic Endoaquults. Aeric Endoaquults are of small extent and occur mostly on the coastal plain of the Southeastern United States. The natural vegetation consisted of forest plants. Most of these soils are nearly level. Some have been cleared and artificially drained and are used as cropland or pasture, and some are used as forest.

Arenic Endoaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 50 and 100 cm thick. Many of the soils developed in somewhat sandier materials and have less clay in the argillic horizon than the Typic Endoaquults. Arenic Endoaquults are mainly on the coastal plain of the Southeastern United States. They are of small extent. The natural vegetation consisted of forest plants. Most of these soils are nearly level. Most are used as forest, but some have been cleared and artificially drained and are used as cropland or pasture.

Grossarenic Endoaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 100 and 200 cm thick in the major part of the pedon, but they are otherwise similar to Typic Endoaquults in defined properties. Grossarenic Endoaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Epiaquults

Epiaquults are the Aquults that have epiaquic saturation and do not have a mollic or umbric epipedon. Water is perched on a less permeable layer, commonly an argillic horizon. These soils have an epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has moderately low or lower saturated hydraulic conductivity. They do not have a kandic horizon. They do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface.

Before cultivation, most Epiaquults supported either deciduous broadleaf or coniferous forest plants. Slopes generally are nearly level.

Definition

Epiaquults are the Aquults that:

1. Do not have a kandic horizon;

2. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have an abrupt textural change at the upper boundary of the argillic horizon if the hydraulic conductivity of that horizon is low;

4. Do not have plinthite that either forms a continuous phase or constitutes more than half the matrix (by volume) in any horizon within 150 cm of the mineral soil surface;

5. Do not have a mollic or umbric epipedon;

6. Have, with increasing depth within 150 cm of the mineral soil surface, a decrease of 20 percent or more (relative) from the maximum clay content and either less than 5 percent (by volume) clay depletions on faces of peds in the layer that has the 20 percent lower clay content or, below that layer, no clay increase or an increase of less than 3 percent (absolute); *and*

7. Have episaturation.

Key to Subgroups

HAHA. Epiaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5

mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Epiaquults

HAHB. Other Epiaquults that have:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Fragic Epiaquults

HAHC. Other Epiaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Epiaquults

HAHD. Other Epiaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Epiaquults

HAHE. Other Epiaquults that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Epiaquults

HAHF. Other Epiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Epiaquults

HAHG. Other Epiaquults.

Typic Epiaquults

Definition of Typic Epiaquults

Typic Epiaquults are the Epiaquults that:

1. Do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

2. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

3. Have more than 50 percent chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm; *and*

4. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Epiaquults.—These are the Epiaquults that have 50 percent or more chroma of 2 or less in all horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm. These soils do not have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks. They do not have a sandy particle-size class throughout a layer extending from the mineral soil surface to the top of the argillic horizon if the argillic horizon is at a depth of 50 cm or more. Soils that have slickensides, wedge-shaped aggregates, a high linear extensibility, or wide cracks are assigned to the Vertic subgroup because these properties are shared with Vertisols.

Typic Epiaquults generally are nearly level. They occur mostly in the Eastern United States and are of very small extent. The natural vegetation consisted of forest plants. The soils commonly are underlain by slowly permeable materials and are difficult to drain. Some are used as cropland, but many are used as pasture or forest.

Aeric Epiaquults.—Chroma in these soils is 3 or more in more than 50 percent of some horizon between the bottom of the A or Ap horizon and a depth of 75 cm. The period of saturation with water in these soils is shorter than the one characteristic of Typic Epiaquults. Aeric Epiaquults range from nearly level to moderately steep. The natural vegetation consisted of forest plants. These soils are of small extent in the Eastern United States. Some are underlain by slowly permeable materials and are difficult to drain. Some are used as cropland, but many are used as pasture or forest.

Aeric Fragic Epiaquults.—Chroma in these soils is 3 or more in more than 50 percent of some horizon between the bottom of the A or Ap horizon and a depth of 75 cm. These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Epiaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 50 and 100 cm thick. They are otherwise like Typic Epiaquults in most other defined properties. Arenic Epiaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Fragic Epiaquults.—These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Grossarenic Epiaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 100 and 200 cm thick in the major part of the pedon. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Vertic Epiaquults.—These soils are similar to Typic Epiaquults, but they are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils are considered intergrades between Epiaquults and Aquerts. Vertic Epiaquults are of very small extent in the United States. The subgroup is provided for use in other parts of the world.

Fragiaquults

These are the Aquults that have a fragipan with an upper boundary within 100 cm of the mineral soil surface. Plinthite does not form a continuous phase or constitute one-half or more of the volume of any layer with an upper boundary within 150 cm of the mineral soil surface. Normally, the fragipan lies below the argillic or kandic horizon. In a few of the soils, however, it may be in the lower part of the argillic or kandic horizon. The fragipan in some Fragiaquults is virtually identical to the one in Alfisols, Inceptisols, and Spodosols. In some Fragiaquults, however, there is one aberrant feature—a small amount of plinthite. At this stage of knowledge, it is not certain that the fragipan that has plinthite is the same as the others. The behavior, however, is the same. For pragmatic reasons, the pan that has plinthite currently is considered to be a fragipan if its upper boundary is within 100 cm of the mineral soil surface.

Definition

Fragiaquults are the Aquults that:

1. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix of any subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HABA. Fragiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and the fragipan.

Aeric Fragiaquults

HABB. Other Fragiaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Fragiaquults

HABC. Other Fragiaquults that have a mollic or umbric epipedon.

Umbric Fragiaquults

HABD. Other Fragiaquults.

Typic Fragiaquults

Definition of Typic Fragiaquults

Typic Fragiaquults are the Fragiaquults that:

1. Do not have a mollic or umbric epipedon;

2. Have 50 percent or more chroma of 2 or less in all horizons between the A or Ap horizon and the fragipan; *and*

3. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface.

Description of Subgroups

Typic Fragiaquults.—The central concept or Typic subgroup of Fragiaquults is fixed on soils that have an ochric epipedon and are gray and mottled in all horizons between the bottom of the A or Ap horizon and the top of the fragipan. These soils have little or no plinthite in the fragipan.

The presence of plinthite is considered abnormal and is used to define the Plinthic subgroup. Chroma of 3 or more in some subhorizon above the fragipan suggests somewhat better drainage than that in Typic Fragiaquults and defines the Aeric subgroup.

Typic Fragiaquults generally are nearly level or gently sloping. They occur mostly in the Eastern United States and are of very small extent. The natural vegetation consisted of forest plants. The fragipan commonly is slowly permeable. As a result, these soils are difficult to drain. Some of the soils are used as cropland, but many are used as pasture or forest.

Aeric Fragiaquults.—These soils have dominant chroma of 3 or more in some horizon between the bottom of the A or Ap horizon and the top of the fragipan. They generally are somewhat better drained than soils of the Typic subgroup. Aeric Fragiaquults range from nearly level to moderately sloping. The natural vegetation consisted of forest plants. These soils are of very small extent in the Eastern United States. The fragipan commonly is slowly permeable. As a result, the soils are difficult to drain. Some of the soils are used as cropland, but many are used as pasture or forest.

Plinthic Fragiaquults.—These soils have plinthite that constitutes between 5 and 50 percent of the matrix in the fragipan. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Umbric Fragiaquults.—These soils have a mollic or umbric epipedon. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Kandiaquults

Kandiaquults are the Aquults that have a kandic horizon and a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils have an epipedon that rests on a kandic horizon without an abrupt textural change if the kandic horizon has moderately low or lower saturated hydraulic conductivity. They do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Kandiaquults are not known to occur in the United States. The great group is provided for use in other parts of the world.

Definition

Kandiaquults are the Aquults that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

4. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface;

5. Do not have a fragipan that has its upper boundary within 100 cm of the mineral soil surface; *and*

6. Do not have both an abrupt textural change between the epipedon or the albic horizon and the kandic horizon and a saturated hydraulic conductivity of 0.4 cm/hr or slower in the kandic horizon.

Key to Subgroups

HADA. Kandiaquults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acraquoxic Kandiaquults

HADB. Other Kandiaquults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiaquults

HADC. Other Kandiaquults that:

1. Have a mollic or umbric epipedon; *and*

2. Have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Umbric Kandiaquults

HADD. Other Kandiaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiaquults

HADE. Other Kandiaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiaquults

HADF. Other Kandiaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiaquults

HADG. Other Kandiaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Kandiaquults

HADH. Other Kandiaquults that have a mollic or umbric epipedon.

Umbric Kandiaquults

HADI. Other Kandiaquults.

Typic Kandiaquults

Definition of Typic Kandiaquults

Typic Kandiaquults are the Kandiaquults that:

1. Do not have a subhorizon that has dominant chroma of 3 or more within 75 cm of the mineral soil surface;

2. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

3. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

4. Do not have a mollic or umbric epipedon; *and*

5. Have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the mineral soil surface.

Description of Subgroups

Typic Kandiaquults.—The central concept or Typic subgroup of Kandiaquults is fixed on soils that (1) have dominantly low chroma between the A or Ap horizon and a depth of 75 cm or more from the mineral soil surface, (2) do not have a mollic or umbric epipedon, (3) do not have a thick epipedon with a sandy or sandy-skeletal particle-size class throughout, (4) have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface, and (5) have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the mineral soil surface.

A chroma higher than that of Typic Kandiaquults is characteristic of soils that are saturated for shorter periods and serves to define intergrades to freely drained soils. Color values, moist, of 2 or 3 in a plow layer indicate a higher-than-normal content of organic matter and form the basis for defining intergrades to other great groups. A thick layer of sand or loamy sand, starting at the mineral soil surface, is the basis for defining the Arenic and Grossarenic subgroups.

Typic Kandiaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Acraquoxic Kandiaquults.—These soils have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface. Recycling of plant nutrients from decaying vegetation is critical for plant growth on the soils. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aeric Kandiaquults.—Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup, but they are otherwise like Typic Kandiaquults in their defined properties and in many other properties. Aeric Kandiaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Kandiaquults.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. These soils are not known to occur in the United States.

Arenic Plinthic Kandiaquults.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. They also have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Umbric Kandiaquults.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm below the mineral soil surface. They also have an umbric or mollic epipedon. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Grossarenic Kandiaquults.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Plinthic Kandiaquults.—These soils have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Umbric Kandiaquults.—These soils are like Typic Kandiaquults, but they have an umbric or mollic epipedon.

They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Kanhaplaquults

Kanhaplaquults are the Aquults that have a kandic horizon and a clay distribution in which the percentage of clay decreases from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, and the layer in which the clay percentage decreases has less than 5 percent of the volume consisting of clay depletions on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils have an epipedon that rests on a kandic horizon without an abrupt textural change if the kandic horizon has moderately low or lower saturated hydraulic conductivity. They do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Kanhaplaquults are not known to occur in the United States. The great group is provided for use in other parts of the world.

Definition

Kanhaplaquults are the Aquults that:

1. Have a kandic horizon;

2. Have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of clay depletions on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface;

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have both an abrupt textural change between the epipedon or the albic horizon and the kandic horizon and saturated hydraulic conductivity of 0.4 cm/hr or slower in the kandic horizon.

Key to Subgroups

HAEA. Kanhaplaquults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

1. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

2. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

3. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

a. In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

b. [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Kanhaplaquults

HAEB. Other Kanhaplaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhaplaquults

HAEC. Other Kanhaplaquults that:

1. Have a mollic or umbric epipedon; *and*

2. Have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Umbric Kanhaplaquults

HAED. Other Kanhaplaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Kanhaplaquults

HAEE. Other Kanhaplaquults that have a mollic or umbric epipedon.

Umbric Kanhaplaquults

HAEF. Other Kanhaplaquults.

Typic Kanhaplaquults

Definition of Typic Kanhaplaquults

Typic Kanhaplaquults are the Kanhaplaquults that:

1. Do not have a mollic or umbric epipedon;

2. Do not have a subhorizon that has dominant chroma of 3 or more within 75 cm of the mineral soil surface;

3. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface; *and*

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0

g/cm^3 or less, measured at 33 kPa water retention, and Al plus ½ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus ½ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Description of Subgroups

Typic Kanhaplaquults.—The central concept or Typic subgroup of Kanhaplaquults is fixed on soils that (1) have dominantly low chroma between the A or Ap horizon and a depth of 75 cm or more from the mineral soil surface, (2) do not have a mollic or umbric epipedon, (3) have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface, and (4) do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals or that consists of slightly or moderately weathered pyroclastic materials.

A chroma higher than that of Typic Kanhaplaquults is characteristic of soils that are saturated for shorter periods and serves to define intergrades to freely drained soils. A mollic or umbric epipedon is the basis for defining the Umbric subgroup.

Typic Kanhaplaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aeric Kanhaplaquults.—Below the A or Ap horizon, these soils have chroma that is too high for the Typic subgroup, but they are otherwise like Typic Kanhaplaquults in their defined properties and in many other properties. Aeric Kanhaplaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aeric Umbric Kanhaplaquults.—These soils have an umbric or mollic epipedon. Below the A or Ap horizon, they have chroma that is too high for the Typic subgroup. They are otherwise like Typic Kanhaplaquults in their defined properties and in many other properties. Aeric Umbric Kanhaplaquults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquandic Kanhaplaquults.—These soils are influenced by volcanic ejecta. When weathered, they have high P-retention, low bulk density, and high porosity. They are not known to occur in the United States.

Plinthic Kanhaplaquults.—These soils have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Umbric Kanhaplaquults.—These soils have an umbric or mollic epipedon. They are otherwise like Typic Kanhaplaquults in their defined properties and in most other properties. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Paleaquults

These are the Aquults that have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent increase in clay content below this layer. These soils have an epipedon that rests on an argillic horizon without an abrupt textural change if the argillic horizon has moderately low or lower saturated hydraulic conductivity. They do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface.

Paleaquults formed mostly on mid-Pleistocene or older land surfaces, on high marine or river terraces or old deltas. They are of large extent in the Southeastern United States. The natural vegetation consisted of forest plants, mostly water-tolerant conifers or hardwood trees.

Definition

Paleaquults are the Aquults that:

1. Have a clay distribution in which the percentage of clay does not decrease from its maximum by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Do not have a kandic horizon;

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

5. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 150 cm of the mineral soil surface; *and*

6. Do not have both an abrupt textural change between the epipedon or the albic horizon and the argillic horizon and saturated hydraulic conductivity of 0.4 cm/hr or slower in the argillic horizon.

Key to Subgroups

HAFA. Paleaquults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleaquults

HAFB. Other Paleaquults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleaquults

HAFC. Other Paleaquults that:

1. Have a mollic or umbric epipedon; *and*

2. Have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Umbric Paleaquults

HAFD. Other Paleaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleaquults

HAFE. Other Paleaquults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleaquults

HAFF. Other Paleaquults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleaquults

HAFG. Other Paleaquults that have 50 percent or more chroma of 3 or more in one or more horizons between either the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm.

Aeric Paleaquults

HAFH. Other Paleaquults that have a mollic or umbric epipedon.

Umbric Paleaquults

HAFI. Other Paleaquults.

Typic Paleaquults

Definition of Typic Paleaquults

Typic Paleaquults are the Paleaquults that:

1. Do not have, between either the bottom of the A or Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm from the mineral soil surface, a horizon that has dominant chroma of 3 or more;

2. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

3. Have less than 5 percent (by volume) plinthite in all horizons within 150 cm of the mineral soil surface;

4. Do not have a mollic or umbric epipedon; *and*

5. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Description of Subgroups

Typic Paleaquults.—The central concept or Typic subgroup of Paleaquults is fixed on soils that have grayish colors in the matrix below the A or Ap horizon, do not have plinthite, have a texture finer than loamy fine sand within 50 cm of the mineral soil surface, and have an ochric epipedon.

Chroma in some subhorizon too high for Typic Paleaquults is a characteristic used to define the Aeric subgroup, an intergrade to Paleudults. A thick sandy layer, starting at the mineral soil surface, defines Arenic and Grossarenic subgroups. A small amount of plinthite suggests intergrades to Plinthaquults. An umbric or mollic epipedon is used to define the Umbric subgroup.

Typic Paleaquults generally are nearly level. They occur mostly on the coastal plain of the Southeastern United States and are of moderate extent. The natural vegetation consisted of forest plants. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Aeric Paleaquults.—These soils have a subhorizon, generally near the surface, that has chroma of 3 or more and normally have a seasonal high water table that is deeper than that in Typic Paleaquults or has more oxygen. Aeric Paleaquults commonly are nearly level or gently sloping. The natural vegetation consisted of forest plants. These soils occur mostly on the coastal plain of the Southeastern United States and are of moderate extent. Many of the soils have been cleared and are used as cropland, but some are used as pasture or forest.

Arenic Paleaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and are permitted to have brownish colors in the matrix below the A or Ap horizon, but they are otherwise like Typic Paleaquults in defined properties. Most Arenic Paleaquults developed in somewhat sandier materials and have less clay in the argillic horizon than the soils in the Typic subgroup. The natural vegetation consisted of forest plants. The Arenic Paleaquults in the United States are mainly on the coastal plains in Georgia, Alabama, and Florida. They are moderately extensive. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Arenic Plinthic Paleaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and have 5 to 50 percent plinthite at a depth of less than 150 cm. The horizons that have plinthite are mostly firm and less permeable than the overlying horizons. The Arenic Plinthic Paleaquults in the United States are mostly in Florida and Georgia. They are of small extent. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Arenic Umbric Paleaquults.—These soils have an umbric or mollic epipedon, and their particle-size class is sandy or sandy-skeletal to a depth between 50 and 100 cm, although the epipedon is not necessarily that thick. These soils formed in somewhat sandier parent materials and in some areas are wetter than Typic Paleaquults. Arenic Umbric Paleaquults are of very small extent in the Southeastern United States. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Grossarenic Paleaquults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 100 and 200 cm thick in the major part of the pedon and are permitted to have brownish colors in the matrix below the A or Ap horizon, but they are otherwise similar to Typic Paleaquults in defined properties. The parent materials commonly are more sandy than those of the soils in the Typic subgroup. Grossarenic Paleaquults are of small extent in the Southeastern United States. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Plinthic Paleaquults.—These soils have 5 to 50 percent (by volume) plinthite in some horizon within 150 cm of the mineral soil surface. They are of small extent in the Southern United States. These soils are used as forest or have been cleared and are used as cropland or pasture.

Umbric Paleaquults.—These soils have an umbric or mollic epipedon but are otherwise like Typic Paleaquults in defined properties. Many Umbric Paleaquults are the wettest of the Paleaquults and are ponded in winter. Umbric Paleaquults are of small extent in the Southeastern United States. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Vertic Paleaquults.—These soils are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. These soils are intergrades between Paleaquults and Aquerts. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Plinthaquults

These are the Aquults that have plinthite that either forms a continuous phase or constitutes more than half the matrix of some subhorizon within 125 cm of the mineral soil surface. These soils are mostly in intertropical areas. They make up a small area in Puerto Rico.

Definition

Plinthaquults are the Aquults that have plinthite that forms a continuous phase or constitutes more than half the matrix of some subhorizon within 125 cm of the mineral soil surface.

Key to Subgroups

HAAA. Plinthaquults that have a kandic horizon or a CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more (by volume) of the argillic horizon if less than 100 cm thick or of its upper 100 cm.

Kandic Plinthaquults

HAAB. Other Plinthaquults.

Typic Plinthaquults

Definition of Typic Plinthaquults

Typic Plinthaquults are the Plinthaquults that have a CEC of 24 cmol(+) or more per kg clay (by 1N NH_4OAc pH 7) in the major part of the argillic horizon or the major part of the upper 100 cm of the argillic horizon if it is thicker than 100 cm.

Description of Subgroups

Typic Plinthaquults.—Typic Plinthaquults are the Plinthaquults that have a CEC of 24 cmol(+) or more per kg clay (by 1N NH_4OAc pH 7) in 50 percent or more of the argillic horizon or of the upper 100 cm of the argillic horizon if it is thicker than 100 cm. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Kandic Plinthaquults.—These are the Plinthaquults that have a kandic horizon or have a CEC of less than 24 cmol(+)

per kg clay (by 1N NH_4OAc pH 7) in 50 percent or more of the argillic horizon or of the upper 100 cm of the argillic horizon if it is thicker than 100 cm. These soils are of very small extent. They are known to occur only in Puerto Rico.

Umbraquults

These are the Aquults that commonly have an umbric epipedon. These soils do not have a horizon within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. They do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface or a kandic horizon. They do not have both an abrupt textural change between an albic horizon and the argillic horizon and low or very low saturated hydraulic conductivity in the argillic horizon. They have, within 150 cm of the mineral soil surface, either a densic, lithic, paralithic, or petroferric contact, or they have, with increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content and less than 5 percent (by volume) skeletans on faces of peds in the layer that has the 20 percent lower clay content or, below that layer, no clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Umbraquults are among the wettest of the Aquults, and their argillic horizon is not so strongly developed as that in most of the other Aquults. The natural vegetation consisted mostly of water-tolerant trees and herbs.

Definition

Umbraquults are the Aquults that:

1. Have an umbric or mollic epipedon;

2. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have plinthite that forms a continuous phase or constitutes more than half of the matrix of any subhorizon within 150 cm of the mineral soil surface;

4. Have a clay distribution in which the percentage of clay decreases from its maximum by 20 percent or more within a depth of 150 cm below the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of clay depletions on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer;

5. Do not have an abrupt textural change at the upper boundary of the argillic horizon if the hydraulic conductivity of that horizon is 0.4 cm/hr or slower; *and*

6. Do not have a kandic horizon.

Key to Subgroups

HAGA. Umbraquults that have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Umbraquults

HAGB. Other Umbraquults.

Typic Umbraquults

Definition of Typic Umbraquults

Typic Umbraquults are the Umbraquults that have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface.

Description of Subgroups

Typic Umbraquults.—These soils are the Umbraquults that do not have plinthite that constitutes 5 percent or more of the matrix of any subhorizon within 150 cm of the soil surface. They are moderately extensive on the low coastal plains along the Atlantic Ocean. Some of the soils have been drained and cleared and are used as cropland or pasture, but many are used as forest.

Plinthic Umbraquults.—These soils have plinthite that constitutes 5 percent or more of the matrix of a horizon within 150 cm of the soil surface. This subgroup is not known to occur in the United States. It is provided for use in other parts of the world.

Humults

Humults are the more or less freely drained, humus-rich Ultisols of mid or low latitudes. At mid latitudes they are mostly dark colored, but at low latitudes the content of humus is not necessarily reflected by the color. These soils are mainly in mountainous areas that have high rainfall but also have a moisture deficit during some season. Most of the Humults in the United States formed in a basic country rock on surfaces that are late Pleistocene or older. Slopes commonly are strong. If the soils are cultivated, the argillic or kandic horizon may be at the surface. To keep the eroded and uneroded soils together in the classification, the definition of the suborder is written in terms of the carbon content of the whole soil or of the argillic or kandic horizon. The natural vegetation consisted mostly of coniferous forest plants at mid latitudes and rain forest plants at low latitudes.

Definition

Humults are the Ultisols that do not have both aquic conditions and the colors defined for Aquults and that meet *either or both* of the following:

1. Have 0.9 percent or more organic carbon in the upper 15 cm of the argillic or kandic horizon; *or*

2. Have 12 kg or more organic carbon in a unit volume of 1 m^2 to a depth of 100 cm, exclusive of any O horizon.

Key to Great Groups

HBA. Humults that have a sombric horizon within 100 cm of the mineral soil surface.

Sombrihumults, p. 747

HBB. Other Humults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Plinthohumults, p. 747

HBC. Other Humults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Kandihumults, p. 741

HBD. Other Humults that have a kandic horizon.

Kanhaplohumults, p. 743

HBE. Other Humults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Palehumults, p. 745

HBF. Other Humults.

Haplohumults, p. 739

Haplohumults

These are the Humults that have an argillic horizon and have one of the following: (1) a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface or (2) with increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content and less than 5 percent (by volume) clay depletions on faces of peds in any layer that has a 20 percent lower clay content or, below that layer, the fine-earth fraction has a clay increase of less than 3 percent. Many of these soils have a thin argillic horizon. The Haplohumults in the United States are mainly in mountains close to the Pacific Ocean and have gentle to very steep slopes. Most of the soils had and still have a coniferous forest vegetation. Their content of organic carbon, in kilograms per hectare, commonly is high relative to that of most other kinds of soil. Some of the soils have an umbric epipedon, but many have a color value and chroma higher than the value and chroma of mollic or umbric epipedons.

Definition

Haplohumults are the Humults that:

1. Do not have a fragipan or kandic horizon;

2. Have a clay distribution in which, with increasing depth, the percentage of clay decreases from its maximum amount by more than 20 percent within 150 cm of the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer;

3. Do not have a sombric horizon within 100 cm of the mineral soil surface; *and*

4. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HBFA. Haplohumults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplohumults

HBFB. Other Haplohumults that have *both*:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or

less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Haplohumults

HBFC. Other Haplohumults that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplohumults

HBFD. Other Haplohumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haplohumults

HBFE. Other Haplohumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haplohumults

HBFF. Other Haplohumults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Haplohumults

HBFG. Other Haplohumults that have an ustic moisture regime.

Ustic Haplohumults

HBFH. Other Haplohumults that have a xeric moisture regime.

Xeric Haplohumults

HBFI. Other Haplohumults.

Typic Haplohumults

Definition of Typic Haplohumults

Typic Haplohumults are the Haplohumults that:

1. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus 1/2 acid-oxalate-extractable iron of more than 1.0 percent;

2. Have a udic moisture regime;

3. In normal years are not saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

4. Do not have a lithic contact within 50 cm of the mineral soil surface; *and*

5. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface.

Description of Subgroups

Typic Haplohumults.—The central concept or Typic subgroup of Haplohumults is fixed on relatively freely drained soils that have a udic moisture regime.

Both the precipitation and the humidity are high. Redox depletions with low chroma and a fluctuating level of ground water are properties shared with Aquults and define the Aquic subgroup. An appreciable amount of plinthite is considered abnormal and is used to define the Plinthic subgroup. Ustic and xeric moisture regimes are considered abnormal but are highly significant to soil-plant relationships and define the Ustic and Xeric subgroups, respectively. A shallow lithic contact is the basis for definition of the Lithic subgroup. Soils that have a thin mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals are excluded because they are considered to be intergrades to Andisols.

Typic Haplohumults are gently sloping to very steep. They are moderately extensive in the Western United States. They are mostly in western Oregon, Puerto Rico, California, and Hawaii. Most of the soils are used as forest. Where slopes are suitable, some of the soils have been cleared and are used as cropland or pasture.

Andic Haplohumults.—These soils have a surface mantle that has a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are rare in the United States and occur only in the western part of the State of Washington. The natural vegetation consisted of coniferous forest plants. Slopes range from gentle to very steep. These soils are used as forest.

Aquandic Haplohumults.—These soils have a surface mantle that has a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. They have redox depletions with low chroma, and the level of ground water fluctuates in the horizons with redoximorphic depletions or the soils are artificially drained. These soils occur in the Pacific Northwest.

Aquic Haplohumults.—These soils have redox depletions with low chroma, and the level of ground water fluctuates in the horizons with redoximorphic depletions or the soils are artificially drained. These soils developed in sediments derived largely from basic rocks. They are of small extent, mostly in

Oregon, in the United States. The natural vegetation consisted of coniferous forest plants. Slopes generally are nearly level or gently sloping. Many of the soils have been cleared and are used as hayland, pasture, or cropland.

Lithic Haplohumults.—These soils have a shallow lithic contact and an argillic horizon that commonly is thin. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Oxyaquic Haplohumults.—These soils are saturated with water for 20 consecutive days and/or 30 cumulative days within 100 cm of the mineral soil surface during normal years. They may or may not have redoximorphic features. If they occur, the redoximorphic features are either weakly expressed or lower in the profile than is defined for the Aquic subgroup. Oxyaquic Haplohumults occur in Oregon and are used for timber production or pasture.

Plinthic Haplohumults.—These soils have a subhorizon with 5 to 50 percent (by volume) plinthite within 150 cm of the mineral soil surface. They are rare in the United States and are known to occur only on marine terraces along the northern California coast. The natural vegetation consisted of coniferous forest plants. Slopes generally are nearly level to moderately steep. Most of these soils are used as forest, but some are used as sites for homes.

Ustic Haplohumults.—These soils have an ustic soil moisture regime. They occur in Hawaii and along the coast of California, where the soil temperature regime is isomesic, isothermic, or isohyperthermic. The natural vegetation consisted of forest plants. Slopes generally are nearly level to moderately steep. Most of these soils are used as pasture, but some are used as cropland or homesites.

Xeric Haplohumults.—These soils have a xeric moisture regime but are otherwise like Typic Haplohumults in defined properties. Most Xeric Haplohumults have an ochric epipedon despite the high content of organic carbon. The color of the epipedon is dark, but the chroma is too high for an umbric epipedon. Xeric Haplohumults are moderately extensive and occur mostly in California and Oregon. In the United States, slopes are nearly level to very steep. Most of these soils are used as forest, but some are used as cropland, pasture, or homesites.

Kandihumults

Kandihumults are the Humults that have a kandic horizon and a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils do not have a sombric horizon. They have no horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Kandihumults are of small extent in California and Hawaii.

Definition

Kandihumults are the Humults that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

4. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

5. Do not have plinthite that forms a continuous phase or that constitutes more than 50 percent of the volume of some subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HBCA. Kandihumults that meet *all* of the following:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, have a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. In one or more horizons within 75 cm of the mineral soil surface, have redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

3. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Andic Ombroaquic Kandihumults

HBCB. Other Kandihumults that have *both*:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. An ustic moisture regime.

Ustandic Kandihumults

HBCC. Other Kandihumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandihumults

HBCD. Other Kandihumults that have, in one or more subhorizons within the upper 25 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandihumults

HBCE. Other Kandihumults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kandihumults

HBCF. Other Kandihumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandihumults

HBCG. Other Kandihumults that have an ustic moisture regime.

Ustic Kandihumults

HBCH. Other Kandihumults that have a xeric moisture regime.

Xeric Kandihumults

HBCI. Other Kandihumults that have an anthropic epipedon.

Anthropic Kandihumults

HBCJ. Other Kandihumults.

Typic Kandihumults

Definition of Typic Kandihumults

Typic Kandihumults are the Kandihumults that:

1. Do not have, in any subhorizon within the upper 25 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. Have a udic moisture regime;

3. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

5. Do not have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

6. Do not have an anthropic epipedon.

Description of Subgroups

Typic Kandihumults.—The central concept or Typic subgroup of Kandihumults is fixed on freely drained soils that do not have an anthropic epipedon and have a udic moisture regime. These soils also have less than 5 percent plinthite in all horizons to a depth of 150 cm or more below the mineral soil surface. Soils that have redox depletions with low chroma near the surface in one or more horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from Typic Kandihumults because these properties are shared with Aquults.

Soils that have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals are excluded from the Typic subgroup because they are considered to be intergrades to Andisols. A soil moisture regime that is ustic or xeric is considered abnormal and defines the Ustic and Xeric subgroups, respectively.

Typic Kandihumults are of small extent in the United States and are known to occur only in California. The natural vegetation consisted of coniferous forest plants. Slopes range from gentle to steep. These soils are used mostly as forest. Where slopes are suitable, some of the soils have been cleared and are used as cropland or pasture.

Andic Kandihumults.—These soils have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals. They are not known to occur in the United States. They are defined for use in other parts of the world.

Andic Ombroaquic Kandihumults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. They also have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Anthropic Kandihumults.—These soils are similar to Typic Kandihumults, but they have been used as cropland for long periods and have an anthropic epipedon. They are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Kandihumults.—These soils are like Typic Kandihumults, but they have redox depletions with low chroma within 75 cm of the mineral soil surface. The redox depletions are caused by periods of wetness. The soils are in nearly level to sloping areas. They are not known to occur in the United States. They are defined for use in other parts of the world.

Ombroaquic Kandihumults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Plinthic Kandihumults.—These soils are similar to Typic Kandihumults, but they have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Ustandic Kandihumults.—These soils have an ustic moisture regime and a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals. They are not known to occur in the United States. They are defined for use in other parts of the world.

Ustic Kandihumults.—These soils are like Typic Kandihumults, but they have an ustic moisture regime. They are intergrades between Kandihumults and Kandiustults. Ustic Kandihumults are not known to occur in the United States. They are defined for use in other parts of the world.

Xeric Kandihumults.—These soils are like Typic Kandihumults, but they have a xeric moisture regime. They are intergrades between Kandihumults and Xerults. Xeric Kandihumults are not known to occur in the United States. They are defined for use in other parts of the world.

Kanhaplohumults

Kanhaplohumults are the Humults that have a kandic horizon and have a clay distribution in which the percentage of clay decreases from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, and the layer in which the clay percentage decreases has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils do not have a sombric horizon within 100 cm of the mineral soil surface. They have no horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Kanhaplohumults are of very small extent and are known to occur only in California and Hawaii in the United States.

Definition

Kanhaplohumults are the Humults that:

1. Have a kandic horizon;

2. Have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer;

3. Do not have a sombric horizon within 150 cm of the mineral soil surface; *and*

4. Do not have plinthite that forms a continuous phase or that constitutes more than 50 percent of the volume of some subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HBDA. Kanhaplohumults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplohumults

HBDB. Other Kanhaplohumults that have *both*:

1. An ustic moisture regime; *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Ustandic Kanhaplohumults

HBDC. Other Kanhaplohumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhaplohumults

HBDD. Other Kanhaplohumults that have, in one or more subhorizons within the upper 25 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplohumults

HBDE. Other Kanhaplohumults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kanhaplohumults

HBDF. Other Kanhaplohumults that have an ustic moisture regime.

Ustic Kanhaplohumults

HBDG. Other Kanhaplohumults that have a xeric moisture regime.

Xeric Kanhaplohumults

HBDH. Other Kanhaplohumults that have an anthropic epipedon.

Anthropic Kanhaplohumults

HBDI. Other Kanhaplohumults.

Typic Kanhaplohumults

Definition of Typic Kanhaplohumults

Typic Kanhaplohumults are the Kanhaplohumults that:

1. Do not have, in any subhorizon within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Have a udic moisture regime;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus 1/2 acid-oxalate-extractable iron of more than 1.0 percent;

5. Have, within 75 cm of the mineral soil surface, hue of 7.5YR or redder in all horizons with a color value, moist, of 4 or more if there are redox concentrations or if the hue becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

6. Do not have an anthropic epipedon.

Description of Subgroups

Typic Kanhaplohumults.—The central concept or Typic subgroup of Kanhaplohumults is fixed on moderately deep or deeper, freely drained soils that do not have an anthropic epipedon and that have a udic moisture regime. Soils that have redox depletions with low chroma near the surface in one or more horizons that also have aquic conditions for some time in normal years (or artificial drainage) are excluded from the Typic subgroup because these properties are shared with Aquults.

Soils that have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals are excluded from the Typic subgroup because they are considered to be intergrades to Andisols. A soil moisture regime that is ustic or xeric is considered abnormal and defines the Ustic and Xeric subgroups, respectively.

Typic Kanhaplohumults are of very small extent in the United States and are known to occur only in California and Hawaii. The natural vegetation consisted of forest plants. Slopes range from nearly level to sloping. These soils are used mostly as forest, cropland, or pasture.

Andic Kanhaplohumults.—These soils have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals. They are not known to occur in the United States. They are defined for use in other parts of the world.

Anthropic Kanhaplohumults.—These soils are similar to Typic Kanhaplohumults, but they have been used as cropland for long periods and have an anthropic epipedon. They are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Kanhaplohumults.—These soils are similar to Typic Kanhaplohumults, but they have redox depletions with low chroma within 75 cm of the mineral soil surface. The redox depletions are caused by periods of wetness. The soils are in nearly level to sloping areas. They are not known to occur in the United States. They are defined for use in other parts of the world.

Lithic Kanhaplohumults.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. They are defined for use in other parts of the world.

Ombroaquic Kanhaplohumults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. They are not known to occur in the United States. They are defined for use in other parts of the world.

Ustandic Kanhaplohumults.—These soils have an ustic moisture regime and a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals. They are not known to occur in the United States. They are defined for use in other parts of the world.

Ustic Kanhaplohumults.—These soils are like Typic Kanhaplohumults, but they have an ustic moisture regime. They are intergrades between Kanhaplohumults and Kanhaplustults. They are not known to occur in the United States. The subgroup is defined for use in other parts of the world.

Xeric Kanhaplohumults.—These soils are like Typic Kanhaplohumults, but they have a xeric moisture regime. They are intergrades between Kanhaplohumults and Xerults. Xeric Kanhaplohumults are not known to occur in the United States. The subgroup is defined for use in other parts of the world.

Palehumults

These are the Humults that are on old stable surfaces and that have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent increase in clay content below this layer. These soils have an argillic horizon. They do not have plinthite that forms a continuous phase or that constitutes more than half the volume of any subhorizon within 125 cm of the mineral soil surface. These soils are moderately extensive. They are mostly in California, western Oregon and Washington, and Hawaii. Like other Humults in the United States, they formed mostly in material weathered from basic rocks or in alluvium derived from basic rocks. Most Palehumults have had a forest vegetation, and many still have a forest vegetation.

Definition

Palehumults are the Humults that:

1. Do not have a kandic horizon;

2. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

3. Do not have a sombric horizon within 100 cm of the mineral soil surface; *and*

4. Do not have plinthite that forms a continuous phase or that constitutes more than half the volume of any subhorizon within 125 cm of the mineral soil surface.

Key to Subgroups

HBEA. Palehumults that have *both*:

1. In one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Palehumults

HBEB. Other Palehumults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palehumults

HBEC. Other Palehumults that have, in one or more subhorizons within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Palehumults

HBED. Other Palehumults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Palehumults

HBEE. Other Palehumults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Palehumults

HBEF. Other Palehumults that have an ustic moisture regime.

Ustic Palehumults

HBEG. Other Palehumults that have a xeric moisture regime.

Xeric Palehumults

HBEH. Other Palehumults.

Typic Palehumults

Definition of Typic Palehumults

Typic Palehumults are the Palehumults that:

1. In normal years are not saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days;

2. Have a udic moisture regime;

3. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface; *and*

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent.

Description of Subgroups

Typic Palehumults.—The central concept or Typic subgroup of Palehumults is fixed on freely drained soils that have a udic moisture regime. These soils typically have an ochric epipedon and albic and argillic horizons. Redox depletions with low chroma and a fluctuating level of ground water are properties shared with Aquults and define the Aquic subgroup. An appreciable amount of plinthite is considered abnormal and is used to define the Plinthic subgroup. Ustic and xeric moisture regimes are considered abnormal but are highly significant to soil-plant relationships and define Ustic and Xeric subgroups, respectively. Soils that have a mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals are excluded from the Typic subgroup because they are considered to be intergrades to Andisols.

Typic Palehumults are moderately extensive in the United States. They are mostly in western Oregon and Washington, in Hawaii, and in Puerto Rico. The natural vegetation consisted mostly of coniferous forest plants in Oregon and Washington and tropical broadleaf forest plants in Hawaii and Puerto Rico. Slopes range from nearly level to very steep. These soils are used mostly as forest. Where slopes are suitable, some of the soils have been cleared and are used as pasture, cropland, or homesites.

Andic Palehumults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are of very small extent in California. The natural vegetation consisted mostly of grasses and shrubs. Slopes range from nearly level to moderately sloping. These soils are used mostly as pasture or cropland.

Aquandic Palehumults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. They have redox depletions with low chroma, and the level of ground water fluctuates in the iron-depleted horizons or the soils are artificially drained. These soils occur in the Pacific Northwest.

Aquic Palehumults.—These soils have redox depletions with low chroma, and the level of ground water fluctuates in the redox-depleted horizons or the soils are artificially drained. In the United States, these soils are of very small extent and occur in western Oregon. The natural vegetation consisted mostly of coniferous forest plants. Slopes range from nearly level to steep. These soils are used mostly as forest. Some of the less sloping soils have been cleared and are used as pasture.

Oxyaquic Palehumults.—These soils are saturated with water for 20 or more consecutive days and/or 30 or more cumulative days during normal years. They may or may not have redoximorphic features. If present, the redoximorphic features are either weakly expressed or lower in the profile than is required for the Aquic subgroup. Oxyaquic Palehumults occur in the Pacific Northwest and are used as pasture or woodland.

Plinthic Palehumults.—These soils have 5 to 50 percent (by volume) plinthite in some horizon within 150 cm of the mineral soil surface but otherwise are similar to the soils in the Typic subgroup. Plinthic Palehumults are of very small extent. They are known to occur in Puerto Rico. The natural vegetation consisted of tropical trees and shrubs. These soils are used mostly as pasture or cropland.

Ustic Palehumults.—These soils have an ustic moisture regime. They are of very small extent in the United States. They are known to occur in Hawaii. They are used mostly as pasture or cropland.

Xeric Palehumults.—These soils have a xeric moisture regime but are otherwise like Typic Palehumults in defined properties. They are moderately extensive in the United States. They occur in the Sierra Nevada and Coast Ranges of California and the Coast Range and western Cascade Mountains of Oregon and Washington. They also occur in the Willamette Valley and Puget lowlands of Oregon and Washington, respectively. The natural vegetation consisted mostly of coniferous forest plants. Slopes range from nearly level to very steep. These soils are used mostly as forest. Where slopes are suitable, some of the soils have been cleared and are used as pasture, cropland, or homesites.

Plinthohumults

Plinthohumults are the Humults that do not have a sombric horizon within 100 cm of the mineral soil surface and have plinthite that forms a continuous phase in, or constitutes more than half the volume of, one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States. The great group has been provided for use in other countries.

Key to Subgroups

HBBA. All Plinthohumults.

Typic Plinthohumults

Sombrihumults

These Humults have a sombric horizon that has its upper boundary within 100 cm of the mineral soil surface. They are not known to occur in the United States. The great group is provided for use elsewhere.

Key to Subgroups

HBAA. All Sombrihumults.

Typic Sombrihumults

Udults

These are the more or less freely drained, humus-poor Ultisols that have a udic moisture regime. They are in humid climates, and most receive well distributed rainfall. Most have light colored upper horizons, commonly a grayish horizon that rests on a yellowish brown to reddish argillic or kandic horizon. A few that developed from basic rocks have a dark brown or reddish brown surface horizon that rests on a dark red or dusky red argillic or kandic horizon. Some have a fragipan or plinthite, or both, in or below the argillic or kandic horizon.

Udults developed in sediments and on surfaces that range from late Pleistocene to Pliocene or possibly older. Many are cultivated, either with the use of soil amendments or in a system in which they are cropped for a very few years and then are returned to forest to allow the trees to regather in their tissues the small supply of nutrients. Most of these soils have or had a forest vegetation, but some have a savanna that probably is anthropic.

Definition

Udults are the Ultisols that:

1. Do not have both aquic conditions and the colors defined for Aquults;

2. Have less than 0.9 percent, by weighted average, organic carbon in the upper 15 cm of the argillic or kandic horizon and have less than 12 kg organic carbon in a unit volume of 1 m^2 to a depth of 100 cm, exclusive of any O horizon; *and*

3. Have a udic moisture regime.

Key to Great Groups

HCA. Udults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.
Plinthudults, p. 766

HCB. Other Udults that have a fragipan with an upper boundary within 100 cm of the mineral soil surface.
Fragiudults, p. 748

HCC. Other Udults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Kandiudults, p. 754

HCD. Other Udults that have a kandic horizon.
Kanhapludults, p. 758

HCE. Other Udults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) clay depletions on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Paleudults, p. 761

HCF. Other Udults that have *both*:

1. An epipedon that has a color value, moist, of 3 or less throughout; *and*

2. In all subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Rhodudults, p. 766

HCG. Other Udults.

Hapludults, p. 750

Fragiudults

These are the Udults that have a fragipan with an upper boundary within 100 cm of the mineral soil surface. They have no horizon within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume. These soils formed mainly in loamy alluvium or in residuum. The fragipan commonly has an upper boundary about 50 to 75 cm below the mineral soil surface. Perched ground water is above the pan at some period during the year, and many of the soils have thick, gray clay depletions near the top of the fragipan and in vertical seams between structural units.

The Fragiudults in the United States are principally on gentle slopes throughout the Southeastern States. The temperature regime is mesic or thermic. The vegetation on the Fragiudults in the United States has been a forest either of conifers or of broadleaf deciduous trees.

Definition

Fragiudults are the Udults that:

1. Have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Key to Subgroups

HCBA. Fragiudults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm.

Arenic Fragiudults

HCBB. Other Fragiudults that have *both* of the following:

1. In one or more horizons within 40 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthaquic Fragiudults

HCBC. Other Fragiudults that meet *both* of the following:

1. Meet *one or more* of the following:

a. Have a glossic horizon above the fragipan; *or*

b. Do not have, above the fragipan, an argillic or kandic horizon that has clay films on both vertical and horizontal surfaces of any structural aggregates; *or*

c. Between the argillic or kandic horizon and the fragipan, have one or more horizons with 50 percent or more chroma of 3 or less and with a clay content 3 percent or more (absolute, in the fine-earth fraction) lower than that in both the argillic or kandic horizon and the fragipan; *and*

2. In one or more horizons within 40 cm of the mineral soil surface, have redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Glossaquic Fragiudults

HCBD. Other Fragiudults that have, in one or more subhorizons above the fragipan and within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Fragiudults

HCBE. Other Fragiudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Fragiudults

HCBF. Other Fragiudults that meet *one or more* of the following:

1. Have a glossic horizon above the fragipan; *or*

2. Do not have, above the fragipan, an argillic or kandic horizon that has clay films on both vertical and horizontal surfaces of any structural aggregates; *or*

3. Between the argillic or kandic horizon and the fragipan, have one or more horizons with 50 percent or more chroma of 3 or less and with a clay content 3 percent or more (absolute, in the fine-earth fraction) lower than that in both the argillic or kandic horizon and the fragipan.

Glossic Fragiudults

HCBG. Other Fragiudults that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) in *either*:

1. An Ap horizon that is 18 cm or more thick; *or*

2. The surface layer after mixing of the upper 18 cm.

Humic Fragiudults

HCBH. Other Fragiudults.

Typic Fragiudults

Definition of Typic Fragiudults

Typic Fragiudults are the Fragiudults that:

1. Above the fragipan, have an argillic or kandic horizon that has some clay films on both vertical and horizontal surfaces of some structural aggregates;

2. Do not have a glossic horizon above the fragipan;

3. Between the argillic or kandic horizon and the fragipan, do not have an intervening horizon (one or more) that has dominant chroma of 3 or less and that has as much as 3 percent less clay (absolute) than both the overlying argillic or kandic horizon and the underlying fragipan;

4. Do not have, in any subhorizon above the fragipan and within the upper 25 cm of the argillic or kandic horizon, redox depletions with chroma of 2 or less and also aquic conditions;

5. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm;

6. Have less than 5 percent (by volume) plinthite in all horizons within 150 cm of the mineral soil surface; *and*

7. Have a color value, moist, of 4 or more or a value, dry, of 6 or more, when crushed and smoothed, in any Ap horizon 18 cm or more thick and in any surface layer after mixing of the upper 18 cm.

Description of Subgroups

Typic Fragiudults.—The central concept or Typic subgroup of Fragiudults is fixed on soils that have an argillic or kandic horizon that is underlain by a fragipan without an intervening eluvial horizon. These soils do not have redox depletions with low chroma in the upper 25 cm of the argillic horizon or above the fragipan if the part of the argillic or kandic horizon above the fragipan is less than 25 cm thick. The soils have less than 5 percent plinthite within 150 cm of the mineral soil surface. The surface layer has a color value of 4 or more, moist, and 6 or more, dry, after mixing of the upper 18 cm.

Typic Fragiudults are more extensive than the soils of the other subgroups. Their characteristics provide the best basis for defining other subgroups. Since no Fragiudult is freely drained, redox depletions with low chroma and ground water at some time of the year must be present at a shallower depth in Aquic Fragiudults than in many other kinds of Aquic subgroups.

A perched water table at the top of the fragipan tends to reduce and remove free iron oxides and accelerate the eluviation of clay and thus to produce a glossic horizon or a second eluvial horizon, an E´. If the marks of this process are distinct, the part of the B horizon above the fragipan is a cambic horizon and the clay films in the fragipan tend to be thick. This combination of horizons defines the glossic intergrades. A thick sandy (sand or loamy sand) layer, starting at the mineral soil surface, is considered abnormal and defines the Arenic subgroup. Plinthite in Fragiudults suggests polygenesis and defines the Plinthic subgroup.

Typic Fragiudults are of large extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to moderately steep. These soils are used mostly as forest. Where slopes are suitable, some of the soils have been cleared and are used as pasture, cropland, or homesites.

Aquic Fragiudults.—These soils have redox depletions with low chroma at a shallow depth and have aquic conditions in the iron-depleted horizon at some time of the year unless the soils have been artificially drained. The soils are otherwise similar to Typic Fragiudults in defined properties and also in most accessory properties. Most Aquic Fragiudults have a mesic soil temperature regime. Aquic Fragiudults are moderately extensive in the Eastern United States. They generally are nearly level to moderately sloping. The natural vegetation consisted of forest plants. Many of these soils are used as forest. Some have been cleared and are used as pasture, cropland, or homesites.

Arenic Fragiudults.—These soils have a sandy layer, starting at the mineral soil surface, that is between 50 and 100 cm thick. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Glossaquic Fragiudults.—These soils have redox depletions with low chroma at a shallow depth and also have aquic conditions in the iron-depleted horizon at some time of the year or have been artificially drained. They meet one or more of the following: (1) have a glossic horizon, (2) do not have an argillic or kandic horizon above the fragipan, or (3) have an eluvial horizon at the top of the fragipan. These soils are of small extent in the Eastern United States. They generally are nearly level or gently sloping. The natural vegetation consisted of forest plants. The soils are used mostly as forest. Some areas have been cleared and are used as cropland or pasture.

Glossic Fragiudults.—These soils meet one or more of the following: (1) have a glossic horizon, (2) do not have an argillic or kandic horizon above the fragipan, or (3) have an eluvial horizon at the top of the fragipan. The soils are otherwise like Typic Fragiudults in defined properties and in other properties. Glossic Fragiudults are moderately extensive in the areas adjoining the lower Mississippi River Valley. They generally are nearly level to strongly sloping. The natural vegetation consisted of forest plants. Many of the soils have been cleared and are used as cropland, but large areas are used as forest.

Humic Fragiudults.—These soils have dark colored surface layers. They are not sandy from the mineral soil surface to a depth of 50 cm or more and do not have aquic conditions close to the surface. They do not have plinthite or a glossic horizon. Most of these soils are forested.

Plinthaquic Fragiudults.—These soils have plinthite in the fragipan, have redox depletions with low chroma at a shallow depth, and have either a fluctuating water table in the iron-depleted zone or artificial drainage. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Plinthic Fragiudults.—These soils have 5 to 50 percent plinthite in some layer within 150 cm of the mineral soil surface. They are of small extent in the United States and occur only on coastal plain in the South. They generally are nearly level or gently sloping. The natural vegetation consisted of forest plants. Many of the soils have been cleared and are used as cropland, but large areas are used as forest.

Hapludults

These are the Udults that do not have a fragipan and that have less than 50 percent plinthite in all horizons within 150 cm of the mineral soil surface. These soils have one of the following: (1) a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface or (2) with increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content and less than 5 percent (by volume) clay depletions on faces of peds in any layer that has a 20 percent lower clay content or, below that layer, the fine-earth fraction has a clay increase of less than 3 percent. Many of the soils have a thin argillic horizon. The color of the argillic horizon is not both dark and reddish throughout the upper 100 cm. Most of the soils formed in areas of acid rocks or sediments on surfaces that are at least of Pleistocene age. Where the soils are not cultivated, the vegetation consists almost exclusively of forest plants, either hardwood trees or conifers.

Hapludults are extensive in the Southeastern United States, in the Middle Atlantic States, and on the coastal plain along the Gulf of Mexico in the Southern States east of the Mississippi River. Slopes generally are gently sloping to steep, but a few of the soils on the lowest part of the coastal plain are nearly level.

Definition

Hapludults are the Udults that:

1. Do not have a kandic horizon;

2. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 150 cm of the mineral soil surface;

4. Have a color:

   a. With hue of 5YR or yellower; *or*

   b. With a value, moist, of 4 or more in some part of the epipedon or a value of 5 or more, dry, or of 4 or more, moist, in some subhorizon of an argillic horizon; *and*

5. Have a clay distribution in which, with increasing depth, the percentage of clay decreases from its maximum amount by more than 20 percent within 150 cm of the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer.

Key to Subgroups

HCGA. Hapludults that have *either or both*:

1. In each pedon, a discontinuous lithic contact within 50 cm of the mineral soil surface; *and*

2. In each pedon, a discontinuous argillic horizon that is interrupted by ledges of bedrock.

Lithic-Ruptic-Entic Hapludults

HCGB. Other Hapludults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapludults

HCGC. Other Hapludults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Hapludults

HCGD. Other Hapludults that have *both*:

1. Fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Hapludults

HCGE. Other Hapludults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. In one or more subhorizons within the upper 60 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Hapludults

HCGF. Other Hapludults that have, in one or more subhorizons within the upper 60 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Hapludults

HCGG. Other Hapludults that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Hapludults

HCGH. Other Hapludults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapludults

HCGI. Other Hapludults that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Hapludults

HCGJ. Other Hapludults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Hapludults

HCGK. Other Hapludults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Hapludults

HCGL. Other Hapludults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Hapludults

HCGM. Other Hapludults that have:

1. No densic, lithic, or paralithic contact within 50 cm of the mineral soil surface; *and*

2. An argillic horizon 25 cm or less thick.

Inceptic Hapludults

HCGN. Other Hapludults that have a color value, moist, of 3 or less and a color value, dry, of 5 or less (crushed and smoothed sample) in *either*:

1. An Ap horizon that is 18 cm or more thick; *or*

2. The surface layer after mixing of the upper 18 cm.

Humic Hapludults

HCGO. Other Hapludults.

Typic Hapludults

Definition of Typic Hapludults

Typic Hapludults are the Hapludults that:

1. Do not have, in any subhorizon within the upper 60 cm of the argillic horizon, redox depletions with a color value, moist,

of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

4. Have an argillic horizon more than 25 cm thick;

5. Have a color value, moist, of 4 or more or a value, dry, of 6 or more, when crushed and smoothed, in any Ap horizon 18 cm or more thick and in any surface layer after mixing of the upper 18 cm;

6. Do not have a lithic contact within 50 cm of the mineral soil surface in some or all parts of each pedon;

7. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

8. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

9. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon; *and*

10. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Hapludults.—The central concept or Typic subgroup of Hapludults is fixed on freely drained soils that are moderately deep or deeper to hard rock, have an ochric epipedon that is not both thick and sandy (not sand or loamy sand), have a loamy or clayey particle-size class in the argillic horizon, but do not have deep cracks in normal years. Ground water at a moderate depth, redox depletions with low chroma at a shallow depth, and a fluctuating level of ground water in the iron-depleted zone are properties shared with Aquults and define the Oxyaquic and Aquic subgroups.

A thick sandy layer, starting at the mineral soil surface, defines Arenic and Grossarenic subgroups. A shallow lithic contact defines the Lithic subgroup. A dark colored, relatively thick ochric epipedon or an umbric epipedon is considered abnormal and indicates an intergrade to Humults. A very thin argillic horizon also is considered abnormal and is used to define the Inceptic subgroup. A sandy particle-size class and lamellae in the argillic horizon indicate development that is weaker than normal and define the Psammentic and Lamellic subgroups. A clayey particle-size class, deep cracks, and a high COLE are properties shared with Vertisols and define the Vertic subgroup.

Typic Hapludults are of very large extent in the Eastern and Southeastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to steep. Where slopes are suitable, many of these soils are used as cropland. Many of the soils, particularly those that are steep, are used as forest. Some are used as pasture or homesites.

Aquic Arenic Hapludults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is 50 to 100 cm thick. They are artificially drained or have ground water that fluctuates in depth, and the horizons that are or were saturated have redox depletions with low chroma. The ground water may be more than 60 cm below the top of the argillic horizon if artificial drainage has been provided. Most of these soils are in the sandy parts of the coastal plain in the Eastern and Southeastern United States. The natural vegetation consisted of forest plants. Aquic Arenic Hapludults are of small extent. Many of these soils are used as cropland or forest. Some are used as pasture or homesites.

Aquic Hapludults.—These soils are artificially drained or have ground water that fluctuates in depth, and the horizons that are or were saturated have redox depletions with low chroma. The ground water may be more than 60 cm below the top of the argillic horizon if artificial drainage has been provided. The level of ground water is high in winter and early spring. These soils are of large extent in the Eastern and Southeastern United States. The natural vegetation consisted of forest plants. Slopes are nearly level to moderately sloping. Many of these soils are used as cropland or forest. Some are used as pasture or homesites.

Arenic Hapludults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. Most of these soils are in the sandy parts of the coastal plain in the Eastern and Southeastern United States. The natural vegetation consisted of forest plants. Arenic Hapludults are of moderate extent. Many of these soils are used as cropland, and many are used as forest. Some are used as pasture or homesites.

Fragiaquic Hapludults.—These soils are similar to Typic Hapludults, but they have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. They have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Fragic Hapludults.—These soils are similar to Typic Hapludults, but they have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Grossarenic Hapludults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is more than 100 cm thick. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Humic Hapludults.—These soils have a dark colored surface layer. Some have an umbric epipedon or, if heavily limed, a mollic epipedon. Humic Hapludults are mainly in the mountains in the Southeastern United States. They are of moderate extent. The natural vegetation consisted of forest plants. Slopes range from nearly level to very steep. Many of these soils are used as cropland or forest. Some are used as pasture.

Inceptic Hapludults.—These soils have a thin argillic horizon. Some of the soils are moderately deep to a lithic, densic, or paralithic contact. Some have a thin argillic horizon over sandy materials. In the United States, Inceptic Hapludults are moderately extensive in the Piedmont and on the coastal plain of the Middle Atlantic and Southern States. The natural vegetation consisted of forest plants. Slopes range from nearly level to very steep. Most of the soils are used as forest, cropland, or pasture.

Lamellic Hapludults.—These soils are like Typic Hapludults, but they have an argillic horizon that consists entirely of lamellae or is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon. In some of the soils, the argillic horizon consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are either two or more lamellae with a combined thickness of 5 cm or more or a combination of lamellae and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Lithic Hapludults.—These soils have a continuous shallow lithic contact and an argillic horizon that is continuous throughout each pedon. These soils are of small extent, mostly in the Eastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to very steep. The soils are used mainly as forest.

Lithic-Ruptic-Entic Hapludults.—These soils have either a discontinuous argillic horizon in each pedon or a shallow lithic contact only in part of each pedon, or both. Where the lithic contact is shallow, the argillic horizon commonly is thin. Where the lithic contact is very shallow, there is no argillic horizon. In some of these soils, depth to the lithic contact varies greatly within a pedon and an argillic horizon is only in the deepest parts of the pedon. Lithic-Ruptic-Entic Hapludults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Oxyaquic Hapludults.—These soils are like Typic Hapludults, but they are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, they are permitted to have a dark colored Ap horizon or a dark colored A horizon after the upper 18 cm has been mixed. These soils are of small extent in the United States. Slopes are gentle to steep. The natural vegetation consisted of forest plants. Most of these soils are used as forest. Some have been cleared and are used as cropland or pasture.

Psammentic Hapludults.—These soils have a sandy or sandy-skeletal particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick. They are of small extent in the United States. They are considered intergrades between Udipsamments and Hapludults. Slopes generally are nearly level to moderately steep. The natural vegetation consisted of forest plants. About half of these soils have been cleared and are used as cropland or pasture, and about half are used as forest.

Vertic Hapludults.—These soils have deep cracks and appreciable amounts of swelling clays. The swelling clays and low saturated hydraulic conductivity seem to be the most important properties of the soils of this subgroup. Most of these soils formed in clayey parent materials. Vertic Hapludults are of small extent. The natural vegetation consisted of forest plants. Slopes are gentle to moderately steep. Most of the soils are used as forest, but some, mostly the less sloping ones, have been cleared and are used as cropland or pasture.

Kandiudults

Kandiudults are the Udults that are very deep and have a kandic horizon and a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Kandiudults are of moderate extent in the Southeastern United States.

Definition

Kandiudults are the Udults that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

4. Do not have plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 150 cm of the mineral soil surface; *and*

5. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

HCCA. Kandiudults that have:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

3. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Arenic Plinthaquic Kandiudults

HCCB. Other Kandiudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Kandiudults

HCCC. Other Kandiudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiudults

HCCD. Other Kandiudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. In all subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Arenic Rhodic Kandiudults

HCCE. Other Kandiudults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kandiudults

HCCF. Other Kandiudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Kandiudults

HCCG. Other Kandiudults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more.

Grossarenic Kandiudults

HCCH. Other Kandiudults that have *both*:

1. An ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Plinthic Kandiudults

HCCI. Other Kandiudults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Kandiudults

HCCJ. Other Kandiudults that have *both*:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kandiudults

HCCK. Other Kandiudults that have *both*:

1. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, *one or more* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more.

Aquandic Kandiudults

HCCL. Other Kandiudults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiudults

HCCM. Other Kandiudults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiudults

HCCN. Other Kandiudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiudults

HCCO. Other Kandiudults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kandiudults

HCCP. Other Kandiudults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kandiudults

HCCQ. Other Kandiudults that have a sombric horizon within 150 cm of the mineral soil surface.

Sombric Kandiudults

HCCR. Other Kandiudults that have, in all subhorizons in the upper 75 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kandiudults

HCCS. Other Kandiudults.

Typic Kandiudults

Definition of Typic Kandiudults

Typic Kandiudults are the Kandiudults that:

1. Do not, in any layer either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, have redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days;

3. Have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

5. In all parts of the upper 75 cm of the kandic horizon, have 50 percent or less colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value;

6. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, *any* of the following:

a. A fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *or*

b. More than 35 percent (by volume) fragments coarser than 2.0 mm, of which more than 66 percent is cinders, pumice, and pumicelike fragments; *or*

c. A fine-earth fraction containing 30 percent or more particles 0.02 to 2.0 mm in diameter; *and*

(1) In the 0.02 to 2.0 mm fraction, 5 percent or more volcanic glass; *and*

(2) [(Al plus $^1/_2$ Fe, percent extracted by ammonium oxalate) times 60] plus the volcanic glass (percent) is equal to 30 or more;

7. Have, within 75 cm of the mineral soil surface, hue of 7.5YR or redder in all horizons with a color value, moist, of 4 or more if there are redox concentrations or if the hue becomes redder with increasing depth within 100 cm of the mineral soil surface;

8. Have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the mineral soil surface; *and*

9. Do not have a sombric horizon within 150 cm of the mineral soil surface.

Description of Subgroups

Typic Kandiudults.—The central concept or Typic subgroup of Kandiudults is fixed on freely drained soils that do not have a sombric horizon and are very deep. The epipedon is not both thick and sandy (not sand or loamy sand). These soils have less than 5 percent plinthite and have a low, but not extremely low, cation-exchange capacity. They do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals.

Ground water at a moderate depth, redox depletions with low chroma at a shallow depth, and a fluctuating level of ground water in the iron-depleted zone are properties shared with Aquults and define the Oxyaquic and Aquic subgroups. A thick sandy layer, starting at the mineral soil surface, defines Arenic and Grossarenic subgroups.

Typic Kandiudults are of small extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to steep. Where slopes are suitable, many of these soils are used as cropland. Where slopes are steep, the soils are used as forest. Some of the soils are used as pasture or homesites.

Acrudoxic Kandiudults.—These soils have an extremely low cation-exchange capacity. Recycling of plant nutrients from decaying vegetation is critical for plant growth on these soils. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Acrudoxic Plinthic Kandiudults.—These soils have an extremely low cation-exchange capacity and have 5 to 50 percent (by volume) plinthite in some subhorizon within 150 cm of the surface. Recycling of plant nutrients from decaying vegetation is critical for plant growth on these soils. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Andic Kandiudults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquandic Kandiudults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. They also have ground water that fluctuates in depth or are artificially drained, and the horizons that are or were saturated have redox depletions with low chroma. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Arenic Kandiudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is 50 to 100 cm thick. They have ground water that fluctuates in depth or are artificially drained, and the horizons that are or were saturated have redox depletions with low chroma. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Kandiudults.—These soils have ground water that fluctuates in depth or are artificially drained, and the horizons that are or were saturated have redox depletions with low chroma. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Kandiudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. Most of the soils are in the sandy parts of the coastal plain in the Southeastern United States. The natural vegetation consisted of mixed forest plants. Arenic Kandiudults are of small extent in the United States. Many of these soils are used as cropland or forest, but some are used as pasture or homesites.

Arenic Plinthaquic Kandiudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). In addition, the soils have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Plinthic Kandiudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They also have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are of very small extent in the United States.

Arenic Rhodic Kandiudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They also have, in the epipedon and the upper part of the kandic horizon, hue of 2.5YR or redder, a value, moist, of 3 or less, and a dry color value no more than 1 unit higher than the moist value. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Grossarenic Kandiudults.—These soils have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. These soils are of small extent in the United States.

Grossarenic Plinthic Kandiudults.—These soils have 5 percent or more plinthite (by volume) in some subhorizon within 150 cm of the surface. In addition, they have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 100 cm or more below the mineral soil surface. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Ombroaquic Kandiudults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Oxyaquic Kandiudults.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Plinthaquic Kandiudults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. Plinthaquic Kandiudults are intergrades between Plinthaquults and Kandiudults. They are not known to occur in the United States. They are defined for use in other parts of the world.

Plinthic Kandiudults.—These soils have 5 to 50 percent (by volume) plinthite in some subhorizon within 150 cm of the surface. They are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodic Kandiudults.—These soils are like Typic Kandiudults, but the upper part of their kandic horizon has hue of 2.5YR or redder, a color value, moist, of 3 or less, and a dry value no more than 1 unit higher than the moist value. Rhodic Kandiudults are of small extent in the United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to moderately steep. Many of these soils are used as cropland. Some, particularly the most sloping ones, are used as forest. Some are used as pasture or homesites.

Sombric Kandiudults.—These soils are like Typic Kandiudults, but they have a sombric horizon. They are not known to occur in the United States. They are defined for use in other parts of the world.

Kanhapludults

Kanhapludults are the Udults that have a kandic horizon. They do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface or plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 150 cm of the soil surface. The soils are less than 150 cm deep, or the kandic horizon has a clay distribution in which the content of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. Most of these soils have a thermic or warmer soil temperature regime. The natural vegetation consisted of forest plants. Many of the soils have been cleared and are used as cropland or pasture.

Definition

Kanhapludults are the Udults that:

1. Have a kandic horizon;

2. Have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 150 cm of the soil surface; *and*

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

HCDA. Kanhapludults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhapludults

HCDB. Other Kanhapludults that have *both*:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Kanhapludults

HCDC. Other Kanhapludults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kanhapludults

HCDD. Other Kanhapludults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kanhapludults

HCDE. Other Kanhapludults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrudoxic Kanhapludults

HCDF. Other Kanhapludults that have *both*:

1. Fragic soil properties:

   a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

   b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Kanhapludults

HCDG. Other Kanhapludults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhapludults

HCDH. Other Kanhapludults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhapludults

HCDI. Other Kanhapludults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days.

Ombroaquic Kanhapludults

HCDJ. Other Kanhapludults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Kanhapludults

HCDK. Other Kanhapludults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhapludults

HCDL. Other Kanhapludults that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Kanhapludults

HCDM. Other Kanhapludults that have, in all subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kanhapludults

HCDN. Other Kanhapludults.

Typic Kanhapludults

Definition of Typic Kanhapludults

Typic Kanhapludults are the Kanhapludults that:

1. Do not, in any layer either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the kandic horizon, have redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. In normal years are not saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

   a. 20 or more consecutive days; *or*

   b. 30 or more cumulative days;

3. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the soil surface;

5. Do not have a lithic contact within 50 cm of the soil surface;

6. Have, within 75 cm of the mineral soil surface, hue of 7.5YR or redder in all horizons with a color value, moist, of 4 or more if there are redox concentrations or if the hue becomes redder with increasing depth within 100 cm of the mineral soil surface;

7. In all parts of the upper 50 cm of the kandic horizon, have 50 percent or less colors that have *all* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less; *and*

   c. A dry value no more than 1 unit higher than the moist value;

8. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-

extractable aluminum plus 1/2 acid-oxalate-extractable iron of more than 1.0 percent;

9. Have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the soil surface; *and*

10. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick.

Description of Subgroups

Typic Kanhapludults.—The central concept or Typic subgroup of Kanhapludults is fixed on freely drained soils that are more than 50 cm deep to a lithic contact. The epipedon is not both thick and sandy (not sand or loamy sand). These soils have less than 5 percent plinthite and have a low, but not extremely low, cation-exchange capacity. They do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals.

Soils that have, in the upper part of the kandic horizon, 50 percent or more colors with hue of 2.5YR or redder, a value, dry, of 3 or less, and moist and dry color values that differ from each other by 1 unit or less than 1 unit are excluded from Typic Kanhapludults because these properties are shared with Rhodudults. Ground water at a moderate depth, redox depletions with low chroma at a shallow depth, and a fluctuating level of ground water in the redox-depleted zone are properties shared with Aquults and define the Oxyaquic and Aquic subgroups. A thick sandy layer, starting at the mineral soil surface, defines the Arenic subgroup.

Typic Kanhapludults are of small extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to steep. Where slopes are suitable, many of the soils are used as cropland. The steeper soils are used as forest. Some of the soils are used as pasture or homesites.

Acrudoxic Kanhapludults.—These soils have an extremely low cation-exchange capacity. Recycling of plant nutrients from decaying vegetation is critical for plant growth on these soils. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Andic Kanhapludults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Kandhapludults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are of very small extent in the United States.

Arenic Kanhapludults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They are of very small extent in the United States. They are on the coastal plain in the Southeastern United States. The natural vegetation consisted of mixed forest plants. These soils are used mostly as cropland or forest.

Arenic Plinthic Kanhapludults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They also have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Fragiaquic Kanhapludults.—These soils have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. They have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Fragic Kanhapludults.—These soils have fragic soil properties in 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface or in 60 percent or more of the volume of a layer 15 cm or more thick anywhere in the soils. These soils are not extensive in the United States.

Lithic Kanhapludults.—These soils have a lithic contact within 50 cm of the mineral soil surface. In addition, they are permitted to have any color, saturation, or redox feature allowed in Kanhapludults. Lithic Kanhapludults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Ombroaquic Kanhapludults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Oxyaquic Kanhapludults.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days or 30 or more cumulative days in normal years. In addition, the soils are permitted, but not required, to have a kandic horizon that has 50 percent or more colors with hue of 2.5YR or redder, a value, dry, of 3 or less, and moist and dry color values that differ from each other by 1 unit or less than 1 unit. These soils are considered intergrades to Aquults. They are of very small extent in the United States.

Plinthaquic Kanhapludults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). They have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. They are intergrades between Plinthaquults and Kanhapludults. They are not known to occur in the United States. The subgroup is defined for use in other parts of the world.

Plinthic Kanhapludults.—These soils have 5 to 50 percent (by volume) plinthite in some subhorizon within 150 cm of the surface. They are not known to occur in the United States. The subgroup is defined for use in other parts of the world.

Rhodic Kanhapludults.—These soils are like Typic Kanhapludults, but the upper part of their kandic horizon has hue of 2.5YR or redder, a color value, moist, of 3 or less, and a dry value no more than 1 unit higher than the moist value. Rhodic Kanhapludults are of small extent in the United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to moderately steep. These soils are used mostly as cropland or forest, but some are used as pasture or homesites.

Paleudults

These are the very deep, more or less freely drained Udults on very old stable land surfaces. These soils do not have a kandic horizon. Many have a thick argillic horizon. The soils have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils do not have a fragipan or a horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface.

Paleudults are extensive in the Southeastern United States and in the Middle Atlantic States. Slopes generally are gently sloping to steep, but a few of the soils on coastal plains are nearly level. The natural vegetation consisted of forest plants, mostly hardwoods or mixed conifers and hardwoods. Many of these soils have been cleared and are used as cropland or pasture.

Definition

Paleudults are the Udults that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the soil surface;

2. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by more than 20 percent within 150 cm of the soil surface, or the layer in which the percentage of clay decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer;

3. Do not have a kandic horizon;

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface; *and*

5. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 150 cm of the soil surface.

Key to Subgroups

HCEA. Paleudults that have *one or both* of the following:

1. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

2. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower.

Vertic Paleudults

HCEB. Other Paleudults that have a horizon 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

1. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

2. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

3. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon.

Spodic Paleudults

HCEC. Other Paleudults that have:

1. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. A sandy or sandy-skeletal particle-size class throughout

a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more; *and*

3. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthaquic Paleudults

HCED. Other Paleudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon that is 50 cm or more below the mineral soil surface; *and*

2. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Aquic Arenic Paleudults

HCEE. Other Paleudults that have *both*:

1. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface; *and*

2. In one or more layers either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Plinthaquic Paleudults

HCEF. Other Paleudults that have *both*:

1. Fragic soil properties:

a. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

b. In 60 percent or more of the volume of a layer 15 cm or more thick; *and*

2. In one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage).

Fragiaquic Paleudults

HCEG. Other Paleudults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Paleudults

HCEH. Other Paleudults that have anthraquic conditions.

Anthraquic Paleudults

HCEI. Other Paleludults that in normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Paleudults

HCEJ. Other Paleudults that have an argillic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Paleudults

HCEK. Other Paleudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Paleudults

HCEL. Other Paleudults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Paleudults

HCEM. Other Paleudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout

a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Grossarenic Plinthic Paleudults

HCEN. Other Paleudults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Paleudults

HCEO. Other Paleudults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm; *and*

2. In all subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.

Arenic Rhodic Paleudults

HCEP. Other Paleudults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Arenic Paleudults

HCEQ. Other Paleudults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 100 cm or more.

Grossarenic Paleudults

HCER. Other Paleudults that have fragic soil properties:

1. In 30 percent or more of the volume of a layer 15 cm or more thick that has its upper boundary within 100 cm of the mineral soil surface; *or*

2. In 60 percent or more of the volume of a layer 15 cm or more thick.

Fragic Paleudults

HCES. Other Paleudults that have, in all subhorizons in the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Paleudults

HCET. Other Paleudults.

Typic Paleudults

Definition of Typic Paleudults

Typic Paleudults are the Paleudults that:

1. Do not, in any layer either within 75 cm of the mineral soil surface or, if the chroma throughout the upper 75 cm results from uncoated sand grains, within the upper 12.5 cm of the argillic horizon, have redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. Do not have anthraquic conditions;

3. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the soil surface;

5. In all parts of the upper 75 cm of the argillic horizon, have 50 percent or less colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value;

6. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

7. Do not have a horizon 5 cm or more thick, either below an Ap horizon or at a depth of 18 cm or more from the mineral soil surface, whichever is deeper, that has *one or more* of the following:

a. In 25 percent or more of each pedon, cementation by organic matter and aluminum, with or without iron; *or*

b. Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling 0.25 or more, and half that amount or less in an overlying horizon; *or*

c. An ODOE value of 0.12 or more, and a value half as high or lower in an overlying horizon;

8. Have fragic soil properties:

a. In less than 30 percent of the volume of all layers 15 cm or more thick that have an upper boundary within 100 cm of the mineral soil surface; *and*

b. In less than 60 percent of the volume of all layers 15 cm or more thick;

9. Do not have *either*:

a. Cracks within 125 cm of the mineral soil surface that are 5 mm or more wide through a thickness of 30 cm or more for some time in normal years, and slickensides or wedge-shaped aggregates in a layer 15 cm or more thick that has its upper boundary within 125 cm of the mineral soil surface; *or*

b. A linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower;

10. Have an argillic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic horizon) and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon; *and*

11. In normal years are not saturated with water in any layer within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Description of Subgroups

Typic Paleudults.—The central concept or Typic subgroup of Paleudults is fixed on freely drained soils that have an epipedon that is not both sandy and thick, that have little or no plinthite, and that have an argillic horizon that is loamy or clayey and is not composed of thin lamellae.

A fluctuating ground water table at a moderately shallow depth, with or without redox depletions with low chroma, is a property shared with Aquults and is used as the basis for defining Aquic and Oxyaquic subgroups. A thick sandy layer, starting at the mineral soil surface, is considered abnormal and is used to define Arenic and Grossarenic subgroups. An appreciable amount of plinthite also is considered abnormal and is used to define the Plinthic subgroup. A dark red argillic horizon is a property shared with Rhodudults and is used to define the Rhodic subgroup. A sandy argillic horizon is used to define the Psammentic subgroup. An argillic horizon composed partly or wholly of lamellae is used to define the Lamellic subgroup.

Typic Paleudults are of large extent in the Eastern and Southeastern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to steep. Where slopes are suitable, many of the soils are used as cropland. The steeper soils are used as forest. Some of the soils are used as pasture or homesites.

Anthraquic Paleudults.—These soils have anthraquic conditions. Nearly all of them have been used for rice in irrigated paddies for long periods of time. Anthraquic Paleudults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Arenic Paleudults.—These soils have a layer, starting at the mineral soil surface, that is 50 cm or more thick and has a sandy or sandy-skeletal particle-size class throughout. They also have ground water that fluctuates in depth or are artificially drained, and the zone in which the water stands or formerly stood has redox depletions with low chroma within 75 cm of the soil surface or in the upper 12.5 cm of the argillic horizon. Commonly, the argillic horizon has more sand and less clay than the argillic horizon in the Typic subgroup. The Aquic Arenic Paleudults in the United States are mostly in areas of sandy deposits on the coastal plain in the Southeastern States. The natural vegetation consisted of forest plants. The soils are of small extent. They are nearly level or gently sloping. Most are used as cropland or forest.

Aquic Paleudults.—These soils have, within 75 cm of the soil surface, ground water that fluctuates in depth or are artificially drained, and the zone in which water stands or formerly stood has redox depletions with low chroma. These soils are extensive on the coastal plains in the Southern United States. The natural vegetation consisted of forest plants. These soils generally are nearly level or gently sloping. Many are used as cropland, and many are used as forest. Some are used as pasture or homesites.

Arenic Paleudults.—These soils have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a sandy or sandy-skeletal particle-size class, that is, the texture is sand or loamy sand. The soils are otherwise like Typic Paleudults in defined properties, but the argillic horizon tends to have more sand and less clay than the one in the Typic subgroup. In the United States, Arenic Paleudults occur on the coastal plain from Maryland to Texas. The natural vegetation consisted of forest plants. The soils are of moderate extent. Slopes generally are nearly level to strongly sloping. Most of the soils are used as cropland or forest, but some are used as pasture.

Arenic Plinthaquic Paleudults.—These soils have a layer, starting at the mineral soil surface, that is 50 cm or more thick and has a sandy or sandy-skeletal particle-size class, that is, the texture of the fine-earth fraction is sand or loamy sand. The soils also have a small or moderate amount of plinthite in the argillic horizon, and the ground water fluctuates at some depth within the epipedon but is sometimes above the argillic horizon. The subhorizons that have plinthite normally restrict the movement of water, and the soils may have a perched water table for short periods. These soils occur on the coastal plains in the Southern United States. The natural vegetation consisted of forest plants. These soils are of small extent. They are nearly level or gently sloping. Most are used as cropland or forest. Some are used as pasture.

Arenic Plinthic Paleudults.—These soils have some plinthite in the argillic horizon and have a layer, starting at the mineral soil surface, that is between 50 and 100 cm thick and has a sandy or sandy-skeletal particle-size class, that is, the texture of the fine-earth fraction is sand or loamy sand. The soils are otherwise like Typic Paleudults in defined properties, but they differ from the Typic subgroup in several respects. The argillic horizon commonly has more sand and less clay than the one in the Typic subgroup, the subhorizons that have plinthite normally slow the movement of water, and the soils may have a perched water table for short periods. The natural vegetation consisted of forest plants. These soils are of small extent in the United States. They are mostly on the coastal plains in the Southern States. They are nearly level or gently sloping. Most are used as cropland or forest. Some are used as pasture.

Arenic Rhodic Paleudults.—These soils have a low color value and are mostly dark red throughout the upper part of the argillic horizon. The epipedon also is normally dark colored, and there is a layer, starting at the mineral soil surface and extending to a depth of 50 to 100 cm, that has a sandy or sandy-skeletal particle-size class. The dark color is caused chiefly by the large amount of free iron oxides rather than by organic matter. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Fragiaquic Paleudults.—These soils have, within 75 cm of the soil surface, ground water that fluctuates in depth or are artificially drained, and the zone in which water stands or formerly stood has redox depletions with low chroma. The soils also have a large amount of soil aggregates with fragic soil properties in a layer 15 cm or more thick. The amount of plinthite in any subhorizon within a depth of 150 cm is restricted to less than 5 percent. These soils are moderately extensive in the Southern United States. They are nearly level or gently sloping. Most are used as cropland or forest. Some are used as pasture.

Fragic Paleudults.—These soils have a large amount of soil aggregates with fragic soil properties in a layer 15 cm or more thick. The amount of plinthite in any subhorizon is restricted to less than 5 percent in any subhorizon within a depth of 150 cm. These soils are of small extent in the Southeastern United States. Most of the soils are used as forest or cropland. Some are used as pasture.

Grossarenic Paleudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class (a texture of sand or loamy sand in the fine-earth fraction) and that is between 100 and 200 cm thick. The argillic horizon tends to have appreciably more sand and less clay than the one in the soils of the Typic subgroup. Grossarenic Paleudults are moderately extensive on the coastal plains in the Southern United States. The natural vegetation consisted of forest plants. Slopes range from nearly level to moderately steep. These soils are used mostly as cropland or forest. Some are used as pasture or homesites.

Grossarenic Plinthic Paleudults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class (a texture of sand or loamy sand in the fine-earth fraction) and that is between 100 and 200 cm thick. These soils have 5 to 50 percent plinthite in some horizon within 150 cm of the soil surface. The argillic horizon has appreciably more sand and less clay than the one in Typic Paleudults. Grossarenic Plinthic Paleudults are of small extent in the Southeastern United States. The natural vegetation consisted of forest plants. These soils generally are nearly level or gently sloping. They are used mostly as forest or cropland.

Lamellic Paleudults.—These soils are similar to Typic Paleudults, but they have an argillic horizon that consists entirely of lamellae or is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon. In some of the soils, the argillic horizon consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are either two or more lamellae with a combined thickness of 5 cm or more or a combination of lamellae and one or more parts of the argillic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon. These soils are of small extent in the Southeastern United States. The natural vegetation consisted of forest plants. These soils generally are nearly level or gently sloping. They are used mostly as forest or cropland. Some are used as pasture or homesites.

Oxyaquic Paleudults.—These soils are saturated with water within 100 cm of the mineral soil surface for 20 or more consecutive days and/or 30 or more cumulative days during normal years. The soils are in scattered areas throughout the Southeastern United States. Many were forested but have been cleared and are used for crop production.

Plinthaquic Paleudults.—These soils have 5 to 50 percent plinthite in some horizon within 150 cm of the soil surface. Ground water in the soils fluctuates in depth, or there is artificial drainage. The subhorizon in which water stands or formerly stood has redox depletions with low chroma, or the soil color is a result of the color of the uncoated sand grains. The argillic horizon, especially the subhorizons that have plinthite, tends to slow the movement of water, and there may be ground water perched above these subhorizons for short periods. These soils are of very small extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes generally are nearly level or gently sloping. These soils are used mostly as forest or cropland.

Plinthic Paleudults.—These soils have 5 to 50 percent plinthite in some horizon within 150 cm of the soil surface. The argillic horizon, especially the subhorizons that have plinthite, tends to slow the movement of water. These soils formed on the coastal plain in the Southeastern United States. They are of moderate extent. The natural vegetation consisted of forest plants. Slopes generally are nearly level to strongly sloping. Plinthic Paleudults are used mostly as cropland or forest. Some are used as pasture.

Psammentic Paleudults.—These soils have an argillic horizon that has a sandy or sandy-skeletal particle-size class throughout or throughout the upper 75 cm if it is more than 75 cm thick. The sand fraction of the Psammentic Paleudults in the United States is dominantly quartz. The upper part of the epipedon commonly is an albic horizon. These soils are of small extent and occur only on the coastal plains of the Southern States. The natural vegetation consisted of forest plants. Slopes generally are nearly level to strongly sloping. These soils are used mostly as forest or cropland. Some are used as pasture or homesites.

Rhodic Paleudults.—These soils have a low color value and are mostly dark red throughout the upper part of the argillic horizon. The epipedon also is normally dark colored. The dark color is mainly the result of a large amount of free iron oxides rather than the content of organic matter, but organic matter tends to be more abundant in these soils than in Typic Paleudults. Most Rhodic Paleudults formed in basic parent materials and tend to have more total phosphorus than the soils of the Typic subgroup. Rhodic Paleudults are of small extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes generally are nearly level to moderately steep. Most of these soils are used as cropland if slopes are gentle. Some of the soils, mainly the most sloping ones, are used as forest or pasture.

Spodic Paleudults.—In these soils, the upper part of the B horizon has a weak accumulation of amorphous materials and the lower part is an argillic horizon. In the Spodic Paleudults in the United States, the horizons above the argillic horizon have a texture of sand or loamy sand. These soils are of very small extent in the Southeastern United States. The natural vegetation consisted of forest plants. The soils are nearly level or gently sloping. They are used mostly as cropland or forest.

Vertic Paleudults.—These soils are high in expanding clays and have cracks 5 mm or more wide, slickensides, wedge-shaped aggregates, or a linear extensibility of 6.0 cm or more between the mineral soil surface and either a depth of 100 cm or a densic, lithic, or paralithic contact, whichever is shallower. The soils are considered intergrades between Paleudults and Uderts. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Plinthudults

These are the more or less freely drained Udults that have a large amount of plinthite in the argillic or kandic horizon. They are mainly in intertropical regions and in some areas are extensive. They are not known to occur in the United States. The great group is provided for use in other parts of the world.

Definition

Plinthudults are the Udults that have plinthite that either forms a continuous phase in, or constitutes more than half the matrix of, one or more horizons within 150 cm of the mineral soil surface.

Key to Subgroups

HCAA. All Plinthudults.

Typic Plinthudults

Rhodudults

These are the freely drained Udults that are of mid or low latitudes and have a dark colored epipedon and an argillic horizon with dark reddish colors throughout the upper part. These soils do not have a fragipan, and they have less than 50 percent plinthite in all horizons within 150 cm of the mineral soil surface. They have one of the following: (1) a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface or (2) with increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content and less than 5 percent (by volume) skeletans on faces of peds in any layer that has a 20 percent lower clay content or, below that layer, the fine-earth fraction has a clay increase of less than 3 percent. Many of the soils have a thin argillic horizon. Rhodudults formed under forest vegetation and commonly from basic rocks or sediments. As a consequence, they tend to have more total phosphorus than most other Udults. They also tend to be less erosive.

Rhodudults range from nearly level to very steep. Most of these soils formed in sediments or on surfaces of the latter half of the Pleistocene (Illinoian or Wisconsinan). Where slopes are suitable, most of the soils are used as cropland. In many of the soils, the plow layer includes material that was part of the argillic horizon.

Definition

Rhodudults are the Udults that:

1. Have an epipedon that has a color value, moist, of 3 or less throughout;

2. In all subhorizons in the upper 100 cm of the argillic

horizon or throughout the entire argillic horizon if it is less than 100 cm thick, have more than 50 percent colors with *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value;

3. Do not have a kandic horizon;

4. Do not have a fragipan with an upper boundary within 100 cm of the mineral soil surface;

5. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 150 cm of the mineral soil surface; *and*

6. Have a clay distribution in which, with increasing depth, the percentage of clay decreases from its maximum amount by more than 20 percent within a depth of 150 cm below the soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer.

Key to Subgroups

HCFA. Rhodudults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodudults

HCFB. Other Rhodudults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Rhodudults

HCFC. Other Rhodudults.

Typic Rhodudults

Definition of Typic Rhodudults

Typic Rhodudults are the Rhodudults that:

1. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick; *and*

2. Do not have a lithic contact within 50 cm of the soil surface.

Description of Subgroups

Typic Rhodudults.—The central concept or Typic subgroup of Rhodudults is fixed on well drained soils that are moderately deep to very deep. The only features that cause exclusions from the Typic subgroup are those that have been used as conventions throughout this taxonomy. The absence of an Aquic subgroup probably reflects the nature of the underlying rock, which seems to preclude the presence of shallow ground water. These soils formed mostly from basic rocks and sediments.

Typic Rhodudults are of moderate extent in the Southeastern United States. The natural vegetation consisted of forest plants. Slopes are nearly level to very steep. Most of these soils are used as cropland if slopes are gentle. Some of the soils, mainly the most sloping ones, are used as forest or pasture.

Lithic Rhodudults.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Psammentic Rhodudults.—These soils have a sandy or sandy-skeletal particle-size class throughout the argillic horizon or throughout the upper 75 cm of the argillic horizon if it is more than 75 cm thick. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Ustults

These are the more or less freely drained Ultisols that have an ustic soil moisture regime and a relatively low content of organic carbon. They occur in regions where rainfall is moderately low to high but evapotranspiration exceeds precipitation. Some Ustults have a single dry season each year, as in areas of a monsoon climate, and others have alternating moist and dry periods throughout the growing season. Ustults can have any soil temperature regime but generally have one that is isomesic, thermic, or warmer.

Most Ustults have an ochric epipedon that rests on an argillic or kandic horizon, which may or may not contain plinthite. A petroferric contact is common in some parts of the world.

The vegetation commonly consists of forest or savanna plants. These soils are of small extent in the United States.

Definition

Ustults are the Ultisols that:

1. Do not have both aquic conditions and the colors defined for Aquults;

2. Have an ustic moisture regime;

3. Have less than 0.9 percent (by weighted average) organic carbon in the upper 15 cm of the argillic or kandic horizon, exclusive of any Ap horizon; *and*

4. Have less than 12 kg organic carbon in a unit volume

of 1 m^2 to a depth of 100 cm below the base of any O horizon or the mineral soil surface.

Key to Great Groups

HDA. Ustults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.
Plinthustults, p. 776

HDB. Other Ustults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a kandic horizon; *and*

3. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Kandiustults, p. 770

HDC. Other Ustults that have a kandic horizon.
Kanhaplustults, p. 773

HDD. Other Ustults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.
Paleustults, p. 776

HDE. Other Ustults that have *both*:

1. An epipedon that has a color value, moist, of 3 or less throughout; *and*

2. In all subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 100 cm thick, more than 50 percent colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value.
Rhodustults, p. 777

HDF. Other Ustults.
Haplustults, p. 768

Haplustults

These are the Ustults that have a thin or moderately thick zone of maximum clay content in the argillic horizon and are very deep to any horizon that is one-half or more plinthite. They are not both dark colored in the epipedon and dark red throughout the argillic horizon. Slopes range from gentle to very steep. Many of these soils are in tropical climates and are farmed by means of shifting cultivation.

Haplustults are of small extent in the United States. They are mainly in Texas, California, and Puerto Rico. They are extensive in some parts of the world.

Definition

Haplustults are the Ustults that:

1. Do not have a kandic horizon;

2. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon within 150 cm of the mineral soil surface;

3. Have a color value of 4 or more, moist, in some part of the epipedon or have an argillic horizon that has a color with hue less red than 2.5YR and a value of 5 or more, dry, or of 4 or more, moist, in some subhorizon; *and*

4. Have a clay distribution in which, with increasing depth, the percentage of clay decreases from its maximum amount by more than 20 percent within 150 cm of the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer.

Key to Subgroups

HDFA. Haplustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplustults

HDFB. Other Haplustults that have a petroferric contact within 100 cm of the mineral soil surface.

Petroferric Haplustults

HDFC. Other Haplustults that have, in one or more layers both within the upper 12.5 cm of the argillic horizon and within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Haplustults

HDFD. Other Haplustults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 cm or more below the mineral soil surface.

Arenic Haplustults

HDFE. Other Haplustults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Haplustults

HDFF. Other Haplustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Haplustults

HDFG. Other Haplustults that have a CEC (by 1N NH_4OAc pH 7) of less than 24 cmol(+)/kg clay in 50 percent or more of the entire argillic horizon if less than 100 cm thick or of its upper 100 cm.

Kanhaplic Haplustults

HDFH. Other Haplustults.

Typic Haplustults

Definition of Typic Haplustults

Typic Haplustults are the Haplustults that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have a petroferric contact within 100 cm of the mineral soil surface;

3. Do not have, in any layer within the upper 12.5 cm of the argillic horizon and within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

4. Have, within 75 cm of the mineral soil surface, hue of 7.5YR or redder in all horizons with a color value, moist, of 4 or more if there are redox concentrations or if the hue becomes redder with increasing depth within 100 cm of the mineral soil surface;

5. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

6. Have a CEC of 24 cmol(+) or more per kg clay (by 1N NH_4OAc pH 7) in the major part of the argillic horizon or in the major part of the upper 100 cm of the argillic horizon if this horizon is thicker than 100 cm; *and*

7. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic horizon at a depth of 50 to 100 cm.

Description of Subgroups

Typic Haplustults.—The central concept or Typic subgroup of Haplustults is fixed on freely drained soils that are deep or moderately deep to hard rock or to a petroferric contact, do not have a thick epipedon of sand or loamy sand, have little or no plinthite, and have clay that is at least semiactive.

Redox depletions with low chroma at a moderately shallow depth accompanied by seasonal ground water in the iron-depleted zone are properties shared with Aquults and define the Aquic subgroup. A yellowish brown or olive brown color in the upper part of the soils along with reddish redox concentrations and a redder hue at some depth are associated with wetness at the surface and define the Ombroaquic subgroup. A thick sandy layer, starting at the mineral soil surface, defines the Arenic subgroup. Clay that has low activity suggests strong weathering, a property of Kanhaplustults, and defines the Kanhaplic subgroup. Plinthite is considered abnormal, and its presence is used to define the Plinthic subgroup. A petroferric contact also is considered abnormal and defines the Petroferric subgroup.

Typic Haplustults are of small extent in the United States. They are mostly in Texas, California, Puerto Rico, and the Virgin Islands. The natural vegetation consisted mostly of coniferous forest plants in California, broadleaf forest or savanna plants in Texas, and tropical forest plants in Puerto Rico and the Virgin Islands. Slopes range from nearly level to very steep. Some of these soils are used as forest. Where slopes are suitable, many of the soils have been cleared and are used as pasture, cropland, or homesites.

Aquic Haplustults.—These soils have ground water in the upper part of the argillic horizon at some time of the year or are artificially drained, and they have redox depletions with low chroma in the horizons that are or were saturated. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Haplustults.—These soils have a thick layer of sand or loamy sand, starting at the mineral soil surfac. The argillic horizon normally has more sand and less clay than the one in

Typic Haplustults. Arenic Haplustults are rare in the United States and are known to occur only in Texas.

Kanhaplic Haplustults.—These soils have a strongly weathered clay fraction that has a moderately low or low CEC. They are otherwise like Typic Haplustults in defined properties, but they tend to have less extractable aluminum and a higher pH. Kanhaplic Haplustults are not known to occur in the United States or in Puerto Rico. The subgroup is provided for use in other parts of the world.

Lithic Haplustults.—These soils have a shallow lithic contact. They are not known to occur in the United States or in Puerto Rico. The subgroup is provided for use in other parts of the world.

Ombroaquic Haplustults.—These soils have yellowish brown or olive brown colors in the upper horizons, commonly on the faces of peds only, and have redder redox concentrations inside the peds. The hue becomes redder with increasing depth. These soils are not known to occur in the United States or in Puerto Rico. The subgroup is provided for use in other parts of the world.

Petroferric Haplustults.—These soils have a petroferric contact within 100 cm of the mineral soil surface but are otherwise similar to Typic Haplustults in defined properties. They are not known to occur in the United States or in Puerto Rico. The subgroup is provided for use in other parts of the world.

Plinthic Haplustults.—These soils have a moderate or small amount of plinthite in or below the argillic horizon but are otherwise like Typic Haplustults in defined properties. They probably have or have had a fluctuating level of ground water, which is or was absent or is present for shorter periods in the soils of the Typic subgroup. Plinthic Haplustults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Kandiustults

Kandiustults are the Ustults that have a kandic horizon. These soils have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. The soils do not have plinthite that forms a continuous phase or constitutes more than half the volume in some subhorizon within 150 cm of the soil surface. Most of the soils have a thermic or warmer soil temperature regime. The natural vegetation consisted of forest or savanna plants. Many of the soils have been cleared and are used as cropland or pasture.

Definition

Kandiustults are the Ustults that:

1. Have a kandic horizon;

2. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface;

3. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of clay depletions on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer; *and*

4. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HDBA. Kandiustults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrustoxic Kandiustults

HDBB. Other Kandiustults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kandiustults

HDBC. Other Kandiustults that have *both*:

1. A sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more; *and*

2. 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Arenic Plinthic Kandiustults

HDBD. Other Kandiustults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 cm or more.

Arenic Kandiustults

HDBE. Other Kandiustults that have *both*:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that is dry in some part for 135 or fewer of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udandic Kandiustults

HDBF. Other Kandiustults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kandiustults

HDBG. Other Kandiustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kandiustults

HDBH. Other Kandiustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A thermic, mesic, or colder soil temperature regime and a moisture control section that in normal years is dry in some part for more than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Kandiustults

HDBI. Other Kandiustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Kandiustults

HDBJ. Other Kandiustults that have, in all subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 75 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kandiustults

HDBK. Other Kandiustults.

Typic Kandiustults

Definition of Typic Kandiustults

Typic Kandiustults are the Kandiustults that:

1. Do not have, in any layer within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

3. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm;

4. In all parts of the upper 75 cm of the kandic horizon, have 50 percent or less colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value;

5. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

6. When neither irrigated nor fallowed to store moisture:

a. If the soil temperature regime is thermic, mesic, or colder, are moist in some part of the moisture control section (not necessarily the same part) for more than six-tenths of the time in normal years when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. If the soil temperature regime is hyperthermic, isomesic, or warmer, have a moisture control section that in normal years:

(1) Is moist in some or all parts for 90 or more consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *or*

(2) Is dry in some part for less than six-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C;

7. When neither irrigated nor fallowed to store moisture:

a. If the soil temperature regime is mesic or thermic, are dry in some part of the moisture control section for more than 135 cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. If the soil temperature regime is hyperthermic, isomesic, or warmer, are dry in some or all parts of the moisture control section for 120 or more cumulative days per year during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

8. Have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the mineral soil surface.

Description of Subgroups

Typic Kandiustults.—The central concept or Typic subgroup of Kandiustults is fixed on freely drained, very deep soils that have an ustic moisture regime that is approaching neither the udic nor the aridic regime. The epipedon is not both thick and sandy (not sand or loamy sand). These soils have less than 5 percent plinthite and have a low, but not extremely low, cation-exchange capacity. They do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals.

Ground water at a moderate depth, redox depletions with low chroma at a shallow depth, and a fluctuating level of ground water in the redox-depleted zone are properties shared with Aquults and define the Aquic subgroup. A thick sandy layer, starting at the mineral soil surface, defines the Arenic subgroup.

Typic Kandiustults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Acrustoxic Kandiustults.—These soils have an extremely low cation-exchange capacity. Recycling of plant nutrients from decaying vegetation is critical for plant growth on these soils. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Andic Kandiustults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Kandiustults.—These soils have ground water that fluctuates in depth or are artificially drained, and the horizons that are or were saturated have redox depletions with low chroma. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Kandiustults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is 50 cm or more thick. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Plinthic Kandiustults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They also have 5 to 50 percent (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface. These soils are of very small extent in the United States.

Aridic Kandiustults.—These soils are drier than Typic Kandiustults. They are intergrades between Argids and Kandiustults. Aridic Kandiustults are not known to occur in the United States. They are defined for use in other parts of the world.

Plinthic Kandiustults.—These soils have 5 to 50 percent (by volume) plinthite in some subhorizon within 150 cm of the surface. They are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodic Kandiustults.—These soils are like Typic Kandiustults, but the upper part of their kandic horizon has hue of 2.5YR or redder, a color value, moist, of 3 or less, and a dry value no more than 1 unit higher than the moist value. Rhodic Kandiustults are not known to occur in the United States. They are defined for use in other parts of the world.

Udandic Kandiustults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. They are dry in some part of the moisture control section for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for fewer than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Kandiustults and Udands. They are not known to occur in the United States. They are defined for use in other parts of the world.

Udic Kandiustults.—These soils are like Typic Kandiustults, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for fewer than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. These soils are intergrades between Kandiustults and Kandiudults. They are not known to occur in the United States. They are defined for use in other parts of the world.

Kanhaplustults

These are the Ustults that have a kandic horizon and are very deep to any horizon that is one-half or more plinthite. They have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of clay depletions on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils have a thin or moderately thick zone of maximum clay content. Slopes range from gentle to very steep. Many of the soils are in tropical climates and are farmed by means of shifting cultivation.

Kanhaplustults are not known to occur in the United States. They are defined for use in other parts of the world.

Definition

Kanhaplustults are the Ustults that:

1. Have a kandic horizon;

2. Have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer; *and*

3. Do not have plinthite that forms a continuous phase or constitutes more than half the volume of some subhorizon within 150 cm of the mineral soil surface.

Key to Subgroups

HDCA. Kanhaplustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Kanhaplustults

HDCB. Other Kanhaplustults that have an ECEC of 1.5 cmol(+)/kg clay or less (sum of bases extracted with 1N NH_4OAc pH 7, plus 1N KCl-extractable Al) in one or more horizons within 150 cm of the mineral soil surface.

Acrustoxic Kanhaplustults

HDCC. Other Kanhaplustults that have, in one or more layers within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Kanhaplustults

HDCD. Other Kanhaplustults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm.

Arenic Kanhaplustults

HDCE. Other Kanhaplustults that have *both*:

1. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0; *and*

2. When neither irrigated nor fallowed to store moisture, *either*:

a. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

b. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udandic Kanhaplustults

HDCF. Other Kanhaplustults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Kanhaplustults

HDCG. Other Kanhaplustults that have 5 percent or more (by volume) plinthite in one or more horizons within 150 cm of the mineral soil surface.

Plinthic Kanhaplustults

HDCH. Other Kanhaplustults that:

1. Have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder

with increasing depth within 100 cm of the mineral soil surface; *and*

2. In normal years are saturated with water in one or more layers within 100 cm of the mineral soil surface for *either or both*:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days.

Ombroaquic Kanhaplustults

HDCI. Other Kanhaplustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A thermic, mesic, or colder soil temperature regime and a moisture control section that in normal years is dry in some part for more than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years:

a. Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

b. Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Aridic Kanhaplustults

HDCJ. Other Kanhaplustults that, when neither irrigated nor fallowed to store moisture, have *either*:

1. A mesic or thermic soil temperature regime and a moisture control section that in normal years is dry in some part for 135 or fewer of the cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 5 °C; *or*

2. A hyperthermic, isomesic, or warmer *iso* soil temperature regime and a moisture control section that in normal years is dry in some or all parts for fewer than 120 cumulative days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C.

Udic Kanhaplustults

HDCK. Other Kanhaplustults that have, in all subhorizons in the upper 50 cm of the kandic horizon or throughout the entire kandic horizon if it is less than 50 cm thick, more than 50 percent colors that have *all* of the following:

1. Hue of 2.5YR or redder; *and*

2. A value, moist, of 3 or less; *and*

3. A dry value no more than 1 unit higher than the moist value.

Rhodic Kanhaplustults

HDCL. Other Kanhaplustults.

Typic Kanhaplustults

Definition of Typic Kanhaplustults

Typic Kanhaplustults are the Kanhaplustults that:

1. Do not have a lithic contact within 50 cm of the mineral soil surface;

2. Do not have, in any layer within 75 cm of the mineral soil surface, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

3. Have, within 75 cm of the mineral soil surface, hue of 7.5YR or redder in all horizons with a color value, moist, of 4 or more if there are redox concentrations or if the hue becomes redder with increasing depth within 100 cm of the mineral soil surface;

4. Have less than 5 percent (by volume) plinthite in all subhorizons within 150 cm of the mineral soil surface;

5. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm;

6. In all parts of the upper 50 cm of the kandic horizon, have 50 percent or less colors that have *all* of the following:

a. Hue of 2.5YR or redder; *and*

b. A value, moist, of 3 or less; *and*

c. A dry value no more than 1 unit higher than the moist value;

7. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

8. Have an ECEC (sum of bases plus 1N KCl-extractable Al) of more than 1.5 cmol(+)/kg clay in all subhorizons to a depth of 150 cm below the mineral soil surface;

9. When neither irrigated nor fallowed to store moisture:

a. If the soil temperature regime is thermic, mesic, or colder, are moist in some part of the moisture control section (not necessarily the same part) for more than six-tenths of the time in normal years when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. If the soil temperature regime is hyperthermic, isomesic, or warmer, in normal years are moist in some or all parts of the moisture control section for 180 or more days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C; *and*

10. When neither irrigated nor fallowed to store moisture:

a. If the soil temperature regime is mesic or thermic, are dry in some part of the moisture control section for more than 135 cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C; *or*

b. If the soil temperature regime is hyperthermic, isomesic, or warmer, in normal years the moisture control section:

(1) Is moist in some or all parts for fewer than 90 consecutive days per year when the temperature at a depth of 50 cm below the soil surface is higher than 8 °C; *and*

(2) Is dry in some part for six-tenths or more of the cumulative days per year when the soil temperature at a depth of 50 cm below the soil surface is higher than 5 °C.

Description of Subgroups

Typic Kanhaplustults.—The central concept or Typic subgroup of Kanhaplustults is fixed on freely drained soils that have an ustic moisture regime that is approaching neither the udic nor the aridic regime. These soils are more than 50 cm deep to a lithic contact. The epipedon is not both thick and sandy (not sand or loamy sand). The soils have less than 5 percent plinthite and have a low, but not extremely low, cation-exchange capacity. They do not have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals.

Soils that have, in the upper part of the kandic horizon, 50 percent or more colors with hue of 2.5YR or redder, a value, dry, of 3 or less, and moist and dry color values that differ from each other by 1 unit or less than 1 unit are excluded from Typic Kanhaplustults because these properties are shared with Rhodustults. Ground water at a moderate depth, redox depletions with low chroma at a shallow depth, and a fluctuating level of ground water in the redox-depleted zone are properties shared with Aquults and define the Oxyaquic and Aquic subgroups. A thick sandy layer, starting at the mineral soil surface, defines the Arenic subgroup.

Typic Kanhaplustults are not known to occur in the United States. They are defined for use in other parts of the world.

Acrudoxic Kanhaplustults.—These soils have an extremely low cation-exchange capacity. Recycling of plant nutrients from decaying vegetation is critical for plant growth on these soils. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Andic Kanhaplustults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aquic Kanhaplustults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox depletions with chroma of 2 or less and also aquic conditions for some time in normal years (or artificial drainage). The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Arenic Kanhaplustults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Aridic Kanhaplustults.—These soils are drier than Typic Kanhaplustults. They are intergrades between Argids and Kanhaplustults. Aridic Kanhaplustults are not known to occur in the United States. They are defined for use in other parts of the world.

Lithic Kanhaplustults.—These soils have a lithic contact within 50 cm of the mineral soil surface. In addition, they are permitted to have any color, saturation, or redox feature allowed in Kanhaplustults. Lithic Kanhaplustults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Ombroaquic Kanhaplustults.—These soils have, in one or more horizons within 75 cm of the mineral soil surface, redox concentrations, a color value, moist, of 4 or more, and hue that is 10YR or yellower and becomes redder with increasing depth within 100 cm of the mineral soil surface. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Plinthic Kanhaplustults.—These soils have 5 to 50 percent (by volume) plinthite in some subhorizon within 150 cm of the surface. They are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodic Kanhaplustults.—These soils are like Typic Kanhaplustults, but the upper part of their kandic horizon has hue of 2.5YR or redder, a color value, moist, of 3 or less, and a dry value no more than 1 unit higher than the moist value. Rhodic Kanhaplustults are not known to occur in the United States. They are defined for use in other parts of the world.

Udandic Kanhaplustults.—These soils have a moisture regime that borders on udic and have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Udic Kanhaplustults.—These soils are like Typic Kanhaplustults, but they are dry in some part of the moisture control section for less than four-tenths of the cumulative days per year when the soil temperature at a depth of 50 cm exceeds 5 °C if the soil temperature regime is mesic or thermic and are dry in some or all parts of the moisture control section for fewer than 90 days during a period when the soil temperature at a depth of 50 cm exceeds 8 °C if the soil temperature regime is hyperthermic, isomesic, or warmer. The soils are intergrades between Kanhaplustults and Kanhapludults. Udic Kanhaplustults are not known to occur in the United States. They are defined for use in other parts of the world.

Paleustults

These are the more or less freely drained Ustults that have an argillic horizon. They have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils have no horizon in which plinthite either forms a continuous phase or constitutes one-half or more of the volume within 150 cm of the mineral soil surface. Many of the soils have a thick argillic horizon. Commonly, there are small or moderate amounts of plinthite at some depth in the soils. Paleustults are on old stable surfaces that have gentle slopes. They are very rare in the United States and are known to occur only in California. The great group is provided for use elsewhere.

Definition

Paleustults are the Ustults that:

1. Within 150 cm of the mineral soil surface, *either*:

   a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

   b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction; *and*

2. Do not have any horizon within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume; *and*

3. Do not have a kandic horizon.

Key to Subgroups

HDDA. All Paleustults.

Typic Paleustults

Plinthustults

These are the more or less freely drained Ustults that have a large amount of plinthite. Slopes are mostly gentle or moderate. These soils are not known to occur in the United States or in Puerto Rico. The great group is provided for use elsewhere.

Definition

Plinthustults are the Ustults that have one or more horizons within 150 cm of the mineral soil surface in which plinthite either forms a continuous phase or constitutes one-half or more of the volume.

Key to Subgroups

HDAA. Plinthustults that have:

1. A densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *or*

2. Within 150 cm of the mineral soil surface, *both*:

   a. With increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content; *and*

   b. Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *or*, below that layer, a clay increase of less than 3 percent (absolute) in the fine-earth fraction.

Haplic Plinthustults

HDAB. Other Plinthustults.

Typic Plinthustults

Definition of Typic Plinthustults

Typic Plinthustults are the Plinthustults that:

1. Do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface; *and*

2. Have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer.

Description of Subgroups

Typic Plinthustults.—These are the very deep Plinthustults that have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases by more than 20 percent has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent (absolute) increase in clay content below this layer. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Haplic Plinthustults.—These are the Plinthustults that are moderately deep or that have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the clay percentage decreases by more than 20 percent has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils are not known to occur in the United States. They are defined for use in other parts of the world.

Rhodustults

These are the Ustults that have a dark colored epipedon and a dark red or dusky red argillic horizon. They are moderately deep or have a clay distribution in which the percentage of clay decreases from its maximum amount by 20 percent or more within a depth of 150 cm from the mineral soil surface, and the layer in which the clay percentage decreases by more than 20 percent has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils formed mainly in material weathered from basic rocks. As a consequence, they tend to have more total phosphorus than most other Ustults.

Rhodustults have gentle to steep slopes. Most of the soils formed in alluvium or on slopes of the later half of the Pleistocene, either Illinoian or Wisconsinan.

Rhodustults are rare in the United States and are known to occur only on the Pacific Trust Islands.

Definition

Rhodustults are the Ustults that:

1. Have an epipedon that has a color value, moist, of 3 or less throughout;

2. In all subhorizons in the upper 100 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 100 cm thick, have more than 50 percent colors with *all* of the following:

   a. Hue of 2.5YR or redder; *and*

   b. A value, moist, of 3 or less; *and*

   c. A dry value no more than 1 unit higher than the moist value;

3. Do not have plinthite that forms a continuous phase or constitutes more than half the matrix in any subhorizon in the upper 150 cm;

4. Have a clay distribution in which, with increasing depth, the percentage of clay decreases from its maximum amount by more than 20 percent within 150 cm of the mineral soil surface, and the layer in which the percentage of clay is less than the maximum has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer; *and*

5. Do not have a kandic horizon.

Key to Subgroups

HDEA. Rhodustults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Rhodustults

HDEB. Other Rhodustults that have a sandy particle-size class throughout the upper 75 cm of the argillic horizon or throughout the entire argillic horizon if it is less than 75 cm thick.

Psammentic Rhodustults

HDEC. Other Rhodustults.

Typic Rhodustults

Definition of Typic Rhodustults

Typic Rhodustults are the Rhodustults that:

1. Have an argillic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic horizon is more than 75 cm thick or in any part if the argillic horizon is less than 75 cm thick;

2. Do not have a lithic contact within 50 cm of the mineral soil surface.

Description of Subgroups

Typic Rhodustults.—The central concept or Typic subgroup of Rhodustults is fixed on well drained soils that are moderately deep to very deep. These soils do not have a lithic contact within 50 cm of the mineral soil surface. The argillic horizon is finer than the sandy or sandy-skeletal particle-size class. The absence of an Aquic subgroup probably reflects the nature of the underlying rock, which seems to preclude the presence of shallow ground water. These soils formed mostly from basic rocks and sediments.

Typic Rhodustults are of small extent on the Pacific Trust Islands of the United States. The natural vegetation consisted of savanna plants. Slopes are nearly level to very steep. Most of these soils are used as cropland if slopes are gentle.

Lithic Rhodustults.—These soils have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Psammentic Rhodustults.—These soils have a sandy or sandy-skeletal particle-size class throughout the entire argillic horizon or throughout the upper 75 cm of the argillic horizon if this horizon is more than 75 cm thick. Psammentic Rhodustults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Xerults

These are more or less freely drained Ultisols of Mediterranean climates. These soils have a xeric moisture regime and a moderate or small amount of organic matter. They generally have an ochric or umbric epipedon that rests on a brownish to reddish argillic or kandic horizon. They are not extensive in the United States, except locally in California and Oregon. They are gently sloping to very steep. Most of the Xerults in the United States are in the mountains. The natural vegetation consisted mostly of coniferous forest plants.

Definition

Xerults are the Ultisols that:

1. Have a xeric soil moisture regime;

2. Have less than 0.9 percent organic carbon in the upper 15 cm of the argillic horizon, exclusive of any Ap horizon;

3. Have less than 12 kg organic carbon in a unit volume of 1 m^2 to a depth of 100 cm below the base of any O horizon or the mineral soil surface; *and*

4. Do not have both aquic conditions and the colors defined for Aquults.

Key to Great Groups

HEA. Xerults that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds or 5 percent or more (by volume) plinthite, or both, in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Palexerults, p. 780

HEB. Other Xerults.

Haploxerults, p. 778

Haploxerults

These are the Xerults that have a clay distribution in which the percentage of clay decreases from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, and the layer in which the clay percentage decreases has less than 5 percent of the volume consisting of skeletans on faces of peds or there is an increase in clay content of less than 3 percent (absolute) below this layer. These soils typically have an ochric epipedon that rests on a brownish or reddish argillic or kandic horizon. In the United States, they occur mostly in the Sierra Nevada and Cascade Mountains and support coniferous forest plants. The soils are moderately extensive in those mountains but are rare elsewhere in the United States.

Definition

Haploxerults are the Xerults that:

1. Have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *or*

2. Within 150 cm of the mineral soil surface, have:

a. With increasing depth, a clay decrease of 20 percent or more (relative) from the maximum clay content; *and*

b. Less than 5 percent (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content or, below that layer, no clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Key to Subgroups

HEBA. Haploxerults that have *both*:

1. A lithic contact within 50 cm of the mineral soil surface; *and*

2. In each pedon, a discontinuous argillic or kandic horizon that is interrupted by ledges of bedrock.

Lithic Ruptic-Inceptic Haploxerults

HEBB. Other Haploxerults that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxerults

HEBC. Other Haploxerults that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Haploxerults

HEBD. Other Haploxerults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Haploxerults

HEBE. Other Haploxerults that have an argillic or kandic horizon that:

1. Consists entirely of lamellae; *or*

2. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

3. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

a. Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic or kandic horizon); *or*

b. A combination of lamellae (that may or may not be part of the argillic or kandic horizon) and one or more parts o the argillic or kandic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Lamellic Haploxerults

HEBF. Other Haploxerults that have a sandy particle-size class throughout the upper 75 cm of the argillic or kandic horizon or throughout the entire horizon if it is less than 75 cm thick.

Psammentic Haploxerults

HEBG. Other Haploxerults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm.

Arenic Haploxerults

HEBH. Other Haploxerults that have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 100 cm or more.

Grossarenic Haploxerults

HEBI. Other Haploxerults.

Typic Haploxerults

Definition of Typic Haploxerults

Typic Haploxerults are the Haploxerults that:

1. Do not have, in any subhorizon within the upper 25 cm of the argillic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions;

2. Do not have a lithic contact within 50 cm of the mineral soil surface;

3. Have an argillic or kandic horizon that is finer than the sandy particle-size class in some part of the upper 75 cm if the argillic or kandic horizon is more than 75 cm thick or in any part if the argillic or kandic horizon is less than 75 cm thick;

4. Do not have, throughout a cumulative thickness of 18 cm or more and within a depth of 75 cm, a bulk density, in the fraction less than 2.0 mm in size, of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and acid-oxalate-extractable aluminum plus $^1/_2$ acid-oxalate-extractable iron of more than 1.0 percent;

5. Do not have a sandy or sandy-skeletal particle-size class throughout a layer extending from the mineral soil surface to the top of an argillic or kandic horizon at a depth of 50 to 100 cm; *and*

6. Have an argillic or kandic horizon that meets *none* of the following:

a. Consists entirely of lamellae; *or*

b. Is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon; *or*

c. Consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are *either*:

(1) Two or more lamellae with a combined thickness of 5 cm or more (that may or may not be part of the argillic or kandic horizon); *or*

(2) A combination of lamellae (that may or may not be part of the argillic or kandic horizon) and one or more parts of the argillic or kandic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon.

Description of Subgroups

Typic Haploxerults.—The central concept or Typic subgroup of Haploxerults is fixed on freely drained soils that are deep or moderately deep to hard rock, have an epipedon that is not both thick and sandy (not sand or loamy sand), have a continuous argillic or kandic horizon throughout the pedon, and do not have a surface mantle that is influenced by pyroclastic materials. Most of the Haploxerults in the United States are Typic Haploxerults. Typic Haploxerults occur mostly in the Sierra Nevada and Cascade Mountains in California and Oregon. The natural vegetation consists mostly of coniferous forest plants, but in some areas it consists of savanna plants or is dominated by shrubs. These soils are of moderate extent. Most are used as forest. Where slopes are suitable, some of the soils have been cleared and are used as cropland, pasture, or homesites.

Andic Haploxerults.—These soils have a surface mantle or layer in the upper 75 cm that has both a low bulk density and a high content of weakly crystalline minerals in at least some part of the upper 75 cm. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Aquic Haploxerults.—These soils have redox depletions with low chroma and also aquic conditions at a shallow depth for some time in normal years. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Arenic Haploxerults.—These soils have a layer, starting at the mineral soil surface, that has a sandy or sandy-skeletal particle-size class and is between 50 and 100 cm thick. The soils are not known to occur in the United States. They are defined for use in other parts of the world.

Grossarenic Haploxerults.—These soils have a layer, starting at the mineral soil surface and extending to the top of the argillic or kandic horizon, that has a sandy or sandy-skeletal particle-size class and is more than 100 cm thick. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Lamellic Haploxerults.—These soils have an argillic or kandic horizon that consists entirely of lamellae or is a combination of two or more lamellae and one or more subhorizons with a thickness of 7.5 to 20 cm, each layer with an overlying eluvial horizon. In some of the soils, the argillic or kandic horizon consists of one or more subhorizons that are more than 20 cm thick, each with an overlying eluvial horizon, and above these horizons there are either two or more lamellae with a combined thickness of 5 cm or more or a combination of lamellae and one or more parts of the argillic or kandic horizon 7.5 to 20 cm thick, each with an overlying eluvial horizon. Lamellic Haploxerults are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Lithic Haploxerults.—These soils are like Typic Haploxerults, but they have a lithic contact within 50 cm of the mineral soil surface. They are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Lithic Ruptic-Inceptic Haploxerults.—These soils have a lithic contact within 50 cm of the mineral soil surface and an intermittent argillic or kandic horizon. They characteristically have an irregular or wavy boundary at the lithic contact. The argillic or kandic horizon typically does not occur in the parts of the pedon that have a very shallow lithic contact. These soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Psammentic Haploxerults.—These soils have an argillic or kandic horizon that has a sandy or sandy-skeletal particle-size class throughout or throughout the upper 75 cm if the horizon is more than 75 cm thick. The soils are not known to occur in the United States. The subgroup is provided for use in other parts of the world.

Palexerults

These are the Xerults that have a clay distribution in which the percentage of clay does not decrease from its maximum amount by as much as 20 percent within a depth of 150 cm from the mineral soil surface, or the layer in which the clay percentage decreases has at least 5 percent of the volume consisting of skeletans on faces of peds and there is at least a 3 percent increase in clay content below this layer. These soils are mainly on old stable or metastable surfaces in the Cascade and coastal mountains of Oregon and California. Slopes are gentle to very steep. The soils are probably rare in the world, but they may be extensive locally in areas of humid Mediterranean climates.

Definition

Palexerults are the Xerults that:

1. Do not have a densic, lithic, or paralithic contact within 150 cm of the mineral soil surface; *and*

2. Within 150 cm of the mineral soil surface, *either*:

a. With increasing depth, do not have a clay decrease of 20 percent or more (relative) from the maximum clay content; *or*

b. Have 5 percent or more (by volume) skeletans on faces of peds in the layer that has a 20 percent lower clay content *and*, below that layer, a clay increase of 3 percent or more (absolute) in the fine-earth fraction.

Key to Subgroups

HEAA. Palexerults that have *both*:

1. In one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations, and also aquic conditions for some time in normal years (or artificial drainage); *and*

2. Throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus $^1/_2$ Fe percentages (by ammonium oxalate) totaling more than 1.0.

Aquandic Palexerults

HEAB. Other Palexerults that have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years (or artificial drainage).

Aquic Palexerults

HEAC. Other Palexerults that have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

Andic Palexerults

HEAD. Other Palexerults.

Typic Palexerults

Definition of Typic Palexerults

Typic Palexerults are the Palexerults that:

1. Do not have, in one or more subhorizons within the upper 25 cm of the argillic or kandic horizon, redox depletions with a color value, moist, of 4 or more and chroma of 2 or less, accompanied by redox concentrations and by aquic conditions for some time in normal years;

2. Do not have, throughout one or more horizons with a total thickness of 18 cm or more within 75 cm of the mineral soil surface, a fine-earth fraction with both a bulk density of 1.0 g/cm^3 or less, measured at 33 kPa water retention, and Al plus 1/2 Fe percentages (by ammonium oxalate) totaling more than 1.0.

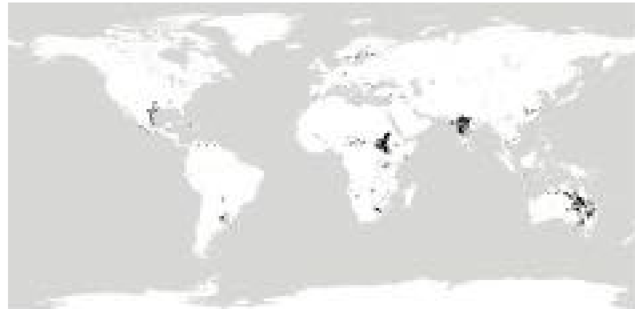
Description of Subgroups

Typic Palexerults.—The central concept or Typic subgroup of Palexerults is fixed on well drained soils that are not significantly influenced by volcanic ash. These soils are on old landscapes, and in some areas the clay mineralogy is influenced by kaolinite. The soils occur in the Pacific Northwest and are used for timber production.

Andic Palexerults.—These are the well drained Palexerults that are significantly influenced by volcanic ash. When weathered, the volcanic ash influences P-retention, porosity, and other soil properties. These soils occur in the Pacific Northwest and are used for timber production.

Aquandic Palexerults.—These soils have aquic conditions in the upper 25 cm of the argillic or kandic horizon and are significantly influenced by volcanic ash. The soils occur in the Pacific Northwest and are used for timber production.

Aquic Palexerults.—These soils have aquic conditions in the upper 25 cm of the argillic or kandic horizon but are not significantly influenced by volcanic ash. The soils occur in the Pacific Northwest and are used for timber production.



CHAPTER 20

Vertisols[1]

The central concept of Vertisols is that of clayey soils that have deep, wide cracks for some time during the year and have slickensides within 100 cm of the mineral soil surface. They shrink when dry and swell when moistened. Vertisols make up a relatively homogeneous order because of the amounts and kinds of clay common to them; however, their microvariability within a pedon is great. Before the advent of modern classification systems, these soils were already well known for their characteristic color, the cracks they produce during the dry season, and the difficulty of their engineering properties.

In many countries where Vertisols are extensive, they are known by local names, such as cracking clays (Australia), Adobe (Philippines), Shachiang (China), Black Cotton soils (India), Smolnitza (Bulgaria, Rumania), Tirs (Morocco), Makande (Malawi), Vleigrond (South Africa), and Sonsosuite (Nicaragua). In addition, numerous coined terms have been used to identify the soils. Examples are Margalite soils (Indonesia), Densinegra soils (Angola), and Grumusols (United States).

These soils generally are sticky in the wet season and hard in the dry season, so they require special cultivation practices regardless of whether modern equipment or traditional implements, such as a hoe or bullock-drawn plow, are used. Because their unique properties restrict engineering uses, the soils are well known among engineers. The movement of these soils can tilt trees; throw fenceposts, telephone poles, and power poles out of line; and break pipelines, highway pavements, and the masonry foundations of buildings.

Vertisols are mapped in many countries. The largest areas are in Australia (80,000,000 ha), India (73,000,000 ha), the Sudan (50,000,000 ha), and the United States (18,000,000 ha). The soil moisture regime is ustic in about 65 percent of the areas where the Vertisols occur, aridic in 18 percent of the areas, udic in 13 percent, and xeric in 4 percent. The defined moisture regimes, however, have little significance in areas of these soils because, when rainfall occurs, the water commonly runs into the cracks, so that the soils are remoistened from both above and below. Because of the difficulty in defining soil moisture regimes in Vertisols, the duration that cracks open and close are used to differentiate the various soil moisture regimes. Vertisols are known to occur in all soil temperature regimes that are cryic and warmer.

The shrink-swell phenomenon, which is responsible for the genesis and behavior of Vertisols, is a complex, dynamic, but incompletely understood set of processes. Expressions of this phenomenon are linear and normal gilgai, cyclic horizons, surface cracking upon desiccation, and the formation of slickensides. Of these properties, cracks when the soils are dry and slickensides are the unifying morphogenetic markers in all Vertisols. Although the process of shrinking and swelling is important in Vertisols, it does not preclude the formation of diagnostic horizons and features. For example, Vertisols can have calcic, gypsic, or salic horizons. Taxa have been developed to accommodate these diagnostic horizons and features.

Internal movement affects the thickness of soil horizons, which can vary widely within a pedon. A black A horizon, for example, may be only a few centimeters thick or even absent on microknolls but is more than 100 cm thick in microdepressions. The organic-matter content and the depth to carbonates or to a Bk horizon can be equally variable.

Shrink-swell processes in soils are related to the total content of clay, the content of fine clay, and mineralogy. Vertisols generally have a high clay content (50 to 70 percent) and a relatively large proportion of fine clay in the clay fraction. The clays in Vertisols consist predominantly of 2:1- and 2:2-layer clay minerals, but some have considerable amounts of other clay minerals. Apart from the amounts and types of clay, a number of other factors determine the morphological features of Vertisols. Prior soil moisture content, for example, is a very important factor in the shrink-swell process; vertic features are best expressed where the soil has undergone maximum change from a wet to a dry state. The moisture change by itself, however, is insufficient to induce all the vertic properties. To produce movement along the slickensides, there must be a confining pressure, which is provided by the thickness of the soil material above the slickensides. The shrink-swell potential of the clays may be reduced by an admixture of organic matter, carbonates, or other particles. The coefficient of linear extensibility (COLE) normally ranges from 0.07 to 0.2.

Intergrades to Vertisols are recognized in several of the

[1] This chapter was rewritten in 1992 following the recommendations of the International Committee on the Classification of Vertisols (ICOMERT), chaired by Dr. Juan Comerma.

other soil orders. There are basically two kinds of intergrades, although both are considered in the same subgroup. One consists of soils that show evidence of swelling and shrinking as a result of changes from a wet to a dry state but that do not meet the minimum requirements for Vertisols. The intergrades of the other kind show little or no evidence of actual soil movement, but they have potential for soil movement because of the relatively high COLE. These intergrades, however, do not become dry enough or moist enough for soil movement to occur, except in years with unusually low or abnormally high precipitation.

Vertisols generally have gentle slopes, although a few are strongly sloping. The natural vegetation is predominantly grass, savanna, open forest, or desert shrub.

Most Vertisols are well suited to mechanized farming if there is plenty of rainfall or irrigation water and if suitable management practices are followed. Large areas of Vertisols in the world are not farmed, however, because their cultivation would require too much energy, especially where traditional, low-input methods are used. This constraint is a major limiting land-use characteristic of Vertisols.

Irrigation of Usterts, Xererts, and Torrerts presents special problems because of very slow permeability. Bypass flow through open cracks is common. Because the permeability of these soils is so slow, irrigation may result in waterlogging and a buildup of salinity unless adequate artificial drainage is provided. A drainage system designed for Alfisols or Ultisols may be totally inadequate for Vertisols.

Definition of Vertisols and Limits Between Vertisols and Soils of Other Orders

Vertisols are mineral soils that have *all* of the following:

1. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped structural units that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

2. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

3. Cracks[2] that open and close periodically.

[2] A crack is a separation between gross polyhedrons. If the surface horizon is strongly self-mulching, i.e., a mass of loose granules, or if the soil is cultivated while cracks are open, the cracks may be largely filled with granular materials from the surface, but they are open in the sense that the polyhedrons are separated. A crack is regarded as open if it controls the infiltration and percolation of water in a dry, clayey soil.

Limits Between Vertisols and Soils of Other Orders

The definition of Vertisols must provide criteria that separate Vertisols from all other soil orders. The aggregate of these criteria defines the limits of Vertisols in relation to the other known kinds of soil.

1. Unlike Gelisols, Vertisols do not have permafrost within 100 cm of the soil surface or both permafrost within 200 cm of the soil surface and gelic materials within 100 cm of the soil surface.

2. Unlike Andisols, Vertisols do not have andic soil properties in 60 percent or more of the thickness between either the mineral soil surface or the top of an organic layer with andic soil properties, whichever is shallower, and a depth of 60 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon, whichever is shallowest.

3. Unlike Spodosols, Vertisols do not have a spodic horizon or an Ap horizon consisting of spodic materials.

4. Unlike Oxisols, Vertisols do not have, within 150 cm of the mineral soil surface, an oxic horizon or a kandic horizon that meets the weatherable-mineral requirements for an oxic horizon and also 40 percent or more clay in the surface 18 cm after mixing.

5. Unlike Alfisols, Ultisols, Inceptisols, Aridisols, and Entisols, Vertisols have the following properties:

   a. A layer 25 cm or more thick, with an upper boundary within 100 cm of the mineral soil surface, that has either slickensides close enough to intersect or wedge-shaped structural units that have their long axes tilted 10 to 60 degrees from the horizontal; *and*

   b. A weighted average of 30 percent or more clay in the fine-earth fraction either between the mineral soil surface and a depth of 18 cm or in an Ap horizon, whichever is thicker, and 30 percent or more clay in the fine-earth fraction of all horizons between a depth of 18 cm and either a depth of 50 cm or a densic, lithic, or paralithic contact, a duripan, or a petrocalcic horizon if shallower; *and*

   c. Cracks that open and close periodically.

Representative Pedon and Data

Following is a description of a representative Vertisol. Data for the pedon identified in this description are given in the table "Characterization Data for a Vertisol."

Classification: Fine, smectitic, isohyperthermic Typic Haplustert
Site identification number: 90P0616
Location: Icrasat Prod. Agriculture Field #Bw1, India
Latitude: 16 degrees 00 minutes 00 seconds N.

Longitude: 78 degrees 00 minutes 00 seconds E.
Landscape: Plains
Landform: Playa
Microrelief: 20 to 50 cm, linear
Slope: 1 percent, plane, northeast facing
Annual precipitation: 760 mm
Weather station: Icrasat
Soil moisture regime: Ustic
Permeability class: Moderately slow
Drainage class: Well drained
Depth to water table: More than 200 cm
Land use: Cropland
Vegetation: Sorghum, pigeon pea
Hazard of erosion or deposition: Slight
Runoff: None
Parent material: Alluvium derived from igneous material
Described by: R.J. Engel

In the following pedon description, colors are for moist soil unless otherwise indicated.

Ap—0 to 15 cm; dusky red (2.5YR 3/2), crushed, clay; moderate medium subangular blocky structure parting to moderate very fine and fine subangular blocky; very firm, very sticky and very plastic; many very fine and fine roots throughout; many very fine and fine vesicular and tubular pores; neutral (pH 7.2); 5 percent igneous pebbles; abrupt smooth boundary.

AB—15 to 30 cm; very dark gray (10YR 3/1), crushed, clay; moderate fine and medium subangular blocky structure; very firm, very sticky and very plastic; common very fine and fine roots throughout; many very fine and fine vesicular and tubular pores; neutral (pH 7.0); 2 percent igneous pebbles; clear wavy boundary.

Bss1—30 to 53 cm; very dark gray (10YR 3/1), crushed, clay; strong fine angular blocky structure parting to strong fine subangular blocky; very firm, very sticky and very plastic; common very fine and fine roots between peds; common very fine and fine tubular pores; few discontinuous distinct intersecting slickensides on horizontal faces of peds; neutral (pH 7.0); 1 percent igneous pebbles; clear wavy boundary.

Bss2—53 to 89 cm; very dark gray (10YR 3/1), crushed, clay; strong fine angular blocky structure; very firm, very sticky and very plastic; few very fine and fine roots between peds; common very fine and fine tubular pores; common continuous distinct intersecting slickensides on horizontal faces of peds; neutral (pH 7.0); gradual wavy boundary.

Bss3—89 to 122 cm; very dark grayish brown (2.5Y 3/2), crushed, clay; strong fine and medium angular blocky structure; very firm, very sticky and very plastic; few very fine and fine roots between peds; common very fine and fine tubular pores; common continuous distinct intersecting slickensides on horizontal faces of peds; neutral (pH 7.0); gradual wavy boundary.

Bssck1—122 to 155 cm; dark grayish brown (2.5Y 4/2), crushed, clay; strong medium and coarse angular blocky structure; very firm, very sticky and very plastic; few very fine and fine roots between peds; common continuous distinct intersecting slickensides on horizontal faces of peds; common irregular carbonate concretions and common medium and coarse rounded dark concretions; moderately alkaline (pH 8.0); gradual wavy boundary.

Bssck2—155 to 193 cm; dark grayish brown (2.5Y 4/2), crushed, clay; strong medium and coarse angular blocky structure; very firm, very sticky and very plastic; few very fine and fine roots between peds; common continuous distinct intersecting slickensides on horizontal faces of peds; common irregular carbonate concretions and common medium and coarse rounded dark concretions; moderately alkaline (pH 8.0); clear smooth boundary.

Bck—193 to 234 cm; olive brown (2.5Y 4/4), crushed, clay; moderate medium and coarse angular blocky structure; very firm, very sticky and very plastic; many irregular carbonate concretions and common medium and coarse rounded dark concretions; moderately alkaline (pH 8.2).

Key to Suborders

FA. Vertisols that have, in one or more horizons within 50 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one or both* of the following:

1. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

a. 2 or less if redox concentrations are present; *or*

b. 1 or less; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquerts, p. 787

FB. Other Vertisols that have a cryic soil temperature regime.
Cryerts, p. 796

FC. Other Vertisols that in normal years have *both*:

1. A thermic, mesic, or frigid soil temperature regime; *and*

2. If not irrigated during the year, cracks that remain *both*:

a. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

Characterization Data for a Vertisol

SITE IDENTIFICATION NO.: 90P0616
CLASSIFICATION: FINE, SMECTITIC, ISOHYPERTHERMIC TYPIC HAPLUSTERT
GENERAL METHODS: 1B1A, 2A1, 2B

-1- -2- -3- -4- -5- -6- -7- -8- -9- -10- -11- -12- -13- -14- -15- -16- -17- -18- -19- -20-

SAMPLE NO.	DEPTH (cm)	HORIZON	TOTAL CLAY LT .002	TOTAL SILT .002 -.05	TOTAL SAND .05 -2	CLAY FINE LT .0002	CLAY CO_3 LT .002	SILT FINE .002 -.02	SILT COARSE .02 -.05	SAND VF .05 -.10	SAND F .10 -.25	SAND M .25 -.50	SAND C .5 -1	SAND VC 1 -2	COARSE FRACTIONS (mm) WEIGHT 2 -5	WEIGHT 5 -20	WEIGHT 20 -75	WEIGHT .1- 75	(>2mm) WT PCT OF WHOLE SOIL
			<- - - Pct of <2mm (3A1)											- - ->	<- Pct of <75mm(3B1)->				
90P3653	0- 14	Ap	49.0	26.3	24.7	8.0		20.4	5.9	4.8	8.9	5.7	3.1	2.2	6	4	1	29	11
90P3654	14- 29	AB	51.3	28.3	20.4	8.4		20.7	7.6	2.5	7.4	5.2	2.7	2.6	6	3	--	25	9
90P3655	29- 54	Bss1	53.5	25.3	21.2	9.9		20.5	4.8	3.9	5.7	4.2	3.1	4.3	4	3	--	23	7
90P3656	54- 89	Bss2	56.6	26.9	16.5	13.8		21.8	5.1	4.0	5.0	3.3	2.4	1.8	3	2	--	17	5
90P3657	89-121	Bss3	61.2	25.9	12.9	18.2		21.6	4.3	2.9	3.5	2.3	2.2	2.0	1	2	--	13	3
90P3658	121-155	Bssck1	61.0	27.4	11.6	24.1		21.6	5.8	2.5	4.1	2.5	1.4	1.1	2	2	--	13	4
90P3659	155-193	Bssck2	60.7	24.5	14.8	27.0	1.3	21.0	3.5	3.1	4.0	2.9	2.4	2.4	5	7	--	22	12
90P3660	193-234	Bck	58.3	24.3	17.4	27.0	1.3	21.0	3.3	3.3	4.4	3.1	2.8	3.8	5	24	--	39	29

DEPTH (cm)	ORGN C 6A1c Pct	TOTAL N 6B3a <2mm	EXTR P 6S3 ppm	TOTAL S 6R3a	DITH-CIT EXTRACTABLE Fe 6C2b	Al 6G7a	Mn 6D2a	(RATIO/CLAY) CEC 8D1	15 BAR 8D1	(ATTERBERG LIMITS) LL 4F1	PI 4F	(BULK DENSITY) FIELD MOIST 4A3a	1/3 BAR 4A1d	OVEN DRY 4A1h	COLE WHOLE SOIL 4D1	(WATER CONTENT) FIELD MOIST 4B4	1/10 BAR 4B1c	1/3 BAR 4B1c	15 BAR 4B2a	WRD WHOLE SOIL 4C1
				<- Percent of <2mm -->						Pct <0.4mm		<- - g/cc - - ->			cm/cm	<- - -Pct of <2mm - ->				cm/cm
0- 14	0.63							1.10	0.38				1.28	1.66	0.085			31.3	18.7	0.15
14- 29	0.42							1.06	0.39				1.27	1.68	0.092			32.7	19.9	0.16
29- 54	0.39							1.04	0.39				1.31	1.79	0.105			33.1	21.1	0.15
54- 89	0.35							1.02	0.42				1.24	1.91	0.151			38.7	23.5	0.18
89-121	0.19							0.92	0.42				1.25	1.91	0.149			37.5	25.4	0.15
121-155	0.11							0.93	0.42				1.19	1.96	0.176			39.7	25.6	0.16
155-193	0.08							0.89	0.41				1.08	1.85	0.181			48.1	24.9	0.24
193-234	0.04							0.86	0.42				1.25	1.89	0.118			36.5	24.2	0.13

DEPTH (cm)	(NH_4OAc EXTRACTABLE BASES) Ca 5B5a 6N2e	Mg 5B5a 6O2d	Na 5B5a 6P2b	K 5B5a 6Q2b	SUM BASES	ACIDITY 6H5a	(CEC) SUM CATS 5A3a	NH_4-OAc 5A8b	EXCH Na 5D2 Pct	SAR 5E	BASE SATURATION SUM 5C3	NH_4OAc 5C1	CO_3 AS $CaCO_3$ <2mm 6E1g	RES. ohms /cm 8E1	$CaSO_4$ AS GYPSUM <2mm 6F1a	<20mm 6F4	(PH) SAT PASTE 8C1b	$CaCl_2$ .01M 8C1f 1:2	H_2O 8C1f 1:1
	<- - - -meq / 100 g - - - ->								Pct		<- -Pct- >		Pct		<- -Pct ->				
0- 14		9.2	0.1	0.8		0.8		54.0	TR	TR		100	1				7.7	7.2	7.6
14- 29		10.0	--	0.7				54.6	--		100	100	4					7.4	8.1
29- 54		13.1	0.1	0.9		1.0		55.9	TR			100	3					7.5	7.9
54- 89		18.2	0.4	0.8				57.5	1		100	100	2					7.6	8.3
89-121		21.2	1.1	0.8				56.4	2	2	100	100	3	1700			7.7	7.7	8.3
121-155		22.7	2.2	0.8				56.5	4		100	100	3					7.7	8.4
155-193		22.8	3.3	0.8				54.3	6		100	100	5					7.8	8.3
193-234		21.6	4.7	0.7				50.4	9	8	100	100	7				8.0	7.8	8.5

DEPTH (cm)	(WATER EXTRACTED FROM SATURATED PASTE) Ca 6N1b	Mg 6O1b	Na 6P1b	K 6Q1b	CO_3 6I1b	HCO_3 6J1b	F 6U1a	Cl 6K1c	SO_4 6L1c	NO_2 6W1a	NO_3 6M1c	H_2O 8A	TOTAL SALTS EST. 8D5	ELEC. COND. 8A3a mmhos /cm	PRED. ELEC. COND. 8I mmhos /cm
	<- - - -meq / liter - - - ->											<- -Pct- ->			
0- 14	4.2	1.1	0.1	0.1	--	4.5	0.1	0.2	0.7	--	--	72.9	TR	0.49	0.29
14- 29															0.19
29- 54															0.17
54- 89															0.20
89-121	1.3	0.8	1.8	TR	--	2.3	0.2	0.1	1.3	0.1	--	91.3	TR	0.39	0.27
121-155															0.02
155-193															0.01
193-234	0.3	0.2	4.2	TR	--	2.6	0.6	0.2	0.9	0.1	0.4	98.4	TR	0.48	0.44

SAMPLE NUMBER	FRACTION	(CLAY MINERALOGY (<.002mm)) X-RAY 7A2i Peak size				THERMAL DTA 7A6 Percent	TGA 7A4b	ELEMENTAL 7C3 Percent SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	Na_2O	EGME RETN 7D2 mg/g	INTERPRETATION
90P3655	TCLY	MT 4	KK 2	MI 2	QZ 1				19.0	9.7			1.0			
90P3657	TCLY	MT 4	KK 3	MI 2	QZ 1				20.0	9.9			1.2			
90P3659	TCLY	MT 4	KK 2	MI 2	QZ 1				19.0	9.7			1.3			

The chemical data are based on the fraction less than 2 mm in size.
Fraction interpretation: TCLY, total clay, <0.002 mm.
Mineral interpretation: MT, montmorillonite; KK, kaolinite; MI, mica; QZ, quartz.
Relative peak size: 5, very large; 4, large; 3, medium; 2, small; 1, very small; 6, no peaks.
Pedon mineralogy based on clay: Smectitic.
Family mineralogy: Smectitic.

b. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xererts, p. 813

FD. Other Vertisols that, if not irrigated during the year, have cracks in normal years that remain closed for less than 60 consecutive days during a period when the soil temperature at a depth of 50 cm from the soil surface is higher than 8 °C.

Torrerts, p. 797

FE. Other Vertisols that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Usterts, p. 804

FF. Other Vertisols.

Uderts, p. 801

Aquerts

Aquerts are the wet Vertisols. They have aquic conditions at or near the surface for extended periods during the year, but they also are dry for periods long enough in normal years for cracks to open. These soils are typically in low areas, such as glacial lake plains, flood plains, stream terraces, and depressions. Previously, there were no provisions for wet Vertisols in soil taxonomy, and these soils were assigned to the Vertic subgroups of Aquolls, Aqualfs, and Aquepts.

Definition

Aquerts are the Vertisols that have, in one or more horizons within 50 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *one or both* of the following:

1. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

   a. 2 or less if redox concentrations are present; *or*

   b. 1 or less; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

FAA. Aquerts that have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Salaquerts, p. 795

FAB. Other Aquerts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Duraquerts, p. 788

FAC. Other Aquerts that have a natric horizon or have an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Natraquerts, p. 795

FAD. Other Aquerts that have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Calciaquerts, p. 787

FAE. Other Aquerts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in 1:1 water).

Dystraquerts, p. 789

FAF. Other Aquerts that have episaturation.

Epiaquerts, p. 793

FAG. Other Aquerts.

Endoaquerts, p. 791

Calciaquerts

Calciaquerts are the Aquerts that have a calcic horizon. In addition, they commonly have a mollic epipedon. In the United States, these soils occur on the northern Great Plains. They are used mostly for crops. Before 1992, most of these soils were classified as Calciaquolls.

Definition of Subgroups

Calciaquerts are the Aquerts that:

1. Have a calcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have a salic horizon or a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a natric horizon or an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Key to Subgroups

FADA. Calciaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of a duripan if shallower, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Calciaquerts

FADB. Other Calciaquerts.

Typic Calciaquerts

Definition of Typic Calciaquerts

Typic Calciaquerts are the Calciaquerts that, in more than half of each pedon, do not have a horizon, between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of a duripan if shallower, that has *any* of the following:

1. Hue of 2.5Y or redder and *either*:

a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y or yellower and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Description of Subgroups

Typic Calciaquerts.—The Typic subgroup of Calciaquerts is centered on poorly drained or very poorly drained soils that have dominantly gleyed colors close to the surface. These soils occur in Minnesota, Montana, South Dakota, and North Dakota and are used for small grain or sugar beets.

Aeric Calciaquerts.—These are the Calciaquerts with dominantly bright colored layers toward the soil surface. These soils do not have aquic conditions that persist for long periods. They occur in Minnesota and are used for small grain, sugar beets, or sunflowers.

Duraquerts

Duraquerts are the Aquerts that have a duripan. These soils commonly are derived from volcanic materials. In the United States, all of these soils have aquic conditions for part of the year and either have a xeric moisture regime or border a xeric moisture regime. Several subgroups are provided for use in other parts of the world.

Definition

Duraquerts are the Aquerts that:

1. Do not have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FABA. Duraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Duraquerts

FABB. Other Duraquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Duraquerts

FABC. Other Duraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Duraquerts

FABD. Other Duraquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of the duripan if shallower, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Duraquerts

FABE. Other Duraquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Duraquerts

FABF. Other Duraquerts.

Typic Duraquerts

Definition of Typic Duraquerts

Typic Duraquerts are the Duraquerts that:

1. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year;

2. Do not have, in more than half of each pedon, a horizon, between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and either a depth of 75 cm or the upper boundary of the duripan if shallower, that has *any* of the following:

a. Hue of 2.5Y or redder and *either*:

(1) A color value, moist, of 6 or more and chroma of 3 or more; *or*

(2) A color value, moist, of 5 or less and chroma of 2 or more; *or*

b. Hue of 5Y or yellower and chroma of 3 or more; *or*

c. Chroma of 2 or more and no redox concentrations;

3. Have, in all horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *and*

4. Do not have both a thermic, mesic, or frigid soil temperature regime and, if not irrigated during the year, cracks in normal years that remain *both*:

a. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

b. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Description of Subgroups

Typic Duraquerts.—The Typic subgroup of Duraquerts is centered on poorly drained or very poorly drained soils with dark colored surface layers. These soils do not have a moisture regime that borders on xeric, aridic, or ustic. They are not known to occur in the United States.

Aeric Duraquerts.—These are the Duraquerts that commonly are considered to be somewhat poorly drained. Bright colors toward the surface indicate that aquic conditions do not persist for long periods. These soils do not have a moisture regime that borders on aridic, ustic, or xeric.

Aridic Duraquerts.—These are the Duraquerts that have aquic conditions for short periods during the year and are dry for most of the year. These soils require cracks to be open 210 cumulative days during normal years.

Chromic Duraquerts.—These are the Duraquerts that have light colored surface layers. They are dominantly gleyed below the surface layers and do not have a moisture regime that borders on aridic, ustic, or xeric.

Ustic Duraquerts.—These are the Duraquerts that have a moisture regime that borders on ustic. These soils have aquic conditions for part of the year but have moisture deficits for much of the growing season.

Xeric Duraquerts.—These are the Duraquerts that have aquic conditions for at least a part of the winter but are dry during the summer. These soils occur in California. They are used for pasture or irrigated crops, including rice.

Dystraquerts

Dystraquerts are the Aquerts that have dominantly low pH values and low electrical conductivity in the upper 50 cm. These soils commonly occur in low areas, such as flood plains and terraces, but a few occur on uplands. The soils are extensive in the Southern United States. Many of them are cropped, but some are forested.

Definition

Dystraquerts are the Aquerts that:

1. Have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in 1:1 water);

2. Do not have a calcic or salic horizon or a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

3. Do not have a natric horizon or an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Key to Subgroups

FAEA. Dystraquerts that have, in one or more horizons within 100 cm of the mineral soil surface, jarosite concentrations and a pH value of 4.0 or less (1:1 water, air-dried slowly in shade).

Sulfaqueptic Dystraquerts

FAEB. Other Dystraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Dystraquerts

FAEC. Other Dystraquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Dystraquerts

FAED. Other Dystraquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Dystraquerts

FAEE. Other Dystraquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Dystraquerts

FAEF. Other Dystraquerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Dystraquerts

FAEG. Other Dystraquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Dystraquerts

FAEH. Other Dystraquerts.

Typic Dystraquerts

Definition of Typic Dystraquerts

Typic Dystraquerts are the Dystraquerts that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, both jarosite concentrations and a pH value of 4.0 or less (1:1 water, air-dried slowly in shade);

2. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year;

3. Do not have, in any horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, *any* of the following in more than half of each pedon:

   a. Hue of 2.5Y or redder and *either*:

      (1) A color value, moist, of 6 or more and chroma of 3 or more; *or*

      (2) A color value, moist, of 5 or less and chroma of 2 or more; *or*

   b. Hue of 5Y or yellower and chroma of 3 or more; *or*

   c. Chroma of 2 or more and no redox concentrations;

4. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

5. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface; *and*

6. Have, in all horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

   a. A color value, moist, of 3 or less; *or*

   b. A color value, dry, of 5 or less.

Description of Subgroups

Typic Dystraquerts.—The Typic subgroup of Dystraquerts is centered on poorly drained or very poorly drained, deep or very deep, clayey soils with dark colored surface layers. These soils do not have concentrations of jarosite or a soil moisture regime that borders on aridic or ustic.

Aeric Dystraquerts.—These are the Dystraquerts that are not dominated by gleyed colors from a depth of 25 to 75 cm. Most of these soils are considered somewhat poorly drained. Aeric Dystraquerts do not have concentrations of jarosite or a soil moisture regime that borders on ustic or aridic. They occur in Texas and are used as woodland.

Aridic Dystraquerts.—These are the Dystraquerts that have aquic conditions for a short period during the year and are dry the remainder of the year. These soils do not have concentrations of jarosite.

Chromic Dystraquerts.—These are the deep or very deep, clayey, poorly drained or very poorly drained Dystraquerts that have light colored surface layers. These soils do not have concentrations of jarosite or a soil moisture regime that borders on aridic or ustic. They occur in many of the Southern States of the United States. Most of these soils have been cleared for crop production. Some are wooded.

Entic Dystraquerts.—These are the deep or very deep, poorly drained or very poorly drained Dystraquerts that have less than 27 percent clay in a layer 25 cm or more thick within 100 cm of the soil surface. These soils do not have concentrations of jarosite or a soil moisture regime that borders on aridic or ustic.

Leptic Dystraquerts.—These are the poorly drained or very poorly drained Dystraquerts that are less than 100 cm to a lithic, densic, or paralithic contact. These soils do not have concentrations of jarosite or a soil moisture regime that borders on ustic or aridic.

Sulfaqueptic Dystraquerts.—These are the Dystraquerts that have concentrations of jarosite. They commonly occur in coastal areas. They have not been recognized in the United States.

Ustic Dystraquerts.—These are the Dystraquerts that have a soil moisture regime that borders on ustic. These soils do not have concentrations of jarosite. They occur in Texas and are wooded.

Endoaquerts

Endoaquerts are the Aquerts that do not have a soil layer that perches water. These soils commonly are wet from the bottom to the top. They occur in the Far Western States, on the northern Great Plains, and in the Southern States. Before 1992, most were considered Haplaquepts.

Definition

Endoaquerts are the Aquerts that:

1. Do not have a salic or calcic horizon or a duripan that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have *both* of the following:

   a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

   b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in 1:1 water) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon;

3. Have endosaturation; *and*

4. Do not have a natric horizon or an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Key to Subgroups

FAGA. Endoaquerts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Endoaquerts

FAGB. Other Endoaquerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Endoaquerts

FAGC. Other Endoaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Endoaquerts

FAGD. Other Endoaquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Endoaquerts

FAGE. Other Endoaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Endoaquerts

FAGF. Other Endoaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

   a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

   b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Endoaquerts

FAGG. Other Endoaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Endoaquerts

FAGH. Other Endoaquerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Endoaquerts

FAGI. Other Endoaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Endoaquerts

FAGJ. Other Endoaquerts.

Typic Endoaquerts

Definition of Typic Endoaquerts

Typic Endoaquerts are the Endoaquerts that:

1. Do not have both a thermic, mesic, or frigid soil temperature regime and, if not irrigated during the year, cracks in normal years that remain *both*:

a. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

b. Closed for 60 or more consecutive days during the 90 days following the winter solstice;

2. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year;

3. Do not have, in any horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, *any* of the following in more than half of each pedon:

a. Hue of 2.5Y or redder and *either*:

(1) A color value, moist, of 6 or more and chroma of 3 or more; *or*

(2) A color value, moist, of 5 or less and chroma of 2 or more; *or*

b. Hue of 5Y or yellower and chroma of 3 or more; *or*

c. Chroma of 2 or more and no redox concentrations;

4. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

5. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

6. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

7. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

8. Have, in all horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less.

Description of Subgroups

Typic Endoaquerts.—The Typic subgroup of Endoaquerts is centered on deep or very deep, poorly drained or very poorly drained, clayey soils with dark colored surface layers. These soils do not have significant amounts of salts or sodium and do not have a soil moisture regime that borders on aridic, xeric, or ustic. They occur in North Dakota, South Dakota, and Minnesota and are used for hay and pasture or for small grain, when drained.

Aeric Endoaquerts.—These are the Endoaquerts that are not dominantly gleyed from a depth of 25 to 75 cm. Most of these soils are considered somewhat poorly drained. Aeric Endoaquerts do not have significant amounts of salts or sodium or a soil moisture regime that borders on aridic, xeric, or ustic. They occur in Texas and are used mostly as native pasture.

Aridic Endoaquerts.—These are the Endoaquerts that have aquic conditions for short periods and are dry for most of the year. These soils do not have significant amounts of salts or sodium. They occur in California and are used as irrigated pasture.

Chromic Endoaquerts.—These are the deep or very deep, poorly drained or very poorly drained, clayey Endoaquerts that have light colored surface layers. These soils do not have significant amounts of sodium or salts or a soil moisture regime that borders on xeric, aridic, or ustic. Chromic Endoaquerts occur in the Dakotas, Montana, Texas, and Arkansas. They are used mostly as pasture, but some are used for hay.

Entic Endoaquerts.—These are the deep or very deep, poorly drained or very poorly drained Endoaquerts that have a layer 25 cm or more thick with less than 27 percent clay. These soils do not have significant amounts of sodium or salts or a soil moisture regime that borders on ustic, aridic, or xeric. They are not known to occur in the United States.

Halic Endoaquerts.—These are the Endoaquerts that have significant amounts of salts. They are not known to occur in the United States.

Leptic Endoaquerts.—These are the poorly drained or very poorly drained Endoaquerts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface. These soils do not have significant amounts of sodium or salts or a moisture regime that borders on ustic, aridic, or xeric. They are rare in the world.

Sodic Endoaquerts.—These are the Endoaquerts that have significant amounts of sodium, but not salts. They occur in California and are used mostly as irrigated cropland or pasture.

Ustic Endoaquerts.—These are the Endoaquerts that have a moisture regime that borders on xeric or aridic. They do not have significant amounts of salts or sodium.

Xeric Endoaquerts.—These are the Endoaquerts that have a soil moisture regime that borders on xeric. They do not have significant amounts of sodium or salts. These soils occur in Oregon, Washington, and California. They are used for pasture, rangeland, or irrigated crops.

Epiaquerts

Epiaquerts are the Aquerts that have one or more soil layers that perch water. Commonly, these layers are close to the surface. These soils occur on a variety of landforms, including flood plains, glacial lake planes, and depressions. In the United States, they occur in a number of Western States, on the northern Great Plains, and in the South. They also occur in Puerto Rico.

Definition

Epiaquerts are the Aquerts that:

1. Do not have a calcic or salic horizon or a duripan that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have *both*:

a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon;

3. Have episaturation; *and*

4. Do not have a natric horizon or an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Key to Subgroups

FAFA. Epiaquerts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Epiaquerts

FAFB. Other Epiaquerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Epiaquerts

FAFC. Other Epiaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Epiaquerts

FAFD. Other Epiaquerts that have a thermic, mesic, or frigid soil temperature regime and that, if not irrigated during the year, have cracks in normal years that remain *both*:

1. 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

2. Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Xeric Epiaquerts

FAFE. Other Epiaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Epiaquerts

FAFF. Other Epiaquerts that have, in one or more horizons between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, 50 percent or more colors as follows:

1. Hue of 2.5Y or redder and *either*:

a. A color value, moist, of 6 or more and chroma of 3 or more; *or*

b. A color value, moist, of 5 or less and chroma of 2 or more; *or*

2. Hue of 5Y and chroma of 3 or more; *or*

3. Chroma of 2 or more and no redox concentrations.

Aeric Epiaquerts

FAFG. Other Epiaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Epiaquerts

FAFH. Other Epiaquerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Epiaquerts

FAFI. Other Epiaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more.

Chromic Epiaquerts

FAFJ. Other Epiaquerts.

Typic Epiaquerts

Definition of Typic Epiaquerts

Typic Epiaquerts are the Epiaquerts that:

1. Do not have both a thermic, mesic, or frigid soil temperature regime and, if not irrigated during the year, cracks in normal years that remain *both*:

   a. 5 mm or more wide, throughout a layer 25 cm or more thick within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

   b. Closed for 60 or more consecutive days during the 90 days following the winter solstice;

2. Do not have, in any horizon between either an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and a depth of 75 cm, *any* of the following in more than half of each pedon:

   a. Hue of 2.5Y or redder and *either*:

      (1) A color value, moist, of 6 or more and chroma of 3 or more; *or*

      (2) A color value, moist, of 5 or less and chroma of 2 or more; *or*

   b. Hue of 5Y or yellower and chroma of 3 or more; *or*

   c. Chroma of 2 or more and no redox concentrations;

3. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

4. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

5. Have, if not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 to 210 or more cumulative days per year;

6. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

7. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

8. Have, in all horizons within 30 cm of the mineral soil surface, *one or both* of the following in more than half of each pedon:

   a. A color value, moist, of 3 or less; *or*

   b. A color value, dry, of 5 or less.

Description of Subgroups

Typic Epiaquerts.—The Typic subgroup of Epiaquerts is centered on deep or very deep, poorly drained or very poorly drained, clayey soils with dark colored surface layers. These soils do not have significant amounts of salts or sodium and do not have a soil moisture regime that borders on aridic, xeric, or ustic. They occur in North Dakota, South Dakota, Minnesota, Montana, Missouri, Arkansas, Louisiana, and Mississippi. They are used for hay and pasture or as cropland, when drained.

Aeric Epiaquerts.—These are the Epiaquerts that are not dominantly gleyed from a depth of 25 to 75 cm. Many of these soils are considered somewhat poorly drained. Aeric Epiaquerts do not have significant amounts of salts or sodium or a soil moisture regime that borders on aridic, xeric, or ustic. They occur in Texas, Louisiana, Oklahoma, Alabama, Mississippi, and Missouri. These soils are mostly cropped, but some are wooded.

Aridic Epiaquerts.—These are the Epiaquerts that have aquic conditions for short periods and are dry for most of the year. These soils do not have significant amounts of salts or sodium.

Chromic Epiaquerts.—These are the deep or very deep, poorly drained or very poorly drained, clayey Epiaquerts that have light colored surface layers. These soils do not have significant amounts of sodium or salts or a soil moisture regime that borders on xeric, aridic, or ustic. They occur in Arkansas. They are used mostly as pasture, but some are used for hay or other crops.

Entic Epiaquerts.—These are the deep or very deep, poorly drained or very poorly drained Epiaquerts that have a layer 25 cm or more thick with less than 27 percent clay. These soils do not have significant amounts of sodium or salts or a soil moisture regime that borders on ustic, aridic, or xeric. They are not known to occur in the United States.

Halic Epiaquerts.—These are the Epiaquerts that have significant amounts of salts. They are not known to occur in the United States.

Leptic Epiaquerts.—These are the poorly drained or very poorly drained Epiaquerts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface. These soils do not have significant amounts of sodium or salts or a moisture regime that borders on ustic, aridic, or xeric.

Sodic Epiaquerts.—These are the Epiaquerts that have significant amounts of sodium, but not salts. They occur in

California, Montana, and Puerto Rico. They are used mostly as irrigated cropland, as wildlife habitat, or as pasture. In Puerto Rico they are used for sugarcane.

Ustic Epiaquerts.—These are the Epiaquerts that have a moisture regime that borders on ustic. These soils do not have significant amounts of salts or sodium. They occur in Texas and Oklahoma and are used as rangeland.

Xeric Epiaquerts.—These are the Epiaquerts that have a soil moisture regime that borders on xeric. These soils do not have significant amounts of sodium or salts. They occur in Oregon, Nevada, Idaho, and California. They are used for pasture, rangeland, or irrigated crops. In some areas they are used for rice production.

Natraquerts

Natraquerts are the Aquerts with significant amounts of sodium. In many areas these soils occur on flood plains or glacial lake plains. The high sodium content limits their use as cropland. Most of the soils are used as rangeland, pasture, or hayland. Most Natraquerts in the United States formed in alluvium or lacustrine deposits derived dominantly from sedimentary rocks. Natraquerts occur in the Dakotas, Montana, Iowa, Nebraska, and Texas.

Definition

Natraquerts are the Aquerts that:

1. Do not have a salic horizon or a duripan that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Have a natric horizon or an exchangeable sodium percentage of 15 percent or more (or a sodium adsorption ratio of 13 or more) within 100 cm of the mineral soil surface.

Key to Subgroups

FACA. All Natraquerts.

Typic Natraquerts

Salaquerts

Salaquerts are the Aquerts with significant amounts of salts. These soils are not known to occur in the United States.

Definition

Salaquerts are the Aquerts that have a salic horizon that has an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FAAA. Salaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Salaquerts

FAAB. Other Salaquerts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Ustic Salaquerts

FAAC. Other Salaquerts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Salaquerts

FAAD. Other Salaquerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Salaquerts

FAAE. Other Salaquerts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Salaquerts

FAAF. Other Salaquerts.

Typic Salaquerts

Definition of Typic Salaquerts

Typic Salaquerts are the Salaquerts that:

1. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year;

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface; *and*

4. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

   a. A color value, moist, of 3 or less; *or*

   b. A color value, dry, of 5 or less; *or*

   c. Chroma of 2 or less.

Description of Subgroups

Typic Salaquerts.—The Typic subgroup of Salaquerts is centered on deep or very deep, clayey soils with dark colored surface layers. These soils do not have a soil moisture regime that borders on ustic or aridic.

Aridic Salaquerts.—These are the Salaquerts that have aquic conditions for short periods during the year and are dry for most of the year.

Chromic Salaquerts.—These are the deep or very deep, clayey Salaquerts that have light colored surface layers. These soils do not a soil moisture regime that borders on aridic or ustic.

Entic Salaquerts.—These are the deep or very deep Salaquerts that have a layer 25 cm or more thick with less than 27 percent clay. These soils do not have a moisture regime that borders on ustic or aridic.

Leptic Salaquerts.—These are the Salaquerts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface. These soils do not have a moisture regime that borders on aridic or ustic.

Ustic Salaquerts.—These are the Salaquerts that have aquic conditions for part of the year but also are dry for significant periods during a normal year.

Cryerts

Cryerts are the Vertisols that have a cryic temperature regime. Previously, the definition of Vertisols limited their extent to warmer climates. Fine textured soils in cold temperature regimes periodically shrink and swell, forming the diagnostic characteristics of Vertisols. Cracks commonly open once a year, late in the summer. Cryerts occur on the cold prairies of Canada, where they commonly are derived from lacustrine deposits. They also occur in the Rocky Mountains of the United States.

Definition

Cryerts are the Vertisols that:

1. Have a cryic soil temperature regime; *and*

2. Do not have, in any horizon within 50 cm of the mineral soil surface, aquic conditions and *any* of the following:

    a. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

        (1) 2 or less if redox concentrations are present; *or*

        (2) 1 or less if redox concentrations are absent; *or*

    b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Key to Great Groups

FBA. Cryerts that have 10 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 50 cm.

Humicryerts, p. 797

FBB. Other Cryerts.

Haplocryerts, p. 796

Haplocryerts

Haplocryerts are the Cryerts without significant accumulations of organic carbon. These soils occur in the Rocky Mountains of the United States. They are of limited extent.

Definition

Haplocryerts are the Cryerts that have less than 10 kg/m^2 organic carbon between the mineral soil surface and a depth of 50 cm.

Key to Subgroups

FBBA. Haplocryerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haplocryerts

FBBB. Other Haplocryerts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haplocryerts

FBBC. Other Haplocryerts.

Typic Haplocryerts

Definition of Typic Haplocryerts

Typic Haplocryerts are the Haplocryerts that have:

1. In all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

2. In all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

    a. A color value, moist, of 3 or less; *or*

    b. A color value, dry, of 5 or less; *or*

    c. Chroma of 2 or less.

Description of Subgroups

Typic Haplocryerts.—The Typic subgroup of Haplocryerts is centered on soils that have dark colored surface horizons and do not have significant amounts of sodium. These soils are rare in the world.

Chromic Haplocryerts.—These are the Haplocryerts that have light colored surface horizons but do not have significant amounts of sodium. These soils are rare in the world.

Sodic Haplocryerts.—These are the Haplocryerts that have significant amounts of sodium. These soils are rare in the world.

Humicryerts

Humicryerts are the Cryerts that have rather high amounts of organic carbon. These soils formed under a variety of vegetative types. They occur in the Rocky Mountains of the United States.

Definition

Humicryerts are the Cryerts that have 10 kg/m^2 or more organic carbon between the mineral soil surface and a depth of 50 cm.

Key to Subgroups

FBAA. Humicryerts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Humicryerts

FBAB. Other Humicryerts.

Typic Humicryerts

Definition of Typic Humicryerts

Typic Humicryerts are the Humicryerts that have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years.

Description of Subgroups

Typic Humicryerts.—The Typic subgroup of Humicryerts is centered on soils that do not have significant amounts of sodium. These soils occur in Idaho and are used as wildlife habitat.

Sodic Humicryerts.—These are the Humicryerts that have significant amounts of sodium. These soils are rare in the world.

Torrerts

Torrerts are the Vertisols of arid climates. Their cracks commonly stay open for most of the year but may close for at least a few days in most years. The cracks are closed for less than 60 days during the growing season. Many of these soils dot the landscape in closed depressions that may be ponded from time to time by runoff from the higher areas. Some Torrerts are more continuous and commonly are underlain by parent materials that tend to weather to smectictic clays, such as basalt.

Torrerts are subdivided by the presence or absence of accumulations of salts, which are important to the use and management of the soils. Salitorrerts, Gypsitorrerts, and Calcitorrerts have a salic, gypsic, and calcic horizon, respectively. Haplotorrerts do not have significant accumulations of salts.

The Torrerts in the United States occur mostly in the Southwest, although a few are in Hawaii. Most commonly, they are used as rangeland.

Definition

Torrerts are the Vertisols that:

1. If not irrigated during the year, have cracks in normal years that remain closed for less than 60 consecutive days during a period when the soil temperature at a depth of 50 cm from the soil surface is continuously higher than 8 °C;

2. Do not have a cryic soil temperature regime;

3. Do not have, in any horizon within 50 cm of the mineral soil surface, aquic conditions and *any* of the following:

   a. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

      (1) 2 or less if redox concentrations are present; *or*

      (2) 1 or less if redox concentrations are absent; *or*

   b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *and*

4. In normal years do not have *both*:

   a. A thermic, mesic, or frigid soil temperature regime; *and*

   b. If not irrigated during the year, cracks that remain *both*:

      (1) 5 mm or more wide, throughout a layer 25 cm or more thick within 50 cm of the soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

      (2) Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Key to Great Groups

FDA. Torrerts that have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Salitorrerts, p. 800

FDB. Other Torrerts that have a gypsic horizon that has its upper boundary within 100 cm of the soil surface.
Gypsitorrerts, p. 798

FDC. Other Torrerts that have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.
Calcitorrerts, p. 798

FDD. Other Torrerts.
Haplotorrerts, p. 799

Calcitorrerts

Calcitorrerts are the Torrerts that have a calcic or petrocalcic horizon. These soils are not extensive among the Torrerts. They are used mostly for grazing by livestock. Some are used for irrigated alfalfa. Calcitorrerts occur in Arizona and other areas of the Southwestern United States.

Definition

Calcitorrerts are the Torrerts that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the soil surface; *and*

2. Do not have a gypsic or salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

FDCA. Calcitorrerts that have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface.
Petrocalcic Calcitorrerts

FDCB. Other Calcitorrerts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the soil surface.
Leptic Calcitorrerts

FDCC. Other Calcitorrerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the soil surface.
Entic Calcitorrerts

FDCD. Other Calcitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.
Chromic Calcitorrerts

FDCE. Other Calcitorrerts.
Typic Calcitorrerts

Definition of Typic Calcitorrerts

Typic Calcitorrerts are the Calcitorrerts that:

1. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the soil surface;

2. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the soil surface;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface; *and*

4. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Calcitorrerts.—The Typic subgroup of Calcitorrerts is centered on deep or very deep soils that have a clay loam or finer texture in all layers within 100 cm of the soil surface and that have relatively dark surface layers. These soils do not have a petrocalcic horizon. They occur in Arizona and are used for grazing by livestock.

Chromic Calcitorrerts.—These are the deep or very deep Calcitorrerts that have a color value, moist, of 4 or more; a dry value of 6 or more; or chroma of 3 or more. These soils have a clay loam or finer texture in all layers from the soil surface to a depth of 100 cm and do not have a petrocalcic horizon.

Entic Calcitorrerts.—These are the deep or very deep Calcitorrerts that have a layer 25 cm or more thick within 100 cm of the soil surface that contains less than 27 percent clay. These soils do not have a petrocalcic horizon.

Leptic Calcitorrerts.—These are the Calcitorrerts that are moderately deep or shallower to a densic, paralithic, or lithic contact or a duripan. These soils do not have a petrocalcic horizon.

Petrocalcic Calcitorrerts.—These are the Calcitorrerts that have a petrocalcic horizon. They occur in Arizona and are used for grazing by livestock.

Gypsitorrerts

Gypsitorrerts are the Torrerts that have a gypsic horizon that has its upper boundary within 100 cm of the soil surface. These soils occur in arid areas of the world where the parent materials are high in content of gypsum. A high shrink-swell potential and gypsum content in these soils limit many building activities unless measures that counteract the shrinking and swelling and the dissolution of gypsum are applied. These soils occur in the Southwestern United States.

Definition

Gypsitorrerts are the Torrerts that:

1. Have a gypsic horizon that has its upper boundary within 100 cm of the soil surface; *and*

2. Do not have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

FDBA. Gypsitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Gypsitorrerts

FDBB. Other Gypsitorrerts.

Typic Gypsitorrerts

Definition of Typic Gypsitorrerts

Typic Gypsitorrerts are the Gypsitorrerts that have, in all horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 3 or less; *or*

2. A color value, dry, of 5 or less; *or*

3. Chroma of 2 or less.

Description of Subgroups

Typic Gypsitorrerts.—The Typic subgroup of Gypsitorrerts is centered on soils that have surface layers with a color value, moist, of 3 or less; a value, dry, of 5 or less; and chroma of 2 or less. These soils are relatively rare, but they occur in Arizona. They are used for grazing by livestock.

Chromic Gypsitorrerts.—These are the Gypsitorrerts that have a color value, moist, of 4 or more; a color value, dry, of 6 or more; or chroma of 3 or more. These soils occur in New Mexico and are used for grazing by livestock.

Haplotorrerts

Haplotorrerts are the Torrerts that do not have a salic, gypsic, or calcic horizon. This is the most extensive great group of Torrerts. These soils occur in many of the Western States and in Texas and Hawaii. They are used as urban land, cropland, or rangeland.

Definition

Haplotorrerts are the Torrerts that do not have a calcic, gypsic, petrocalcic, or salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

FDDA. Haplotorrerts that have, throughout a layer 15 cm or more thick within 100 cm of the soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Haplotorrerts

FDDB. Other Haplotorrerts that have, in one or more horizons within 100 cm of the soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haplotorrerts

FDDC. Other Haplotorrerts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the soil surface.

Leptic Haplotorrerts

FDDD. Other Haplotorrerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the soil surface.

Entic Haplotorrerts

FDDE. Other Haplotorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haplotorrerts

FDDF. Other Haplotorrerts.

Typic Haplotorrerts

Definition of Typic Haplotorrerts

Typic Haplotorrerts are the Haplotorrerts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the soil surface;

2. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the soil surface;

3. Have, in all layers 15 cm or more thick within 100 cm of the soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

4. Have, in all horizons within 100 cm of the soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

5. Have, in all horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Haplotorrerts.—The Typic subgroup of Haplotorrerts is centered on soils that are deep or very deep, that have a clay loam or finer texture in all horizons between the soil surface and a depth of 100 cm, that have relatively dark colored surface horizons, and that do not have significant amounts of salts or sodium. In Texas, New Mexico, and Arizona, these soils are used for rangeland or irrigated crops. In Hawaii the soils are used for irrigated sugarcane.

Chromic Haplotorrerts.—These are the deep or very deep Haplotorrerts that have a color value, moist, of 4 or more; a color value, dry, of 6 or more; or chroma of 3 or more. These soils do not have significant amounts of salts or sodium. They occur in Idaho, California, Colorado, New Mexico, and Texas. Most commonly, they are used for grazing.

Entic Haplotorrerts.—These are the deep or very deep Haplotorrerts that have a layer 25 cm or more thick within 100 cm of the soil surface that has 27 percent or less clay. These soils do not have significant amounts of salts or sodium. They occur in New Mexico and are used as urban land, rangeland, or irrigated cropland.

Halic Haplotorrerts.—These are the Haplotorrerts that have a significant accumulation of salts. They occur in Texas and New Mexico and are used for grazing by livestock.

Leptic Haplotorrerts.—These are the Haplotorrerts that have a lithic, paralithic, or densic contact or a duripan within 100 cm of the soil surface. These soils do not have significant amounts of salts or sodium. They are known to occur in New Mexico and Hawaii, where they are used as rangeland and pasture, respectively.

Sodic Haplotorrerts.—These are the Haplotorrerts that have a significant accumulation of sodium and do not have significant amounts of salts. These soils occur in Nevada, California, and Texas. They are used for rangeland or irrigated crops.

Salitorrerts

Salitorrerts are the Torrerts that have a salic horizon. In some of these soils, salts accumulate because of a periodic water table. In others, scant precipitation and the impermeable nature of the soils facilitate the accumulation of salts. Salitorrerts have not been recognized in the United States.

Definition

Salitorrerts are the Torrerts that have a salic horizon that has its upper boundary within 100 cm of the soil surface.

Key to Subgroups

FDAA. Salitorrerts that have, in one or more horizons within 100 cm of the soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Salitorrerts

FDAB. Other Salitorrerts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the soil surface.

Leptic Salitorrerts

FDAC. Other Salitorrerts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the soil surface.

Entic Salitorrerts

FDAD. Other Salitorrerts that have, in one or more horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Salitorrerts

FDAE. Other Salitorrerts.

Typic Salitorrerts

Definition of Typic Salitorrerts

Typic Salitorrerts are the Salitorrerts that:

1. Do not have, in any horizon within 100 cm of the soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

2. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the soil surface;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the soil surface; *and*

4. Have, in all horizons within 30 cm of the soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Salitorrerts.—The Typic subgroup of Salitorrerts is centered on deep or very deep soils that have a clay loam or finer texture from the soil surface to a depth of 100 cm. These soils do not have aquic conditions within 100 cm of the soil surface, and they have relatively dark colored surface layers.

Aquic Salitorrerts.—These are the Salitorrerts that have aquic conditions within 100 cm of the soil surface for some time in normal years. The aquic conditions commonly are of very short duration.

Chromic Salitorrerts.—These are the deep or very deep Salitorrerts that have a color value, moist, of 4 or more; a color value, dry, of 6 or more; or chroma of 3 or more. These soils have a clay loam or finer texture from the soil surface to a depth of 100 cm.

Entic Salitorrerts.—These are the deep or very deep Salitorrerts that have a layer 25 cm or more thick that has 27 percent or less clay within 100 cm of the soil surface. These soils do not have aquic conditions within 100 cm of the soil surface.

Leptic Salitorrerts.—These are the Salitorrerts that are moderately deep or shallower to a lithic, paralithic, or densic contact or a duripan or petrocalcic horizon. These soils do not have aquic conditions within 100 cm of the soil surface.

Uderts

Uderts are the Vertisols of humid areas. These soils have cracks that open and close, depending upon the amount of precipitation. In some years the cracks may not open completely.

The Uderts in the United States occur on gentle slopes and are derived dominantly from marine shales, marls, and alluvium. At one time many of these soils supported grass, although some support a hardwood or pine forest.

Definition

Uderts are the Vertisols that:

1. Do not have a cryic soil temperature regime;

2. Do not have, in any horizon within 50 cm of the mineral soil surface, aquic conditions and *any* of the following:

a. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if redox concentrations are present; *or*

(2) 1 or less if redox concentrations are absent; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. In normal years do not have *both*:

a. A thermic, mesic, or frigid soil temperature regime; *and*

b. If not irrigated during the year, cracks that remain *both*:

(1) 5 mm or more wide, throughout a layer 25 cm or more thick within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

(2) Closed for 60 or more consecutive days during the 90 days following the winter solstice;

4. If not irrigated during the year, do not have cracks in normal years that remain closed for less than 60 consecutive days during a period when the soil temperature at a depth of 50 cm from the soil surface is continuously higher than 8 ^{o}C; *and*

5. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days.

Key to Great Groups

FFA. Uderts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Dystruderts, p. 801

FFB. Other Uderts.

Hapluderts, p. 803

Dystruderts

Dystruderts are the acid Uderts. These soils are derived dominantly from acid, fine textured materials and occur on alluvial plains, deltas, interfluves, and side slopes. Commonly, they are underlain by sediments high in bases. Some of these soils have diagnostic horizons, including argillic, calcic, and gypsic horizons.

In the United States, these soils occur in Texas and in the Southeastern States from Arkansas to Florida. They are used as cropland, pasture, or woodland.

Definition

Dystruderts are the Uderts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Key to Subgroups

FFAA. Dystruderts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Dystruderts

FFAB. Other Dystruderts that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for *either or both*:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Dystruderts

FFAC. Other Dystruderts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Dystruderts

FFAD. Other Dystruderts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Dystruderts

FFAE. Other Dystruderts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Dystruderts

FFAF. Other Dystruderts.

Typic Dystruderts

Definition of Typic Dystruderts

Typic Dystruderts are the Dystruderts that:

1. Do not have, in any horizon within 100 cm of the mineral soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

2. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

5. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Dystruderts.—The Typic subgroup of Dystruderts is centered on deep or very deep, dark colored soils that are not saturated within 100 cm of the soil surface for extended periods. These soils do not have a layer as much as 25 cm thick with less than 27 percent clay from the soil surface to a depth of 100 cm.

Aquic Dystruderts.—These are the Dystruderts that have aquic conditions and redoximorphic features within 100 cm of the mineral soil surface. These soils do not have high amounts of aluminum. In the United States, they commonly formed in thick sediments of acid clays over more alkaline clays. These soils occur in Mississippi, Alabama, Arkansas, and Louisiana and are used as cropland, pasture, or woodland.

Chromic Dystruderts.—These are the deep or very deep Dystruderts that have light colored layers within 30 cm of the mineral soil surface. These soils are not saturated for extended periods within 100 cm of the mineral soil surface. They do not have layers with less than 27 percent clay within 100 cm of the mineral soil surface. The soils are extensive in the Southeastern United States and commonly are wooded.

Entic Dystruderts.—These are the deep or very deep Dystruderts that have a layer 25 cm or more thick that contains less than 27 percent clay and has its upper boundary within 100 cm of the mineral soil surface. These soils are not saturated within 100 cm of the mineral soil surface for significant periods.

Leptic Dystruderts.—These are the shallow or moderately deep Dystruderts. They are not saturated within a depth of 100 cm for significant periods. They are not known to occur in the United States.

Oxyaquic Dystruderts.—These are the Dystruderts that are saturated for significant periods within 100 cm of the mineral soil surface but do not have redoximorphic features. These soils occur in Texas and Louisiana.

Hapluderts

Hapluderts are the Uderts with pH values that are dominantly above 5.0 in the upper 50 cm. These soils typically have high base saturation, and some have diagnostic horizons, including argillic horizons. Hapluderts occur on uplands and in lower areas. They formed in a variety of fine textured parent material, including alluvium.

In the United States, these soils commonly occur in the Southeast but also occur on the northern Great Plains and in the Pacific Northwest.

Definition

Hapluderts are the Uderts that do not have *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon.

Key to Subgroups

FFBA. Hapluderts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Hapluderts

FFBB. Other Hapluderts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Hapluderts

FFBC. Other Hapluderts that are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal years for:

1. 20 or more consecutive days; *or*

2. 30 or more cumulative days.

Oxyaquic Hapluderts

FFBD. Other Hapluderts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Hapluderts

FFBE. Other Hapluderts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Hapluderts

FFBF. Other Hapluderts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Hapluderts

FFBG. Other Hapluderts.

Typic Hapluderts

Definition of Typic Hapluderts

Typic Hapluderts are the Hapluderts that:

1. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

4. Are not saturated with water in any layer within 100 cm of the mineral soil surface in normal years for:

a. 20 or more consecutive days; *or*

b. 30 or more cumulative days; *and*

5. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Hapluderts.—The Typic subgroup of Hapluderts is centered on deep or very deep soils that are not saturated for significant periods within 100 cm of the mineral soil surface. These soils have rather dark colored surface layers and a clay loam or finer texture throughout. They occur in Texas, Alabama, Oklahoma, and Arkansas and on the northern Great Plains. They are used as cropland, pasture, or rangeland.

Aquic Hapluderts.—These are the Hapluderts that have aquic conditions and redoximorphic features within 100 cm of the mineral soil surface. They do not have a lithic contact within 50 cm of the mineral soil surface. These soils occur in Alabama, Texas, Oklahoma, Kansas, Louisiana, and Puerto Rico. They are used as cropland, woodland, or pasture.

Chromic Hapluderts.—These are the deep or very deep Hapluderts that have light colored surface layers. These soils are not saturated for extended periods within 100 cm of the mineral soil surface. They have a clay loam or finer texture from the mineral soil surface to a depth of 100 cm. These soils are common in the South, in the Southeast, and on the northern Great Plains. They are used as cropland, pasture, or woodland.

Entic Hapluderts.—These are the deep or very deep Hapluderts that have a layer 25 cm or more thick that contains less than 27 percent clay within 100 cm of the mineral soil surface. These soils are not saturated for extended periods within 100 cm of the mineral soil surface. They are uncommon. They occur in Texas and are used as pasture or cropland.

Leptic Hapluderts.—These are the Hapluderts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface but do not have a lithic contact within 50 cm of the mineral soil surface. These soils are not saturated for extended periods within 100 cm of the mineral soil surface. They occur in Alabama and Louisiana and are used as cropland, pasture, or hayland.

Lithic Hapluderts.—These are the Hapluderts that have a lithic contact within 50 cm of the mineral soil surface. They are not common and have not been recognized in the United States.

Oxyaquic Hapluderts.—These are the Hapluderts that are saturated with water for extended periods within 100 cm of the mineral soil surface but do not have redoximorphic features. They also do not have a lithic contact within 50 cm of the mineral soil surface. They are extensive and occur in the South, the Southeast, and the Pacific Northwest. They are used mostly as cropland or pasture.

Usterts

These are the Vertisols in temperate areas that do not receive high amounts of rainfall during the summer, in areas of monsoonal climate, and in tropical and subtropical areas that have two rainy and two dry seasons. Cracks open and close once or twice during the year. Usterts are extensive in Texas, on the Great Plains, in Australia, in Africa south of the Sahara, and in India. Many of these soils formed in gently sloping areas of fine textured marine deposits or alluvium. Some are derived from basic igneous rocks. If irrigated, Usterts are used intensively, but large areas are used for grazing because of a lack of machinery to till the soils.

Definition

Usterts are the Vertisols that:

1. Do not have a cryic soil temperature regime;

2. Do not have, in any horizon within 50 cm of the mineral soil surface, aquic conditions and *any* of the following:

a. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if redox concentrations are present; *or*

(2) 1 or less if redox concentrations are absent; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. In normal years do not have *both*:

a. A thermic, mesic, or frigid soil temperature regime; *and*

b. If not irrigated during the year, cracks that remain *both*:

(1) 5 mm or more wide, throughout a layer 25 cm or more thick within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

(2) Closed for 60 or more consecutive days during the 90 days following the winter solstice;

4. If not irrigated during the year, do not have cracks in normal years that remain closed for less than 60 consecutive days during a period when the soil temperature at a depth of 50 cm from the soil surface is continuously higher than 8 ^{o}C; *and*

5. If not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more cumulative days per year.

Key to Great Groups

FEA. Usterts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^{o}C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Dystrusterts, p. 806

FEB. Other Usterts that have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Salusterts, p. 811

FEC. Other Usterts that have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Gypsiusterts, p. 808

FED. Other Usterts that have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Calciusterts, p. 805

FEE. Other Usterts.
Haplusterts, p. 809

Calciusterts

Calciusterts are the Usterts that have a calcic or petrocalcic horizon. These soils commonly are derived from parent materials rich in carbonates, such as marine deposits or even eolian material. Previously, it was thought that diagnostic horizons could not form in Vertisols because of self-churning. These earlier concepts were not accurate. Some Calciusterts have mollic epipedons. Although Calciusterts have limited acreage in the United States, they are significant in other parts of the world.

Definition

Calciusterts are the Usterts that:

1. Have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have *both*:

   a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 ^oC; *and*

   b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon; *and*

3. Do not have a gypsic or salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FEDA. Calciusterts that have a lithic contact within 50 cm of the mineral soil surface.
Lithic Calciusterts

FEDB. Other Calciusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.
Halic Calciusterts

FEDC. Other Calciusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.
Sodic Calciusterts

FEDD. Other Calciusterts that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.
Petrocalcic Calciusterts

FEDE. Other Calciusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.
Aridic Calciusterts

FEDF. Other Calciusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.
Udic Calciusterts

FEDG. Other Calciusterts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the mineral soil surface.
Leptic Calciusterts

FEDH. Other Calciusterts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.
Entic Calciusterts

FEDI. Other Calciusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*
2. A color value, dry, of 6 or more; *or*
3. Chroma of 3 or more.

Chromic Calciusterts

FEDJ. Other Calciusterts.
Typic Calciusterts

Definition of Typic Calciusterts

Typic Calciusterts are the Calciusterts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface;

2. Do not have a layer 25 cm or more thick that contains less

than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

3. If not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 150 to 210 cumulative days per year;

4. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

5. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

6. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Calciusterts.—The Typic subgroup of Calciusterts is centered on deep or very deep soils that do not have significant amounts of salts or sodium. In addition, these soils do not have a petrocalcic horizon, soil moisture regimes that border on aridic or udic, a layer with less than 27 percent clay, or light colored surface layers. These soils are rare in the United States but occur in Puerto Rico, where they are used for pasture or sugarcane.

Aridic Calciusterts.—These are the Calciusterts that have a soil moisture regime that borders on aridic. These soils do not have a lithic contact within 50 cm of the soil surface, a petrocalcic horizon, or significant amounts of salts or sodium. They are of small extent in the Southwestern United States and are used as rangeland.

Chromic Calciusterts.—These are the deep or very deep Calciusterts that have light colored surface layers but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon, soil moisture regimes that border on aridic or udic, or a layer with less than 27 percent clay. The soils are rare in the United States.

Entic Calciusterts.—These are the deep or very deep Calciusterts that have a layer with less than 27 percent clay but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon or soil moisture regimes that border on aridic or udic. The soils are rare in the United States.

Halic Calciusterts.—These are the Calciusterts that have a significant accumulation of salts. These soils do not have a lithic contact within 50 cm of the soil surface. They are not known to occur in the United States.

Leptic Calciusterts.—These are the Calciusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of salts or sodium, a moisture regime that borders on udic or aridic, or a petrocalcic horizon. The soils are rare in the United States.

Lithic Calciusterts.—These are the Calciusterts that have a lithic contact within 50 cm of the soil surface. They are not known to occur in the United States.

Petrocalcic Calciusterts.—These are the Calciusterts that have a petrocalcic horizon. They do not have a lithic contact within 50 cm of the soil surface or significant amounts of salts or sodium. These soils occur in Texas and are used as rangeland or pasture.

Sodic Calciusterts.—These are the Calciusterts that have significant amounts of sodium, but not salts. They do not have a lithic contact within 50 cm of the soil surface. These soils are rare in the United States and are used as rangeland.

Udic Calciusterts.—These are the Calciusterts that have a soil moisture regime that borders on udic. They do not have a petrocalcic horizon, a lithic contact within 50 cm of the soil surface, or significant amounts of salts or sodium. These soils occur in Texas. They commonly are used as rangeland, but some are used for cultivated crops.

Dystrusterts

Dystrusterts are the Usterts that have a dominant pH value of 5.0 or less and an electrical conductivity of less than 4.0 dS/m within 50 cm of the soil surface. These soils commonly formed in acid clays and are underlain by more alkaline parent materials. They commonly are derived from marine sediments. They are not known to occur in the United States but were established to accommodate other countries.

Definition

Dystrusterts are the Usterts that have, throughout one or more horizons with a total thickness of 25 cm or more within 50 cm of the mineral soil surface, *both*:

1. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

2. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste).

Key to Subgroups

FEAA. Dystrusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Dystrusterts

FEAB. Other Dystrusterts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Dystrusterts

FEAC. Other Dystrusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Dystrusterts

FEAD. Other Dystrusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days.

Udic Dystrusterts

FEAE. Other Dystrusterts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the mineral soil surface.

Leptic Dystrusterts

FEAF. Other Dystrusterts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Dystrusterts

FEAG. Other Dystrusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Dystrusterts

FEAH. Other Dystrusterts.

Typic Dystrusterts

Definition of Typic Dystrusterts

Typic Dystrusterts are the Dystrusterts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the mineral soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

4. If not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 150 to 210 cumulative days per year; *and*

5. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Dystrusterts.—The Typic subgroup of Dystrusterts is centered on deep or very deep soils that do not have a soil moisture regime that borders on udic or aridic. These soils do not have aquic conditions for significant periods within 100 cm of the soil surface. In addition, they do not have a layer with less than 27 percent clay or light colored surface layers.

Aquic Dystrusterts.—These are the Dystrusterts that have aquic conditions for extended periods within 100 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface.

Aridic Dystrusterts.—These are the Dystrusterts that have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface or aquic conditions for extended periods within 100 cm of the soil surface.

Chromic Dystrusterts.—These are the deep or very deep Dystrusterts that have light colored surface layers but do not have a lithic contact within 50 cm of the soil surface or aquic conditions for extended periods within 100 cm of the soil surface. These soils do not have soil moisture regimes that border on aridic or udic or a layer with less than 27 percent clay.

Entic Dystrusterts.—These are the deep or very deep Dystrusterts that have a layer with less than 27 percent clay but do not have a lithic contact within 50 cm of the soil surface. These soils do not have soil moisture regimes that border on aridic or udic or aquic conditions for extended periods within 100 cm of the soil surface.

Leptic Dystrusterts.—These are the Dystrusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have a moisture regime that borders on udic or aridic or aquic conditions for extended periods within 100 cm of the soil surface.

Lithic Dystrusterts.—These are the Dystrusterts that have a lithic contact within 50 cm of the soil surface.

Udic Dystrusterts.—These are the Dystrusterts that have a soil moisture regime that borders on udic. They do not have a lithic contact within 50 cm of the soil surface or aquic conditions for extended periods within 100 cm of the soil surface.

Gypsiusterts

These are the Usterts that have a gypsic horizon. They are derived from parent materials rich in gypsum. Even in areas of an ustic moisture regime, the gypsum is not leached because of the very slow permeability associated with these soils. Some of the soils occur on the edges of depressions where gypsum is deposited at the capillary fringe. Gypsiusterts are rare in the United States, but they occur in Texas, where they are used as rangeland or pasture.

Definition

Gypsiusterts are the Usterts that:

1. Have a gypsic horizon that has its upper boundary within 100 cm of the mineral soil surface;

2. Do not have *both*:

a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon; *and*

3. Do not have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FECA. Gypsiusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Gypsiusterts

FECB. Other Gypsiusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Gypsiusterts

FECC. Other Gypsiusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Gypsiusterts

FECD. Other Gypsiusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Gypsiusterts

FECE. Other Gypsiusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Udic Gypsiusterts

FECF. Other Gypsiusterts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface.

Leptic Gypsiusterts

FECG. Other Gypsiusterts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Gypsiusterts

FECH. Other Gypsiusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Gypsiusterts

FECI. Other Gypsiusterts.

Typic Gypsiusterts

Definition of Typic Gypsiusterts

Typic Gypsiusterts are the Gypsiusterts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface;

2. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

3. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

4. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years;

5. If not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 150 to 210 cumulative days per year; *and*

6. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Gypsiusterts.—The Typic subgroup of Gypsiusterts is centered on deep or very deep soils that do not have significant amounts of salts or sodium. In addition, these soils do not have soil moisture regimes that border on aridic or udic, a layer with less than 27 percent clay, or light colored surface layers.

Aridic Gypsiusterts.—These are the Gypsiusterts that have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface or significant amounts of salts or sodium.

Chromic Gypsiusterts.—These are the deep or very deep Gypsiusterts that have light colored surface layers but do not have significant amounts of salts or sodium. These soils do not have soil moisture regimes that border on aridic or udic or a layer with less than 27 percent clay.

Entic Gypsiusterts.—These are the deep or very deep Gypsiusterts that have a layer with less than 27 percent clay but do not have significant amounts of salts or sodium. These soils do not have a soil moisture regime that borders on aridic or udic.

Halic Gypsiusterts.—These are the Gypsiusterts that have a significant accumulation of salts. These soils do not have a lithic contact within 50 cm of the soil surface.

Leptic Gypsiusterts.—These are the Gypsiusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of salts or sodium or a moisture regime that borders on udic or aridic.

Lithic Gypsiusterts.—These are the Gypsiusterts that have a lithic contact within 50 cm of the soil surface.

Sodic Gypsiusterts.—These are the Gypsiusterts that have significant amounts of sodium, but not salts. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in Texas and are used as rangeland or pasture.

Udic Gypsiusterts.—These are the Gypsiusterts that have a soil moisture regime that borders on udic. They do not have a lithic contact within 50 cm of the soil surface or significant amounts of salts or sodium.

Haplusterts

Haplusterts are the most common of the Usterts. They are derived from a variety of parent materials, including sedimentary rocks, alluvium, marl, and basic igneous rocks. Slopes range from nearly level to strongly sloping.

Haplusterts occur in many Western and Southwestern States, on the northern Great Plains, and in Puerto Rico and the Virgin Islands. They are used as rangeland, cropland, or pasture.

Definition

Haplusterts are the Usterts that:

1. Do not have *both*:

a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon; *and*

2. Do not have a calcic, gypsic, petrocalcic, or salic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FEEA. Haplusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haplusterts

FEEB. Other Haplusterts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Haplusterts

FEEC. Other Haplusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haplusterts

FEED. Other Haplusterts that have a petrocalcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Petrocalcic Haplusterts

FEEE. Other Haplusterts that have a gypsic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Gypsic Haplusterts

FEEF. Other Haplusterts that have a calcic horizon that has its upper boundary within 150 cm of the mineral soil surface.

Calcic Haplusterts

FEEG. Other Haplusterts that have *both*:

1. A densic, lithic, or paralithic contact within 100 cm of the mineral soil surface; *and*

2. If not irrigated during the year, cracks in normal years

that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Leptic Haplusterts

FEEH. Other Haplusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Haplusterts

FEEI. Other Haplusterts that have *both*:

1. A densic, lithic, or paralithic contact within 100 cm of the mineral soil surface; *and*

2. If not irrigated during the year, cracks in 6 or more out of 10 years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Leptic Udic Haplusterts

FEEJ. Other Haplusterts that have *both*:

1. A layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Entic Udic Haplusterts

FEEK. Other Haplusterts that have *both*:

1. In one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

   a. A color value, moist, of 4 or more; *or*

   b. A color value, dry, of 6 or more; *or*

   c. Chroma of 3 or more; *and*

2. If not irrigated during the year, cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Chromic Udic Haplusterts

FEEL. Other Haplusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 150 cumulative days per year.

Udic Haplusterts

FEEM. Other Haplusterts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan, within 100 cm of the mineral soil surface.

Leptic Haplusterts

FEEN. Other Haplusterts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Haplusterts

FEEO. Other Haplusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haplusterts

FEEP. Other Haplusterts.

Typic Haplusterts

Definition of Typic Haplusterts

Typic Haplusterts are the Haplusterts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface;

2. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

3. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m or more (saturated paste) for 6 or more months in normal years;

4. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years;

5. If not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 150 to 210 cumulative days per year;

6. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

   a. A color value, moist, of 3 or less; *or*

   b. A color value, dry, of 5 or less; *or*

   c. Chroma of 2 or less; *and*

7. Do not have a calcic or gypsic horizon with an upper boundary within 150 cm of the mineral soil surface.

Description of Subgroups

Typic Haplusterts.—The Typic subgroup of Haplusterts is centered on deep or very deep soils that do not have significant amounts of salts or sodium. In addition, these soils do not have a petrocalcic horizon, soil moisture regimes that border on aridic or udic, a calcic or gypsic horizon within a depth of 150 cm, a layer with less than 27 percent clay, or light colored surface layers. In the United States, these soils occur in Texas, New Mexico, Oklahoma, South Dakota, Hawaii, and Puerto Rico. They are used for crop production as well as rangeland.

Aridic Haplusterts.—These are the Haplusterts that have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface, a petrocalcic horizon, or significant amounts of salts or sodium. These soils occur in South Dakota, Montana, Colorado, Nebraska, Texas, and Wyoming. They commonly are used as rangeland.

Aridic Leptic Haplusterts.—These are the Haplusterts that have a soil moisture regime that borders on aridic and that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have a petrocalcic horizon or significant amounts of salts or sodium. They occur on the northern Great Plains and in the Southwestern United States and commonly are used as rangeland.

Calcic Haplusterts.—These are the Haplusterts that have a calcic horizon with its upper boundary within 150 cm of the soil surface. They do not have significant accumulations of salts or sodium. These soils occur in India and the United States. Most are used as cropland.

Chromic Haplusterts.—These are the deep or very deep Haplusterts that have light colored surface layers but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon, soil moisture regimes that border on aridic or udic, or a layer with less than 27 percent clay. They occur in New Mexico and Texas and are used mostly as rangeland.

Chromic Udic Haplusterts.—These are the deep or very deep Haplusterts that have light colored surface layers and a moisture regime that borders on udic but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon or a layer with less than 27 percent clay. They occur in Colorado, Texas, Montana, North Dakota, Wyoming, and Oklahoma. They are used as rangeland or cropland.

Entic Haplusterts.—These are the deep or very deep Haplusterts that have a layer with less than 27 percent clay but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon or soil moisture regimes that border on aridic or udic. They are rare in the United States.

Entic Udic Haplusterts.—These are the deep or very deep Haplusterts that have a layer with less than 27 percent clay and a moisture regime that borders on udic but do not have significant amounts of salts or sodium. These soils do not have a petrocalcic horizon. They occur in Texas, where they are used as rangeland, and in Puerto Rico, where they are used for sugarcane.

Gypsic Haplusterts.—These are the Haplusterts that have a gypsic horizon with its upper boundary within 150 cm of the soil surface. They do not have significant accumulations of salts or sodium. These soils occur in India and the United States. Many are used as cropland. Some of the soils in India are mined for gypsum.

Halic Haplusterts.—These are the Haplusterts that have a significant accumulation of salts. These soils do not have a lithic contact within 50 cm of the soil surface. They are not known to occur in the United States.

Leptic Haplusterts.—These are the Haplusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of salts or sodium, a moisture regime that borders on udic or aridic, or a petrocalcic horizon. They occur in South Dakota and Nebraska and are used as rangeland or cropland.

Leptic Udic Haplusterts.—These are the Haplusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface and a moisture regime that borders on udic but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of salts or sodium or a petrocalcic horizon. They occur in the Southwestern United States and on the northern Great Plains. They are used as cropland, rangeland, or pasture.

Lithic Haplusterts.—These are the Haplusterts that have a lithic contact within 50 cm of the soil surface. They are rare in the United States.

Petrocalcic Haplusterts.—These are the Haplusterts that have a petrocalcic horizon. They do not have a lithic contact within 50 cm of the soil surface or significant amounts of salts or sodium. These soils are not known to occur in the United States.

Sodic Haplusterts.—These are the Haplusterts that have significant amounts of sodium, but not salts. They do not have a lithic contact within 50 cm of the soil surface. These soils occur in Montana, Utah, Puerto Rico, Texas, South Dakota, the Virgin Islands, and the Channel Islands off the coast of southern California. Most of the soils are used as rangeland, but some are used as cropland.

Udic Haplusterts.—These are the Haplusterts that have a soil moisture regime that borders on udic. They do not have a petrocalcic horizon, a lithic contact within 50 cm of the soil surface, or significant amounts of salts or sodium. These soils occur in the Southwestern United States and on the northern Great Plains. They commonly are used as rangeland, but some are used for cultivated crops.

Salusterts

These are the Usterts that have a salic horizon. Many of these soils are derived from salty marine deposits. Salts are difficult to leach in Salusterts, and few areas are used as cropland. These soils are not known to occur in the United States.

Definition

Salusterts are the Usterts that:

1. Have a salic horizon that has its upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have *both*:

a. An electrical conductivity in the saturation extract of less than 4.0 dS/m at 25 °C; *and*

b. A pH value of 4.5 or less in 0.01 M $CaCl_2$ (5.0 or less in saturated paste) in more than 50 percent of the soil volume between the mineral soil surface and a depth of 50 cm in each pedon.

Key to Subgroups

FEBA. Salusterts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Salusterts

FEBB. Other Salusterts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Salusterts

FEBC. Other Salusterts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Salusterts

FEBD. Other Salusterts that, if not irrigated during the year, have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year.

Aridic Salusterts

FEBE. Other Salusterts that have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface.

Leptic Salusterts

FEBF. Other Salusterts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Salusterts

FEBG. Other Salusterts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Salusterts

FEBH. Other Salusterts.

Typic Salusterts

Definition of Typic Salusterts

Typic Salusterts are the Salusterts that:

1. Do not have a densic, lithic, or paralithic contact, or the upper boundary of a duripan or petrocalcic horizon, within 100 cm of the mineral soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. If not irrigated during the year, do not have cracks in normal years that are 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 210 or more cumulative days per year;

4. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

5. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years; *and*

6. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Salusterts.—The Typic subgroup of Salusterts is centered on deep or very deep soils that do not have significant amounts of sodium. In addition, these soils do not have a soil moisture regime that borders on aridic, aquic conditions within 100 cm of the soil surface, a layer with less than 27 percent clay, or light colored surface layers.

Aquic Salusterts.—These are the Salusterts that have aquic conditions within 100 cm of the soil surface. These soils do not have a lithic contact within 50 cm of the soil surface or significant amounts of sodium.

Aridic Salusterts.—These are the Salusterts that have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface, aquic conditions within 100 cm of the soil surface, or significant amounts of sodium.

Chromic Salusterts.—These are the deep or very deep Salusterts that have light colored surface layers but do not have significant amounts of sodium. These soils do not have a soil moisture regime that borders on aridic, a layer with less than 27 percent clay, or aquic conditions within 100 cm of the soil surface.

Entic Salusterts.—These are the deep or very deep Salusterts that have a layer with less than 27 percent clay but do not have significant amounts of sodium. These soils do not have a soil moisture regime that borders on aridic or aquic conditions within 100 cm of the soil surface.

Leptic Salusterts.—These are the Salusterts that have a lithic, paralithic, or densic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of sodium, a moisture regime that borders on aridic, or aquic conditions within 100 cm of the soil surface.

Lithic Salusterts.—These are the Salusterts that have a lithic contact within 50 cm of the soil surface.

Sodic Salusterts.—These are the Salusterts that have significant amounts of sodium. These soils do not have a lithic contact within 50 cm of the soil surface.

Xererts

Xererts are the Vertisols of Mediterranean climates, which are typified by cool, wet winters and warm, dry summers. These soils have cracks that regularly close and open each year. Because the soils dry every summer and remoisten in the winter, damage to structures and roads is very significant. If not irrigated, these soils are used for small grain or grazing. In the United States, most of the soils supported grasses before they were cultivated.

Definition

Xererts are the Vertisols that:

1. Do not have a cryic soil temperature regime;

2. Do not have, in any horizon within 50 cm of the mineral soil surface, aquic conditions and *any* of the following:

a. In more than half of each pedon, either on faces of peds or in the matrix if peds are absent, 50 percent or more chroma of *either*:

(1) 2 or less if redox concentrations are present; *or*

(2) 1 or less if redox concentrations are absent; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated; *and*

3. In normal years, have *both*:

a. A thermic, mesic, or frigid soil temperature regime; *and*

b. If not irrigated during the year, cracks that remain *both*:

(1) 5 mm or more wide, throughout a layer 25 cm or more thick within 50 cm of the mineral soil surface, for 60 or more consecutive days during the 90 days following the summer solstice; *and*

(2) Closed for 60 or more consecutive days during the 90 days following the winter solstice.

Key to Great Groups

FCA. Xererts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Durixererts, p. 814

FCB. Other Xererts that have a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Calcixererts, p. 813

FCC. Other Xererts.

Haploxererts, p. 816

Calcixererts

Calcixererts are the Xererts that have a calcic or petrocalcic horizon. Many of these soils formed in fine textured sedimentary rocks. In the United States, some of the soils are used for irrigated crops. The others are used as rangeland, pasture, or nonirrigated cropland.

Definition

Calcixererts are the Xererts that:

1. Have a calcic or petrocalcic horizon with an upper boundary within 100 cm of the mineral soil surface; *and*

2. Do not have a duripan with an upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FCBA. Calcixererts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Calcixererts

FCBB. Other Calcixererts that have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Petrocalcic Calcixererts

FCBC. Other Calcixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 180 or more consecutive days.

Aridic Calcixererts

FCBD. Other Calcixererts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Calcixererts

FCBE. Other Calcixererts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Calcixererts

FCBF. Other Calcixererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Calcixererts

FCBG. Other Calcixererts.

Typic Calcixererts

Definition of Typic Calcixererts

Typic Calcixererts are the Calcixererts that:

1. Do not that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

2. If not irrigated during the year, do not have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 180 or more consecutive days;

3. Do not have a petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface;

4. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface; *and*

5. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Calcixererts.—The Typic subgroup of the Calcixererts is centered on deep or very deep soils that do not have a petrocalcic horizon or a soil moisture regime that borders on aridic. These soils tend to have dark colored surface layers and a clay loam or finer texture throughout.

Aridic Calcixererts.—These are the Calcixererts that have a soil moisture regime that borders on aridic and do not have a lithic contact within 50 cm of the soil surface. These soils are used for irrigated crops or rangeland.

Chromic Calcixererts.—These are the deep or very deep Calcixererts that have light colored surface layers. These soils do not have a petrocalcic horizon or a soil moisture regime that borders on aridic. They typically have a clay loam or finer texture throughout. These soils occur in Idaho and are used as rangeland or for irrigated or nonirrigated crops.

Entic Calcixererts.—These are the deep or very deep Calcixererts that have a layer 25 cm or more thick that contains less than 27 percent clay. These soils do not have a petrocalcic horizon or a soil moisture regime that borders on aridic. They occur in California and Idaho and are used as rangeland or for irrigated or nonirrigated crops.

Leptic Calcixererts.—These are the Calcixererts that have a densic, lithic, or paralithic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. They do not have a petrocalcic horizon or a soil moisture regime that borders on aridic. These soils occur in California and are used for pasture and hay.

Lithic Calcixererts.—These are the Calcixererts that have a lithic contact within 50 cm of the soil surface. These soils are not extensive in the world and are not known to occur in the United States.

Petrocalcic Calcixererts.—These are the Calcixererts that have a petrocalcic horizon. They do not have a lithic contact within 50 cm of the soil surface or a soil moisture regime that borders on aridic. These soils occur in California and are used for pasture, rangeland, or irrigated or nonirrigated crops.

Durixererts

Durixererts are the Xererts that have a duripan. Most of these soils are derived from basic igneous rocks, but some formed in mixed alluvium. The Durixererts in the United States occur in California and Idaho and are used for crop production or rangeland.

Definition

Durixererts are the Xererts that have a duripan that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FCAA. Durixererts that have, throughout a layer 15 cm or more thick above the duripan, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Durixererts

FCAB. Other Durixererts that have, in one or more horizons above the duripan, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Durixererts

FCAC. Other Durixererts that have, in one or more horizons above the duripan, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Durixererts

FCAD. Other Durixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more above the duripan, for 180 or more consecutive days.

Aridic Durixererts

FCAE. Other Durixererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more above the duripan, for less than 90 consecutive days.

Udic Durixererts

FCAF. Other Durixererts that have a duripan that is not indurated in any subhorizon.

Haplic Durixererts

FCAG. Other Durixererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Durixererts

FCAH. Other Durixererts.

Typic Durixererts

Definition of Typic Durixererts

Typic Durixererts are the Durixererts that:

1. Do not have, in any horizon above the duripan, aquic conditions and *either*:

   a. Redoximorphic features; *or*

   b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

2. Have, throughout all layers 15 cm or more thick above the duripan, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

3. Have, in all horizons above the duripan, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years;

4. If not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, throughout a layer 25 cm or more thick above the duripan, for 90 to 180 consecutive days;

5. Have a duripan that is either platy or massive and also is indurated in some subhorizon; *and*

6. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

   a. A color value, moist, of 3 or less; *or*

   b. A color value, dry, of 5 or less; *or*

   c. Chroma of 2 or less.

Description of Subgroups

Typic Durixererts.—The Typic subgroup of Durixererts is centered on soils that have dark colored surface layers and a duripan that is indurated in at least some part. These soils do not have significant amounts of salts and sodium. In addition, they do not have aquic conditions within 100 cm of the soil surface or a soil moisture regime that borders on aridic or udic.

Aquic Durixererts.—These are the Durixererts that have aquic conditions within 100 cm of the soil surface for extended periods. These soils do not have significant amounts of salts and sodium. They occur in California and are used for crop production, pasture, or rangeland.

Aridic Durixererts.—These are the Durixererts that have a soil moisture regime that borders on aridic. They do not have significant amounts of salts or sodium or aquic conditions for significant periods within 100 cm of the soil surface. These soils occur in California and are used mostly for irrigated crops.

Chromic Durixererts.—These are the Durixererts that have light colored surface layers and a duripan that is indurated in at least some part. These soils do not have significant amounts of salts and sodium, a moisture regime that borders on aridic or udic, or aquic conditions for extended periods within 100 cm of the soil surface. They occur in Idaho and California and are used as rangeland.

Halic Durixererts.—These are the Durixererts that have significant amounts of salts. They are not known to occur in the United States.

Haplic Durixererts.—These are the Durixererts that have a duripan that is not indurated in any part. These soils do not have significant amounts of salts and sodium, a moisture regime that borders on aridic or udic, or aquic conditions for significant periods within 100 cm of the soil surface. They occur in California and are used for crop production or rangeland.

Sodic Durixererts.—These are the Durixererts that have significant amounts of sodium, but not salts. These soils are not known to occur in the United States.

Udic Durixererts.—These are the Durixererts that have a soil moisture regime that borders on udic. These soils do not have significant amounts of salts or sodium or aquic conditions for extended periods within 100 cm of the soil surface.

Haploxererts

Haploxererts are the Xererts that do not have a calcic or petrocalcic horizon or a duripan. These are the most common of the Xererts. They formed in a variety of parent materials, including volcanic and sedimentary rocks, lacustrine deposits, and alluvium. In many areas these soils are used for grazing by livestock. In some areas they are used for citrus, small grain, truck crops, or rice.

Definition

Haploxererts are the Xererts that do not have a duripan or a calcic or petrocalcic horizon that has its upper boundary within 100 cm of the mineral soil surface.

Key to Subgroups

FCCA. Haploxererts that have a lithic contact within 50 cm of the mineral soil surface.

Lithic Haploxererts

FCCB. Other Haploxererts that have, throughout a layer 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of 15 dS/m or more (saturated paste) for 6 or more months in normal years.

Halic Haploxererts

FCCC. Other Haploxererts that have, in one or more horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of 15 or more (or a sodium adsorption ratio of 13 or more) for 6 or more months in normal years.

Sodic Haploxererts

FCCD. Other Haploxererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 180 or more consecutive days.

Aridic Haploxererts

FCCE. Other Haploxererts that have, in one or more horizons within 100 cm of the mineral soil surface, aquic conditions for some time in normal years (or artificial drainage) and *either*:

1. Redoximorphic features; *or*

2. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated.

Aquic Haploxererts

FCCF. Other Haploxererts that, if not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for less than 90 consecutive days.

Udic Haploxererts

FCCG. Other Haploxererts that have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface.

Leptic Haploxererts

FCCH. Other Haploxererts that have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface.

Entic Haploxererts

FCCI. Other Haploxererts that have, in one or more horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

1. A color value, moist, of 4 or more; *or*

2. A color value, dry, of 6 or more; *or*

3. Chroma of 3 or more.

Chromic Haploxererts

FCCJ. Other Haploxererts.

Typic Haploxererts

Definition of Typic Haploxererts

Typic Haploxererts are the Haploxererts that:

1. Do not have a densic, lithic, or paralithic contact within 100 cm of the mineral soil surface;

2. Do not have, in any horizon within 100 cm of the mineral soil surface, aquic conditions and *either*:

a. Redoximorphic features; *or*

b. Enough active ferrous iron (Fe^{2+}) to give a positive reaction to alpha,alpha-dipyridyl at a time when the soil is not being irrigated;

3. Do not have a layer 25 cm or more thick that contains less than 27 percent clay in its fine-earth fraction and has its upper boundary within 100 cm of the mineral soil surface;

4. Have, throughout all layers 15 cm or more thick within 100 cm of the mineral soil surface, an electrical conductivity of less than 15 dS/m (saturated paste) for 6 or more months in normal years;

5. Have, in all horizons within 100 cm of the mineral soil surface, an exchangeable sodium percentage of less than 15 (or a sodium adsorption ratio of less than 13) for 6 or more months in normal years;

6. If not irrigated during the year, have cracks in normal years that remain 5 mm or more wide, through a thickness of 25 cm or more within 50 cm of the mineral soil surface, for 90 or more but less than 180 consecutive days; *and*

7. Have, in all horizons within 30 cm of the mineral soil surface, 50 percent or more colors as follows:

a. A color value, moist, of 3 or less; *or*

b. A color value, dry, of 5 or less; *or*

c. Chroma of 2 or less.

Description of Subgroups

Typic Haploxererts.—The Typic subgroup of Haploxererts is centered on deep or very deep, clayey soils with dark colored surface layers. These soils do not have significant amounts of sodium or salts, a soil moisture regime that borders on aridic or udic, or aquic conditions within 100 cm of the soil surface for extended periods. They occur in Oregon, Idaho, and California and are used for rangeland, pasture, or dryland or irrigated crops.

Aquic Haploxererts.—These are the Haploxererts that have aquic conditions within 100 cm of the soil surface for extended periods. These soils do not have significant amounts of salts or sodium or a lithic contact within 50 cm of the soil surface. They occur in Oregon and California and are used for pasture or irrigated crops, including rice.

Aridic Haploxererts.—These are the Haploxererts that have a soil moisture regime that borders on aridic. They do not have a lithic contact within 50 cm of the soil surface or significant amounts of sodium and salts. These soils occur in Nevada and California, including the Channel Islands off the coast of southern California. The soils are used for rangeland or crop production. In some areas they are irrigated and planted to citrus.

Chromic Haploxererts.—These are the deep or very deep, clayey Haploxererts with light colored surface layers. These soils do not have significant amounts of sodium or salts, a soil moisture regime that borders on udic or aridic, or aquic conditions for significant periods within 100 cm of the soil surface. They occur in California, Idaho, and Oregon. They generally are used as rangeland, but the more nearly level areas are used for irrigated or nonirrigated crops.

Entic Haploxererts.—These are the deep or very deep Haploxererts that have a layer 25 cm or more thick with less than 27 percent clay. These soils do not have significant amounts of salts or sodium, a moisture regime that borders on aridic or udic, or aquic conditions for extended periods within 100 cm of the soil surface. They occur in Oregon and are used as rangeland.

Halic Haploxererts.—These are the Haploxererts that have significant amounts of salts. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in California, including the Channel Islands off the coast of southern California. They are used for rangeland or irrigated crops.

Leptic Haploxererts.—These are the Haploxererts that have a densic, lithic, or paralithic contact within 100 cm of the soil surface but do not have a lithic contact within 50 cm of the soil surface. These soils do not have significant amounts of sodium or salts, a soil moisture regime that borders on udic or aridic, or aquic conditions for extended periods within 100 cm of the soil surface. They occur in Nevada, California, Oregon, and Idaho. They are used mostly as rangeland, but small areas are used for irrigated crops.

Lithic Haploxererts.—These are the Haploxererts that have a lithic contact within 50 cm of the soil surface. They are not known to occur in the United States.

Sodic Haploxererts.—These are the Haploxererts that have significant amounts of sodium, but not salts. These soils do not have a lithic contact within 50 cm of the soil surface. They occur in California. Some of the soils are used for crops, including rice.

Udic Haploxererts.—These are the Haploxererts that have a soil moisture regime that borders on udic. These soils do not have significant amounts of sodium or salts, a lithic contact within 50 cm of the soil surface, or aquic conditions for significant periods within 100 cm of the soil surface. They occur in Oregon, where they are used for nonirrigated or irrigated crops, including orchards.

CHAPTER 21

Family and Series Differentiae and Names

As was noted in chapter 6, families and series serve purposes that are largely pragmatic, the series name is abstract, and the technical family name is descriptive. In the paragraphs that follow, the descriptive terms used in the names of families are defined, the control sections to which the terms apply are given, and the criteria, including the taxa in which they are used, are indicated. An example of a family is given to show how the family name is derived, and the differences between two series in that family are pointed out as examples of series differentiae.

Family Differentiae for Mineral Soils and Mineral Layers of Some Organic Soils

The following differentiae are used to distinguish families of mineral soils and the mineral layers of some organic soils within a subgroup. The class names of these components are used to form the family name. The components are listed and defined in the same sequence in which the components appear in the family names.

Particle-Size Classes and Their Substitutes

Definition of Particle-Size Classes and Their Substitutes for Mineral Soils

The first part of the family name is the name of either a particle-size class or a substitute for a particle-size class. The term particle-size class is used to characterize the grain-size composition of the whole soil, including both the fine earth and the rock and pararock fragments up to the size of a pedon, but it excludes organic matter and salts more soluble than gypsum. Substitutes for particle-size classes are used for soils that have andic soil properties or a high content of volcanic glass, pumice, or cinders.

The particle-size classes of this taxonomy represent a compromise between conventional divisions in pedologic and engineering classifications. Engineering classifications have set the limit between sand and silt at a diameter of 74 microns, while pedologic classifications have set it at either 50 or 20 microns. Engineering classifications have been based on grain-size percentages, by weight, in the soil fraction less than 74 mm in diameter, while textural classes in pedologic classifications have been based on percentages, by weight, in the fraction less than 2.0 mm in diameter. In engineering classifications, the separate very fine sand (diameter between 50 and 100 microns or 0.05 and 0.1 mm) has been subdivided at 74 microns. In defining the particle-size classes for this taxonomy, a similar division has been made, but in a different way. Soil materials that have a texture of fine sand or loamy fine sand normally have an appreciable amount of very fine sand, most of which is coarser than 74 microns. A silty sediment, such as loess, may also contain an appreciable amount of very fine sand, most of which is finer than 74 microns. Thus, in the design of particle-size classes for this taxonomy, the very fine sand has been allowed to "float." It is included with the sand if the texture (fine-earth fraction) of a soil is sand, loamy fine sand, or coarser. It is treated as silt, however, if the texture is very fine sand, loamy very fine sand, sandy loam, silt loam, or finer.

No single set of particle-size classes seems adequate to serve as family differentiae for all of the different kinds of soil. Thus, this taxonomy provides 2 generalized and 11 more narrowly defined classes, which permit relatively fine distinctions between families of soils for which particle size is important, while providing broader groupings for soils in which narrowly defined particle-size classes would produce undesirable separations. Thus, the term "clayey" is used for some soil families to indicate a clay content of 35 percent (30 percent in Vertisols) or more in specific horizons, while in other families the more narrowly defined terms "fine" and "very-fine" indicate that these horizons have a clay content either of 35 (30 percent in Vertisols) to 60 percent or of 60 percent or more in their fine-earth fraction. Fine earth refers to particles smaller than 2.0 mm in diameter. Rock fragments are particles 2.0 mm or more in diameter that are strongly cemented or more resistant to rupture and include all particles with horizontal dimensions smaller than the size of a pedon. Cemented fragments 2.0 mm or more in diameter that are in a rupture-resistance class that is less cemented than the strongly cemented class are referred to as pararock fragments. Pararock fragments, like rock fragments, include all particles between 2.0 mm and a horizontal dimension smaller than the size of a pedon. Most pararock fragments are broken into fragments 2.0 mm or less in diameter during the preparation of samples for particle-size analysis in the laboratory. Therefore, pararock fragments are generally included with the fine earth in the particle-size classes, although cinders, pumice, and pumicelike fragments are treated as fragments in the substitutes for classes, regardless of their rupture-resistance class.

Substitutes for particle-size classes are used for soils that have andic soil properties or a high content of volcanic glass, pumice, or cinders. These materials cannot be readily dispersed, and the results of dispersion vary. Consequently, normal particle-size classes do not adequately characterize these components. Substitutes for particle-size class names are used for those parts of soils that have andic soil properties or a high amount of volcanic glass, pumice, or cinders, as is the case with Andisols and many Andic and Vitrandic subgroups of other soil orders. Some Spodosols, whether identified in Andic subgroups or not, have andic soil properties in some horizons within the particle-size control section, and particle-size substitute class names are used for these horizons.

Neither a particle-size class name nor a substitute for a particle-size class name is used for Psamments, Psammaquents, and Psammentic subgroups that are in a sandy particle-size class. These taxa have, by definition, either a sandy particle-size class or an ashy substitute class. The sandy particle-size class is considered redundant in the family name. The ashy substitute class, however, is named, if appropriate in these taxa.

Particle-size class names are applied, although with reservations, to spodic horizons and other horizons that do not have andic soil properties but contain significant amounts of allophane, imogolite, ferrihydrite, or aluminum-humus complexes. The isotic mineralogy class (defined below) is helpful in identifying these particle-size classes.

In general, the weighted average particle-size class of the whole particle-size control section (defined below) determines what particle-size class name is used as a component of the family name.

Strongly Contrasting Particle-Size Classes

If the particle-size control section consists of two parts with strongly contrasting particle-size or substitute classes (listed below), if both parts are 12.5 cm or more thick (including parts not in the control section), and if the transition zone between them is less than 12.5 cm thick, both class names are used. For example, the family particle-size class is sandy over clayey if all of the following criteria are met: the soil meets criterion D (listed below) under the control section for particle-size classes or their substitutes; any Ap horizon is less than 30 cm thick; the weighted average particle-size class of the upper 30 cm of the soil is sandy; the weighted average of the lower part is clayey; and the transition zone is less than 12.5 cm thick. If a substitute name applies to one or more parts of the particle-size control section and the parts are not strongly contrasting classes, the name of the thickest part (cumulative) is used as the soil family name.

Aniso Class

If the particle-size control section includes more than one pair of the strongly contrasting classes, listed below, then the soil is assigned to an aniso class named for the pair of adjacent classes that contrast most strongly. The aniso class is considered part of the particle-size class name and is set off by commas after the particle-size name. An example is a sandy over clayey, aniso, mixed, active, mesic Aridic Haplustoll.

Generalized Particle-Size Classes

Two generalized particle-size classes, loamy and clayey, are used for shallow classes (defined below) and for soils in Arenic, Grossarenic, and Lithic subgroups. The clayey class is used for all strongly contrasting particle-size classes with more than 35 percent clay (30 percent in Vertisols). The loamy particle-size class is used for contrasting classes, where appropriate, to characterize the lower part of the particle-size control section. The generalized classes, where appropriate, are also used for all strongly contrasting particle-size classes that include a substitute class. For example, loamy over pumiceous or cindery (not fine-loamy over pumiceous or cindery) is used.

Six generalized classes, defined later in this chapter, are used for Terric subgroups of Histosols and Histels.

Control Section for Particle-Size Classes or Their Substitutes in Mineral Soils

The particle-size and substitute class names listed below are applied to certain horizons, or to the soil materials within specific depth limits, that have been designated as the particle-size control section. The lower boundary of the control section may be at a specified depth (in centimeters) below the mineral soil surface or below the upper boundary of an organic layer with andic soil properties, or it may be at the upper boundary of a root-limiting layer. Unless otherwise indicated, the following are considered root-limiting layers in this chapter: a duripan; a fragipan; petrocalcic, petrogypsic, and placic horizons; continuous ortstein; and densic, lithic, paralithic, and petroferric contacts. The following list of particle-size control sections for particular kinds of mineral soils is arranged as a key. This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one all classes that include criteria that do not fit the soil in question. The soil belongs to the first class for which it meets all of the criteria listed. The upper boundary of an argillic, natric, or kandic horizon is used in the following key. This boundary is not always obvious. If one of these horizons is present but the upper boundary is irregular or broken, as in an A/B or B/A horizon, the depth at which half or more of the volume has the fabric of an argillic, natric, or kandic horizon should be considered the upper boundary.

Key to the Control Section for Particle-Size Classes or Their Substitutes in Mineral Soils

A. For mineral soils that have a root-limiting layer (listed above) within 36 cm of the mineral soil surface or below the upper boundary of organic soil materials with andic soil properties, whichever is shallower: From the mineral soil surface or the upper boundary of the organic soil materials with andic soil properties, whichever is shallower, to the root-limiting layer; *or*

B. For Andisols: Between either the mineral soil surface or the upper boundary of an organic layer with andic soil properties, whichever is shallower, and the shallower of the following: (a) a depth 100 cm below the starting point or (b) a root-limiting layer; *or*

C. For those Alfisols, Ultisols, and great groups of Aridisols and Mollisols, excluding soils in Lamellic subgroups, that have an argillic, kandic, or natric horizon that has its upper boundary within 100 cm of the mineral soil surface and its lower boundary at a depth of 25 cm or more below the mineral soil surface or that are in a Grossarenic or Arenic subgroup, use 1 through 4 below. For other soils, go to D below.

1. Strongly contrasting particle-size classes (defined and listed later) within or below the argillic, kandic, or natric horizon and within 100 cm of the mineral soil surface: The upper 50 cm of the argillic, kandic, or natric horizon or to a depth of 100 cm, whichever is deeper, but not below the upper boundary of a root-limiting layer; *or*

2. All parts of the argillic, kandic, or natric horizon in or below a fragipan: Between a depth of 25 cm from the mineral soil surface and the top of the fragipan; *or*

3. A fragipan at a depth of less than 50 cm below the top of the argillic, kandic, or natric horizon: Between the upper boundary of the argillic, kandic, or natric horizon and the top the fragipan; *or*

4. Other soils that meet C above: Either the whole argillic, kandic, or natric horizon if 50 cm or less thick or the upper 50 cm of the horizon if more than 50 cm thick.

D. For those Alfisols, Ultisols, and great groups of Aridisols and Mollisols that are in a Lamellic subgroup or have an argillic, kandic, or natric horizon that has its upper boundary at a depth of 100 cm or more from the mineral surface and that are not in a Grossarenic or Arenic subgroup: Between the lower boundary of an Ap horizon or a depth of 25 cm from the mineral soil surface, whichever is deeper, and 100 cm below the mineral soil surface or a root-limiting layer, whichever is shallower; *or*

E. For other soils that have an argillic or natric horizon that has its lower boundary at a depth of less than 25 cm from the mineral surface: Between the upper boundary of the argillic or natric horizon and a depth of 100 cm below the mineral soil surface or a root-limiting layer, whichever is shallower; *or*

F. All other mineral soils: Between the lower boundary of an Ap horizon or a depth of 25 cm below the mineral soil surface, whichever is deeper, and the shallower of the following: (a) a depth of 100 cm below the mineral soil surface or (b) a root-limiting layer.

Key to the Particle-Size and Substitute Classes of Mineral Soils

This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one all classes that include criteria that do not fit the soil or layer in question. The class or substitute name for each layer within the control section must be determined from the key. If any two layers meet the criteria for strongly contrasting particle-size classes (listed below), the soil is named for that strongly contrasting class. If more than one pair meets the criteria for strongly contrasting classes, the soil is also in an aniso class named for the pair of adjacent classes that contrast most strongly. If the soil has none of the strongly contrasting classes, the weighted average soil materials within the particle-size control section generally determine the class. Exceptions are soils that are not strongly contrasting and that have a substitute class name for one or more parts of the control section. In these soils the class or substitute name of the thickest (cumulative) part within the control section is used to determine the family name.

A. Mineral soils that have, in the thickest part of the control section (if the control section is not in one of the strongly contrasting particle-size classes listed below), *or* in a part of the control section that qualifies as an element in one of the strongly contrasting particle-size classes listed below, *or* throughout the control section, a fine-earth component (including associated medium and finer pores) of less than 10 percent of the total volume *and* that meet one of the following sets of substitute class criteria:

1. Have, in the whole soil, more than 60 percent (by weight) volcanic ash, cinders, lapilli, pumice, and pumicelike[1] fragments *and*, in the fraction coarser than

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[1] Pumicelike—vesicular pyroclastic materials other than pumice that have an apparent specific gravity (including vesicles) of less than 1.0 g/cm^3.

2.0 mm, two-thirds or more (by volume) pumice and/or pumicelike fragments.

Pumiceous

or

2. Have, in the whole soil, more than 60 percent (by weight) volcanic ash, cinders, lapilli, pumice, and pumicelike fragments *and*, in the fraction coarser than 2.0 mm, less than two-thirds (by volume) pumice and pumicelike fragments.

Cindery

or

3. Other mineral soils that have a fine-earth component of less than 10 percent (including associated medium and finer pores) of the total volume.

Fragmental

or

B. Other mineral soils that have a fine-earth component of 10 percent or more (including associated medium and finer pores) of the total volume and meet, in the thickest part of the control section (if the control section is not in one of the strongly contrasting particle-size classes listed below), *or* in a part of the control section that qualifies as an element in one of the strongly contrasting particle-size classes listed below, *or* throughout the control section, one of the following sets of substitute class criteria:

1. They:

a. Have andic soil properties and have a water content at 1500 kPa tension of less than 30 percent on undried samples and less than 12 percent on dried samples; *or*

b. Do not have andic soil properties, have a total of 30 percent or more of the fine-earth fraction in the 0.02 to 2.0 mm fraction, and have (by grain count) 30 percent or more of that fraction consisting of volcanic glass, glass aggregates, glass-coated grains, and other vitric volcaniclastics; *and*

c. Have one of the following;

(1) A total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Ashy-pumiceous

or

(2) 35 percent or more (by volume) rock fragments.

Ashy-skeletal

or

(3) Less than 35 percent (by volume) rock fragments.

Ashy

or

2. Have a fine-earth fraction that has andic soil properties *and* that has a water content at 1500 kPa tension of 12 percent or more on air-dried samples or of 30 to 100 percent on undried samples; *and*

a. Have a total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Medial-pumiceous

or

b. Have 35 percent or more (by volume) rock fragments.

Medial-skeletal

or

c. Have less than 35 percent (by volume) rock fragments.

Medial

or

3. Have a fine-earth fraction that has andic soil properties and that has a water content at 1500 kPa tension of 100 percent or more on undried samples; *and*

a. Have a total of 35 percent or more (by volume) rock and pararock fragments, of which two-thirds or more (by volume) is pumice or pumicelike fragments.

Hydrous-pumiceous

or

b. Have 35 percent or more (by volume) rock fragments.

Hydrous-skeletal

or

c. Have less than 35 percent (by volume) rock fragments.

Hydrous

or

Note: In the following classes, “clay” excludes clay-size carbonates. Carbonates of clay size are treated as silt. If the ratio of percent water retained at 1500 kPa tension to the percentage of measured clay is 0.25 or less or 0.6 or more in half or more of the particle-size control section or part of the particle-size control section in strongly contrasting classes, then the percentage of clay is estimated by the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon).

C. Other mineral soils that, in the thickest part of the control section (if part of the control section has a substitute for particle-size class and is not in one of the strongly contrasting particle-size classes listed below), *or* in a part of the control section that qualifies as an element in one of the strongly contrasting particle-size classes listed below, *or* throughout the control section, meet one of the following sets of particle-size class criteria:

1. Have 35 percent or more (by volume) rock fragments *and* a fine-earth fraction with a texture of sand or loamy sand, including less than 50 percent (by weight) very fine sand.

Sandy-skeletal

or

2. Have 35 percent or more (by volume) rock fragments *and* less than 35 percent (by weight) clay.

Loamy-skeletal

or

3. Have 35 percent or more (by volume) rock fragments.

Clayey-skeletal

or

4. Have a texture of sand or loamy sand, including less than 50 percent (by weight) very fine sand in the fine-earth fraction.

Sandy

or

5. Have a texture of loamy very fine sand, very fine sand, or finer, including less than 35 percent (by weight) clay in the fine-earth fraction (excluding Vertisols), and are in a shallow family (defined below) or in a Lithic, Arenic, or Grossarenic subgroup, or the layer is an element in a strongly contrasting particle-size class (listed below) and the layer is the lower element or the other element is a substitute for particle-size class.

Loamy

or

6. Have, in the fraction less than 75 mm in diameter, 15 percent or more (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including rock fragments up to 7.5 cm in diameter) *and*, in the fine-earth fraction, less than 18 percent (by weight) clay.

Coarse-loamy

or

7. Have, in the fraction less than 75 mm in diameter, 15 percent or more (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including rock fragments up to 7.5 cm in diameter) *and* 18 to 35 percent (by weight) clay (Vertisols are excluded).

Fine-loamy

or

8. Have, in the fraction less than 75 mm in diameter, less than 15 percent (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including rock fragments up to 7.5 cm in diameter) *and*, in the fine-earth fraction, less than 18 percent (by weight) clay.

Coarse-silty

or

9. Have, in the fraction less than 75 mm in diameter, less than 15 percent (by weight) particles with diameters of 0.1 to 75 mm (fine sand or coarser, including rock fragments up to 7.5 cm in diameter) *and*, in the fine-earth fraction, 18 to 35 percent (by weight) clay (Vertisols are excluded).

Fine-silty

or

10. Have 35 percent or more (by weight) clay (more than 30 percent in Vertisols) and are in a shallow family (defined below) or in a Lithic, Arenic, or Grossarenic subgroup, or the layer is an element in a strongly contrasting particle-size class (listed below).

Clayey

or

11. Have (by weighted average) less than 60 percent (by weight) clay in the fine-earth fraction.

Fine

or

12. Have 60 percent or more clay.

Very-fine

Strongly Contrasting Particle-Size Classes

The purpose of strongly contrasting particle-size classes is to identify changes in pore-size distribution or composition that are not identified in higher soil categories and that seriously affect the movement and retention of water and/or nutrients.

The following particle-size or substitute classes are considered strongly contrasting if both parts are 12.5 cm or more thick (including parts not in the particle-size control section; however, substitute class names are used only if the soil materials to which they apply extend 10 cm or more into the upper part of the particle-size control section) and if the transition zone between the two parts of the particle-size control section is less than 12.5 cm thick.

Some classes, such as sandy and sandy-skeletal, have been combined in the following list. In those cases the combined name is used as the family class if part of the control section meets the criteria for either class.

1. Ashy over clayey

2. Ashy over clayey-skeletal

3. Ashy over loamy-skeletal

4. Ashy over loamy

5. Ashy over medial-skeletal

6. Ashy over medial (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 10 percent or less for the ashy materials and 15 percent or more for the medial materials)

7. Ashy over pumiceous or cindery

8. Ashy over sandy or sandy-skeletal

9. Ashy-skeletal over fragmental or cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the ashy-skeletal part than in the fragmental or cindery part)

10. Cindery over loamy

11. Cindery over medial-skeletal

12. Cindery over medial

13. Clayey over fine-silty (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

14. Clayey over fragmental

15. Clayey over loamy (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

16. Clayey over loamy-skeletal (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

17. Clayey over sandy or sandy-skeletal

18. Clayey-skeletal over sandy or sandy-skeletal

19. Coarse-loamy over clayey

20. Coarse-loamy over fragmental

21. Coarse-loamy over sandy or sandy-skeletal (if the coarse-loamy material contains less than 50 percent fine sand or coarser sand)

22. Coarse-silty over clayey

23. Coarse-silty over sandy or sandy-skeletal

24. Fine-loamy over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

25. Fine-loamy over fragmental

26. Fine-loamy over sandy or sandy-skeletal

27. Fine-silty over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

28. Fine-silty over fragmental

29. Fine-silty over sandy or sandy-skeletal

30. Hydrous over clayey-skeletal

31. Hydrous over clayey

32. Hydrous over fragmental

33. Hydrous over loamy-skeletal

34. Hydrous over loamy

35. Hydrous over sandy or sandy-skeletal

36. Loamy over sandy or sandy-skeletal (if the loamy material contains less than 50 percent fine sand or coarser sand)

37. Loamy over pumiceous or cindery

38. Loamy-skeletal over cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the loamy-skeletal part than in the cindery part)

39. Loamy-skeletal over clayey (if there is an absolute difference of 25 percent or more between clay percentages of the fine-earth fraction in the two parts of the control section)

40. Loamy-skeletal over fragmental (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the loamy-skeletal part than in the fragmental part)

41. Loamy-skeletal over sandy or sandy-skeletal (if the loamy material has less than 50 percent fine sand or coarser sand)

42. Medial over ashy (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 15 percent or more for the medial materials and 10 percent or less for the ashy materials)

43. Medial over ashy-pumiceous or ashy-skeletal (if the water content at 1500 kPa tension in dried samples of the fine-earth fraction is 15 percent or more for the medial materials and 10 percent or less for the ashy part)

44. Medial over clayey-skeletal

45. Medial over clayey

46. Medial over fragmental

47. Medial over hydrous (if the water content at 1500 kPa tension in undried samples of the fine-earth fraction is 75 percent or less for the medial materials)

48. Medial over loamy-skeletal

49. Medial over loamy

50. Medial over pumiceous or cindery

51. Medial over sandy or sandy-skeletal

52. Medial-skeletal over fragmental or cindery (if the volume of the fine-earth fraction is 35 percent or more [absolute] greater in the medial-skeletal part than the fragmental or cindery part)

53. Pumiceous or ashy-pumiceous over loamy

54. Pumiceous or ashy-pumiceous over medial-skeletal

55. Pumiceous or ashy-pumiceous over medial

56. Pumiceous or ashy-pumiceous over sandy or sandy-skeletal

57. Sandy over clayey

58. Sandy over loamy (if the loamy material contains less than 50 percent fine sand or coarser sand)

59. Sandy-skeletal over loamy (if the loamy material contains less than 50 percent fine sand or coarser sand)

Mineralogy Classes

The mineralogy of soils is known to be useful in making predictions about soil behavior and responses to management. Some mineralogy classes occur or are important only in certain taxa or particle-size classes, and others are important in all particle-size classes. The following key to mineralogy classes is designed to make those distinctions.

Control Section for Mineralogy Classes

The control section for mineralogy classes is the same as that defined for the particle-size classes and their substitutes.

Key to Mineralogy Classes

This key, like other keys in this taxonomy, is designed in such a way that the reader makes the correct classification by going through the key systematically, starting at the beginning and eliminating one by one any classes that include criteria that do not fit the soil in question. The soil belongs to the first class for which it meets all of the required criteria. The user should first check the criteria in section A and, if the soil in question does not meet the criteria listed there, proceed on to sections B, C, D, and E, until the soil meets the criteria listed. All criteria are based on a weighted average.

For soils with strongly contrasting particle-size classes, the mineralogy for both named particle-size classes or substitutes are given, unless they are the same. Examples are an ashy over clayey, mixed (if both the ashy and clayey parts are mixed), superactive, mesic Typic Vitraquand and a clayey over sandy or sandy-skeletal, smectitic over mixed, thermic Vertic Haplustept.

A. Oxisols and “kandi” and “kanhap” great groups of Alfisols and Ultisols that in the mineralogy control section have:

1. More than 40 percent iron oxide (more than 28 percent Fe), by dithionite citrate, in the fine-earth fraction.
Ferritic

or

2. More than 40 percent gibbsite in the fine-earth fraction.
Gibbsitic

or

3. Both:

a. 18 to 40 percent iron oxide (12.6 to 28 percent Fe), by dithionite citrate, in the fine-earth fraction; *and*

b. 18 to 40 percent gibbsite in the fine-earth fraction.
Sesquic

or

4. 18 to 40 percent iron oxide (12.6 to 28 percent Fe), by dithionite citrate, in the fine-earth fraction.
Ferruginous

or

5. 18 to 40 percent gibbsite in the fine-earth fraction.
Allitic

or

6. More than 50 percent (by weight) kaolinite plus halloysite, dickite, nacrite, and other 1:1 and nonexpanding 2:1 layer minerals and gibbsite in the fraction less than 0.002 in size and more kaolinite than halloysite.
Kaolinitic

or

7. More than 50 percent (by weight) halloysite plus kaolinite and allophane in the fraction less than 0.002 in size.
Halloysitic

or

8. All other properties.
Mixed

or

B. Other soil layers or horizons, in the mineralogy control section, that have a substitute class that replaces the particle-size class, other than fragmental, and that:

1. Have a sum of 8 times the Si (percent by weight extracted by acid oxalate) plus 2 times the Fe (percent by weight extracted by acid oxalate) of 5 or more, and 8 times the Si is more than 2 times the Fe.

Amorphic

or

2. Other soils that have a sum of 8 times the Si (percent by weight extracted by acid oxalate) plus 2 times the Fe (percent by weight extracted by acid oxalate) of 5 or more.

Ferrihydritic

or

3. Other soils that have 30 percent or more (by grain count) volcanic glass in the 0.02 to 2.0 mm fraction.

Glassy

or

4. All other soils that have a substitute class.

Mixed

or

C. Other mineral soil layers or horizons, in the mineralogy control section, in all other mineral soil orders and in Terric subgroups of Histosols and Histels that have:

1. Any particle-size class and more than 40 percent (by weight) carbonates (expressed as $CaCO_3$) plus gypsum, with gypsum constituting more than 35 percent of the total weight of carbonates plus gypsum, either in the fine-earth fraction or in the fraction less than 20 mm in size, whichever has a higher percentage of carbonates plus gypsum.

Gypsic

or

2. Any particle-size class and more than 40 percent (by weight) carbonates (expressed as $CaCO_3$) plus gypsum, either in the fine-earth fraction or in the fraction less than 20 mm in size, whichever has a higher percentage of carbonates plus gypsum.

Carbonatic

or

3. Any particle-size class, except for fragmental, and more than 40 percent (by weight) iron oxide (extractable by dithionite citrate), reported as Fe_2O_3 (or 28 percent reported as Fe), in the fine-earth fraction.

Ferritic

or

4. Any particle-size class, except for fragmental, and more than 40 percent (by weight) hydrated aluminum oxides, reported as gibbsite and bohemite, in the fine-earth fraction.

Gibbsitic

or

5. Any particle-size class, except for fragmental, and more than 40 percent (by weight) magnesium-silicate minerals, such as the serpentine minerals (antigorite, chrysotile, and lizardite) plus talc, olivines, Mg-rich pyroxenes, and Mg-rich amphiboles, in the fine-earth fraction.

Magnesic

or

6. Any particle-size class, except for fragmental, and a total iron oxide, by weight (Fe extracted by citrate-dithionite times 1.43 is used to determine the iron oxide), plus percent (by weight) gibbsite of more than 10 percent in the fine-earth fraction.

Parasesquic

or

7. Any particle-size class, except for fragmental, and more than 20 percent (by weight) glauconitic pellets in the fine-earth fraction.

Glauconitic

or

D. Other mineral soil layers or horizons, in the mineralogy control section, of soils in all other mineral orders and in Terric subgroups of Histosols and Histels, in a clayey, clayey-skeletal, fine or very-fine particle-size class, that in the fraction less than 0.002 mm in size:

1. Have more than one-half (by weight) halloysite plus kaolinite and allophane and more halloysite than any other single mineral.

Halloysitic

or

2. Have more than one-half (by weight) kaolinite plus halloysite, dickite, and nacrite, and other 1:1 or nonexpanding 2:1 layer minerals or gibbsite, and less than 10 percent (by weight) smectite.

Kaolinitic

or

3. Have more smectite (montmorillonite, beidellite, and nontronite), by weight, than any other single kind of clay mineral.

Smectitic

or

4. Have more than one-half (by weight) illite (hydrous mica) and commonly more than 4 percent K_2O.

Illitic

or

5. Have more vermiculite than any other single kind of clay mineral.

Vermiculitic

or

6. In more than one-half of the thickness, meet all of the following:

a. Have no free carbonates; *and*

b. The pH of a suspension of 1 g soil in 50 ml 1 M NaF is more than 8.4 after 2 minutes; *and*

c. The ratio of 1500 kPa water to measured clay is 0.6 or more.

Isotic

or

7. All other soils in this category.

Mixed

or

E. All other mineral soil layers or horizons (except for those in Quartzipsamments), in the mineralogy control section, that have:

1. More than 40 percent (by weight) (80 percent by grain count) mica and stable mica pseudomorphs in the 0.02 to 2.0 mm fraction.

Micaceous

or

2. More than 25 percent (by weight) (65 percent by grain count) mica and stable mica pseudomorphs in the 0.02 to 2.0 mm fraction.

Paramicaceous

or

3. In more than one-half of the thickness, all of the following:

a. No free carbonates; *and*

b. The pH of a suspension of 1 g soil in 50 ml 1 M NaF is more than 8.4 after 2 minutes; *and*

c. A ratio of 1500 kPa water to measured clay of 0.6 or more.

Isotic

or

4. More than 90 percent (by weight) silica minerals (quartz, chalcedony, or opal) and other extremely durable minerals that are resistant to weathering, in the 0.02 to 2.0 mm fraction.

Siliceous

or

5. All other properties.

Mixed

Cation-Exchange Activity Classes

The cation-exchange activity classes help in making interpretations of mineral assemblages and of the nutrient-holding capacity of soils in mixed and siliceous mineralogy classes of clayey, clayey-skeletal, coarse-loamy, coarse-silty, fine, fine-loamy, fine-silty, loamy, loamy-skeletal, and very-fine particle-size classes. Cation-exchange activity classes are not assigned to Histosols and Histels, and they are not assigned to Oxisols and “kandi” and “kanhap” great groups and subgroups of Alfisols and Ultisols because assigning such classes to them would be redundant. Cation-exchange activity classes are not assigned to the sandy, sandy-skeletal, or fragmental particle-size class because the low clay content causes cation-exchange activity classes to be less useful and less reliable.

The cation-exchange capacity (CEC) is determined by NH_4OAc at pH 7 on the fine-earth fraction. The CEC of the organic matter, sand, silt, and clay is included in the determination. The criteria for the classes use ratios of CEC to the percent, by weight, of silicate clay, both by weighted average in the control section. In the following classes “clay” excludes clay-size carbonates. If the ratio of percent water retained at 1500 kPa tension to the percentage of measured clay is 0.25 or less or 0.6 or more in half or more of the particle-size control section (or part in contrasting families), then the percentage of clay is estimated by the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon).

Control Section for Cation-Exchange Activity Classes

The control section for cation-exchange activity classes is the same as that used to determine the particle-size and mineralogy classes. For soils with strongly contrasting particle-size classes, where both named parts of the control section use a cation-exchange activity class, the class associated with the particle-size class that has the most clay is named. For example, in a pedon with a classification of loamy over clayey, mixed, active, calcareous, thermic Typic Udorthent, the cation-exchange activity class “active” is associated with the clayey part of the control section.

Key to Cation-Exchange Activity Classes

A. Soils that are not Histosols, Histels, or Oxisols, that are not in “kandi” or “kanhap” great groups or subgroups of Alfisols and Ultisols, that are in either a mixed or siliceous mineralogy class, that are not in a fragmental, sandy, or sandy-skeletal particle-size class or any substitute for a particle-size class, and that have a ratio of cation-exchange capacity (by NH_4OAc at pH 7) to clay (percent by weight) of:

1. 0.60 or more.

Superactive

2. 0.40 to 0.60.

Active

3. 0.24 to 0.40.

Semiactive

4. Less than 0.24.

Subactive

or

B. All other soils: No cation-exchange activity classes used.

Calcareous and Reaction Classes of Mineral Soils

The presence or absence of carbonates, soil reaction, and the presence of high concentrations of aluminum in mineral soils are treated together because they are so intimately related. There are four classes—calcareous, acid, nonacid, and allic. These are defined later in the key to calcareous and reaction classes. The classes are not used in all taxa, nor is more than one used in the same taxa.

Use of the Calcareous and Reaction Classes

The calcareous, acid, and nonacid classes are used in the names of the families of Entisols, Aquands, and Aquepts, except they are not used in any of the following:

1. Duraquands and Placaquands

2. Sulfaquepts, Fragiaquepts, and Petraquepts

3. Sandy, sandy-skeletal, cindery, pumiceous, or fragmental families

4. Families with carbonatic or gypsic mineralogy

The calcareous class, in addition to those listed above, is used in the names of the families of Aquolls, except it is not used with any of the following:

1. Calciaquolls, Natraquolls, and Argiaquolls

2. Cryaquolls and Duraquolls that have an argillic horizon

3. Families with carbonatic or gypsic mineralogy

The allic class is used only in families of Oxisols.

Control Section for Calcareous and Reaction Classes

The control section for the calcareous class is one of the following:

1. Soils with a root-limiting layer that is 25 cm or less below the mineral soil surface: A 2.5-cm-thick layer directly above the root-limiting layer.

2. Soils with a root-limiting layer that is 26 to 50 cm below the mineral soil surface: The layer between a depth of 25 cm below the mineral soil surface and the root-limiting layer.

3. All other listed soils: Between a depth of 25 and 50 cm below the mineral soil surface.

The control section for the acid, nonacid, and allic classes is the same as that for particle-size classes.

Key to Calcareous and Reaction Classes

A. Oxisols that have a layer, 30 cm or more thick within the control section, that contains more than 2 cmol(+) of KCl-extractable Al per kg soil in the fine-earth fraction.

Allic

B. Other listed soils that, in the fine-earth fraction, effervesce (in cold dilute HCl) in all parts of the control section.

Calcareous

C. Other listed soils with a pH of less than 5.0 in 0.01 M $CaCl_2$ (1:2) (about pH 5.5 in H_2O, 1:1) throughout the control section.

Acid

D. Other listed soils with a pH of 5.0 or more in 0.01 M $CaCl_2$ (1:2) in some or all layers in the control section.

Nonacid

It should be noted that a soil containing dolomite is calcareous and that effervescence of dolomite, when treated with cold dilute HCl, is slow.

The calcareous, acid, nonacid, and allic classes are listed in the family name, when appropriate, following the mineralogy and cation-exchange activity classes.

Soil Temperature Classes

Soil temperature classes, as named and defined here, are used as part of the family name in both mineral and organic soils. Temperature class names are used as part of the family name unless the criteria for a higher taxon carry the same limitation. Thus, frigid is implied in all cryic suborders, great groups, and subgroups and would be redundant if used in the names of families within these classes.

The Celsius (centigrade) scale is the standard. It is assumed that the temperature is that of a soil that is not being irrigated.

Control Section for Soil Temperature

The control section for soil temperature either is at a depth of 50 cm from the soil surface or is at the upper boundary of a root-limiting layer, whichever is shallower. The soil temperature classes, defined in terms of the mean annual soil temperature and the difference between mean summer and mean winter temperatures, are determined by the following key.

Key to Soil Temperature Classes

A. Gelisols that have a mean annual soil temperature as follows:

1. -10 °C or lower.

Hypergelic

or

2. -4 °C to -10 °C.

Pergelic

or

3. +1 °C to -4 °C.

Subgelic

or

B. Other soils that have a difference in soil temperature of 6 °C or more between mean summer (June, July, and August in the Northern Hemisphere) and mean winter (December, January, and February in the Northern Hemisphere) and a mean annual soil temperature of:

1. Lower than 8 °C (47 °F).

Frigid

or

2. 8 °C (47 °F) to 15 °C (59 °F).

Mesic

or

3. 15 °C (59 °F) to 22 °C (72 °F).

Thermic

or

4. 22 °C (72 °F) or higher.

Hyperthermic

or

C. All other soils that have a mean annual soil temperature as follows:

1. Lower than 8 °C (47 °F).

Isofrigid

or

2. 8 °C (47 °F) to 15 °C (59 °F).

Isomesic

or

3. 15 °C (59 °F) to 22 °C (72 °F).

Isothermic

or

4. 22 °C (72 °F) or higher.

Isohyperthermic

Soil Depth Classes

Soil depth classes are used in all families that have a root-limiting layer at a specified depth from the mineral soil surface, except for those families in Lithic subgroups and those with a fragipan. The root-limiting layers included in soil depth classes are duripans; petrocalcic, petrogypsic, and placic horizons; continuous ortstein (90 percent or more); and densic, lithic, paralithic, and petroferric contacts. Soil depth classes for Histosols and Histels are given later in this chapter. One soil depth class name, “shallow,” is used to characterize certain mineral soil families that have one of the depths indicated in the following key.

Key to Soil Depth Classes

A. Oxisols that are less than 100 cm deep (from the mineral soil surface) to a root-limiting layer and are not in a Lithic subgroup.

Shallow

or

B. Soils in all other mineral soil orders that are less than 50 cm deep (from the mineral soil surface) to a root-limiting layer and are not in a Lithic subgroup.

Shallow

or

C. All other mineral soils: No soil depth class used.

Rupture-Resistance Classes

In this taxonomy, some partially cemented soil materials, such as durinodes, serve as differentiae in categories above the family, while others, such as partially cemented spodic materials (ortstein), do not. No single family, however, should include soils both with and without partially cemented horizons. In Spodosols, a partially cemented spodic horizon is used as a family differentia. The following rupture-resistance class is defined for families of Spodosols:

A. Spodosols that have an ortstein horizon.

Ortstein

or

B. All other soils: No rupture-resistance class used.

Classes of Coatings (on Sands)

Despite the emphasis given to particle-size classes in this taxonomy, variability remains in the sandy particle-size class, which includes sands and loamy sands. Some sands are very clean, i.e., almost completely free of silt and clay, while others are mixed with appreciable amounts of finer grains. Clay is more efficient at coating sand than is silt. A weighted average silt (by weight) plus 2 times the weighted average clay (by weight) of more than 5 makes a reasonable division of the sands at the family level. Two classes of Quartzipsamments are defined in terms of their content of silt plus 2 times their content of clay.

Control Section for Classes of Coatings

The control section for classes of coatings is the same as that for particle-size classes or their substitutes and for mineralogy classes.

Key to Classes of Coatings

A. Quartzipsamments that have a sum of the weighted average silt (by weight) plus 2 times the weighted average clay of more than 5.

Coated

or

B. Other Quartzipsamments.

Uncoated

Classes of Permanent Cracks

Some Hydraquents consolidate or shrink after drainage and become Fluvaquents or Humaquepts. In the process they can form polyhedrons roughly 12 to 50 cm in diameter, depending on their *n* value and texture. These polyhedrons are separated by cracks that range in width from 2 mm to more than 1 cm. The polyhedrons may shrink and swell with changes in the moisture content of the soils, but the cracks are permanent and can persist for several hundreds of years, even if the soils are cultivated. The cracks permit rapid movement of water through the soils, either vertically or laterally. Such soils may have the same texture, mineralogy, and other family properties as soils that do not form cracks or that have cracks that open and close with the seasons. Soils with permanent cracks are very rare in the United States.

Control Section for Classes of Permanent Cracks

The control section for classes of permanent cracks is from the base of any plow layer or 25 cm from the soil surface, whichever is deeper, to 100 cm below the soil surface.

Key to Classes of Permanent Cracks

A. Fluvaquents or Humaquepts that have, throughout a layer 50 cm or more thick, continuous, permanent, lateral and vertical cracks 2 mm or more wide, spaced at average lateral intervals of less than 50 cm.

Cracked

or

B. All other Fluvaquents and Humaquepts: No class of permanent cracks used.

Family Differentiae for Histosols and Histels

Most of the differentiae that are used to distinguish families of Histosols and Histels have already been defined, either because they are used as differentiae in mineral soils as well as Histosols and Histels or because their definitions are used for the classification of some Histosols and Histels in categories higher than the family. In the following descriptions, differentiae not previously mentioned are defined and the classes in which they are used are enumerated.

The order in which family classes, if appropriate for a particular family, are placed in the technical family names of Histosols and Histels is as follows:

Particle-size classes
Mineralogy classes, including the nature of limnic deposits in Histosols
Reaction classes
Soil temperature classes
Soil depth classes (used only in Histosols)

Particle-Size Classes

Particle-size classes are used only for the family names of Terric subgroups of Histosols and Histels. The classes are determined from the properties of the mineral soil materials in the control section through use of the key to particle-size classes. The classes are more generalized than those for soils in other orders.

Control Section for Particle-Size Classes

The particle-size control section is the upper 30 cm of the mineral layer or of that part of the mineral layer that is within the control section for Histosols and Histels (given in chapter 4), whichever is thicker.

Key to Particle-Size Classes of Histosols and Histels

A. Terric subgroups of Histosols and Histels that have (by weighted average) in the particle-size control section:

1. A fine-earth component of less than 10 percent (including associated medium and finer pores) of the total volume.

Fragmental

or

2. A texture (of the fine earth) of sand or loamy sand, including less than 50 percent (by weight) very fine sand in the fine-earth fraction.

Sandy or sandy-skeletal

or

3. Less than 35 percent clay in the fine-earth fraction and a content of rock fragments of 35 percent or more of the total volume.

Loamy-skeletal

or

4. A content of rock fragments of 35 percent or more of the total volume.

Clayey-skeletal

or

5. A clay content of 35 percent or more in the fine-earth fraction.

Clayey

or

6. All other Terric subgroups of Histosols and Histels.

Loamy

or

B. All other Histosols and Histels: No particle-size class used.

Mineralogy Classes

There are three different kinds of mineralogy classes recognized for families in certain great groups and subgroups of Histosols. The first kind is the ferrihumic soil material defined below. The second is three types of limnic materials—coprogenous earth, diatomaceous earth, and marl, defined in chapter 4. The third is mineral layers of Terric subgroups. The key to mineralogy classes for these mineral layers is the same as that for mineral soils. Terric subgroups of Histels also have the same mineralogy classes as those for mineral soils.

Ferrihumic Mineralogy Class

Ferrihumic soil material, i.e., bog iron, is an authigenic (formed in place) deposit consisting of hydrated iron oxide mixed with organic matter, either dispersed and soft or cemented into large aggregates, in a mineral or organic layer that has all of the following characteristics:

1. Saturation with water for more than 6 months per year (or artificial drainage);

2. 2 percent or more (by weight) iron concretions having lateral dimensions ranging from less than 5 to more than 100 mm and containing 10 percent or more (by weight) free iron oxide (7 percent or more Fe) and 1 percent or more (by weight) organic matter; *and*

3. A dark reddish or brownish color that changes little on drying.

The ferrihumic mineralogy class is used for families of Fibrists, Hemists, and Saprists, but it is not used for Sphagnofibrists and Sphagnic subgroups of other great groups. If the ferrihumic class is used in the family name of a Histosol, no other mineralogy classes are used in that family because the presence of iron is considered to be by far the most important mineralogical characteristic.

Mineralogy Classes Applied Only to Limnic Subgroups

Limnic materials (defined in chapter 4) with a thickness of 5 cm or more are mineralogy class criteria if the soil does not also have ferrihumic mineralogy. The following family classes are used: coprogenous, diatomaceous, and marly.

Control Section for the Ferrihumic Mineralogy Class and Mineralogy Classes Applied to Limnic Subgroups

The control section for the ferrihumic mineralogy class and the classes applied to Limnic subgroups is the same as the control section for Histosols.

Mineralogy Classes Applied Only to Terric Subgroups

For Histosols and Histels in Terric subgroups, use the same key to mineralogy classes as that used for mineral soils unless a Histosol also has ferrihumic mineralogy.

Control Section for Mineralogy Classes Applied Only to Terric Subgroups

For Terric subgroups of Histosols and Histels, use the same control section for mineralogy classes as that used for the particle-size classes.

Key to Mineralogy Classes

A. Histosols (except for Folists), Sphagnofibrists, and Sphagnic subgroups of other great groups that have ferrihumic soil material within the control section for Histosols.

Ferrihumic

or

B. Other Histosols that have, within the control section for

Histosols, limnic materials, 5 cm or more thick, that consist of:

1. Coprogenous earth.

Coprogenous

or

2. Diatomaceous earth.

Diatomaceous

or

3. Marl.

Marly

or

C. Histels and other Histosols in Terric subgroups: Use the key to mineralogy classes for mineral soils.

or

D. All other Histels and Histosols: No mineralogy class used.

Reaction Classes

Reaction classes are used in all families of Histosols and Histels. The two classes recognized are defined in the following key:

A. Histosols and Histels that have a pH value, on undried samples, of 4.5 or more (in 0.01 M $CaCl_2$) in one or more layers of organic soil materials within the control section for Histosols.

Euic

or

B. All other Histosols and Histels.

Dysic

Soil Temperature Classes

The soil temperature classes of Histosols are determined through use of the same key and definitions as those used for mineral soils. Histels have the same temperature classes as other Gelisols.

Soil Depth Classes

Soil depth classes refer to the depth to a root-limiting layer, a fragmental particle-size class, or a cindery or pumiceous substitute class. The root-limiting layers included in soil depth classes of Histosols are duripans; petrocalcic, petrogypsic, and placic horizons; continuous ortstein; and densic, lithic, paralithic, and petroferric contacts. The following key is used for families in all subgroups of Histosols. The shallow class is not used in the suborder Folists.

Key to Soil Depth Classes

A. Histosols that are less than 18 cm deep to a root-limiting layer, to a fragmental particle-size class, or to a cindery or pumiceous substitute class.

Micro

or

B. Other Histosols, excluding Folists, that have a root-limiting layer, a fragmental particle-size class, or a cindery or pumiceous substitute class at a depth between 18 and 50 cm from the soil surface.

Shallow

or

C. All other Histosols: No soil depth class used.

Series Differentiae Within a Family

The function of the series is pragmatic, and differences within a family that affect the use of a soil should be considered in classifying soil series. The separation of soils at the series level of this taxonomy can be based on any property that is used as criteria at higher levels in the system. The criteria most commonly used include presence of, depth to, thickness of, and expression of horizons and properties diagnostic for the higher categories and differences in texture, mineralogy, soil moisture, soil temperature, and amounts of organic matter. The limits of the properties used as differentiae must be more narrowly defined than the limits for the family. The properties used, however, must be reliably observable or be inferable from other soil properties or from the setting or vegetation.

The differentiae used must be within the series control section. Differences in soil or regolith that are outside the series control section and that have not been recognized as series differentiae but are relevant to potential uses of certain soils are considered as a basis for phase distinctions.

Control Section for the Differentiation of Series

The control section for the soil series is similar to that for the family, but it differs in a few important respects. The particle-size and mineralogy control sections for families end at the upper boundary of a fragipan, duripan, or petrocalcic horizon because these horizons have few roots. In contrast to the control section for the series, the thickness of such horizons is not taken into account in the control sections for the family. The series control section includes materials starting at the soil surface and also the first 25 cm below a densic or paralithic contact if its upper boundary is less than 125 cm below the mineral soil surface. Properties of horizons and layers below the particle-size control section, a depth between 100 and 150 cm (or to 200 cm if in a diagnostic horizon) from the mineral soil surface, also are considered.

Key to the Control Section for the Differentiation of Series

The part of a soil to be considered in differentiating series within a family is as follows:

A. Mineral soils that have permafrost within 150 cm of the soil surface: From the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of 100 cm if the depth to permafrost is less than 75 cm; *or*

3. 25 cm below the upper boundary of permafrost if that boundary is 75 cm or more below the soil surface; *or*

4. 25 cm below a densic or paralithic contact; *or*

5. A depth of 150 cm; *or*

B. Other mineral soils: From the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of either 25 cm below a densic or paralithic contact or 150 cm below the soil surface, whichever is shallower, if there is a densic or paralithic contact within 150 cm; *or*

3. A depth of 150 cm if the bottom of the deepest diagnostic horizon is less than 150 cm from the soil surface; *or*

4. The lower boundary of the deepest diagnostic horizon or a depth of 200 cm, whichever is shallower, if the lower boundary of the deepest diagnostic horizon is 150 cm or more below the soil surface; *or*

C. Organic soils (Histosols and Histels): From the soil surface to the shallowest of the following:

1. A lithic or petroferric contact; *or*

2. A depth of 25 cm below a densic or paralithic contact; *or*

3. A depth of 100 cm if the depth to permafrost is less than 75 cm; *or*

4. 25 cm below the upper boundary of permafrost if that boundary is between a depth of 75 and 125 cm below the soil surface; *or*

5. The base of the bottom tier.

Application of Family and Series Differentiae

Application of Family Differentiae

The differentiae of families, like those of the higher categories, can be more readily understood if they are applied to real soils. A rather complex family can demonstrate how the family criteria are determined. The Boistfort and Bunker series are in the medial over clayey, mixed over parasesquic, mesic family of Pachic Fulvudands. A pedon (not the typifying pedon) of the Boistfort series has been sampled and studied in the laboratory. The discussion that follows shows how the classes used as components of the family name are selected.

The particle-size class or substitute class is the first component in the name of a family. Before the class can be selected, the control section must be known, and before the control section can be determined, the diagnostic horizons and properties must be identified. The epipedon of the Boistfort soils has andic soil properties. It is not dark colored enough for a melanic epipedon but is dark enough, is thick enough, and has enough organic carbon for a mollic or umbric epipedon. The base saturation is less than 6 percent throughout. Thus, the epipedon is umbric. The 2Bw horizon in the Boistfort soils does not have the evidence that organic carbon and aluminum have been moved from an eluvial to an illuvial horizon required for spodic materials. The soils have the required thickness of andic soil properties in the required location (item D in the “Key to Soil Orders” in chapter 8) for the Andisol order. The control section for particle-size is determined through use of the criteria in item B (a). The particle-size control section is from 5 cm (the mineral soil surface) to 105 cm.

The upper part of the particle-size control section, from 5 to 53 cm, in the type location meets the criteria for medial listed in item B-2-c in the key to particle-size classes and substitutes for classes. The lower part, from 53 to 105 cm, in the type location meets the criteria for clayey, item 10 under C. The soil materials meet the requirements for strongly contrasting particle-size classes, and the combination “medial over clayey” is included as number 45 on the list of classes considered as strongly contrasting.

The control section for mineralogy classes is the same as that used for the particle-size classes. The mineralogy classes are given for both named particle-size classes for families with strongly contrasting particle-size classes, unless the mineralogy classes are the same for both parts. The mineralogy classes are determined through use of the key to mineralogy classes. “Medial” is a substitute class name that replaces the name of particle-size classes. This family is part of the Andisol soil order. Thus, it fails item A and meets item B of the key. Based on the laboratory data, this part of the control section has mixed mineralogy. The clayey part fails items A and B. This layer meets the criteria listed in item C. The parasesquic class, item 6 under C, is the first class in the key for which this layer meets all of the criteria. The family mineralogy is mixed over parasesquic.

Cation-exchange activity classes are used only for layers with both mixed or siliceous mineralogy and a clayey, clayey-skeletal, coarse-loamy, coarse-silty, fine, fine-loamy, fine-silty, loamy, loamy-skeletal, or very-fine particle-size class. In this family, the mixed mineralogy is associated with the medial substitute for a particle-size class and the parasesquic mineralogy is associated with the clayey particle-size class. Therefore, no cation-exchange activity class is used in this family name.

Calcareous and reaction classes are not used in families of Udands.

The mean soil temperatures are estimated from climatic data. The mean winter soil temperature is about 3 °C (38 °F), the mean summer soil temperature is about 16 °C (60 °F), and the mean annual soil temperature is about 15 °C (59 °F). These data are within the class criteria for mesic temperatures, item 2 under B, in the key to temperature classes.

The Boistfort and Bunker soils have no root-limiting layers within 100 cm. They therefore fail items A and B in the key to soil depth classes but meet criterion C. No soil depth class is used for soils that meet criterion C.

The keys indicate that families of Andisols do not have rupture-resistance classes, classes of coatings (on sands), or classes of permanent cracks.

The classes that are components of the family name are medial over clayey, mixed over parasesquic, and mesic. The family name is medial over clayey, mixed over parasesquic, mesic Pachic Fulvudands.

Application of Series Differentiae

Standard descriptions of the Boistfort and Bunker series are given at the end of this chapter. If we compare the descriptions of the typifying pedons of these two series, we note that the particle-size control section of the Bunker soils averages 15 to 35 percent basalt fragments and that of the Boistfort soils averages less than 10 percent. This difference is relatively small but reflects differences in setting and parent materials that affect the use of the soils. The Boistfort soils formed in material weathered from basalt in the more stable positions on foothills and mountains, and the Bunker soils formed in colluvium derived from basalt on metastable slopes. Both of the soils are used for the production of lumber. The differences in these soils affect both tree growth and the construction and maintenance of the roads needed when the trees are harvested.

The Bunker series allows basalt at a depth of 100 to more than 150 cm from the mineral soil surface. This range in depth to a lithic contact could be used as a criterion to divide the Bunker series into two series, as the lithic contact is within the control section for the series. Because this depth difference is difficult to separate in mapping and has little effect on the use of these soils for the production of lumber, the series is allowed this wide range in soil depth. Many soil series that are in other climates or that have more intensive uses are separated on the basis of having or not having a lithic contact between 100 and 150 cm.

This example shows the nature of series differentiae. Generally, the series within a given family have several small differences in the nature or arrangement of horizons, in the absence of horizons, in the nature of the soil materials in the series control section, or in soil moisture or soil temperature. These differences commonly reflect differences in setting, climate, and/or parent materials that have important effects on the use of the soils. The differences permit, but do not require, the separation of soil series within a family. The differentiae are discussed under the category of series in chapter 6.

A full treatment of series differentiae within families is beyond the scope of this text. Series differentiae vary among families, subgroups, great groups, and even orders. The principle, however, remains the same. The series are distinguished within a family primarily because of the need to facilitate quantitative interpretations of soil behavior.

LOCATION BOISTFORT WA

Established Series
Rev. CJM/RFP/RJE/TLA
08/98

BOISTFORT SERIES

The Boistfort series consists of very deep, well drained soils formed in material weathered from basalt and a component of volcanic ash in the upper part. Boistfort soils are on foothills and mountains and have slopes of 0 to 65 percent. The average annual precipitation is about 2,300 mm, and the average annual temperature is about 10 degrees C.

TAXONOMIC CLASS: Medial over clayey, mixed over parasesquic, mesic Pachic Fulvudands

TYPICAL PEDON: Boistfort silt loam - forested. (Colors are for moist soil unless otherwise stated. All textures are apparent field textures.)

Oi—0 to 5 cm (0 to 2 inches); slightly decomposed twigs, needles, and moss.

Ac—5 to 28 cm (2 to 11 inches); dark brown (7.5YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; soft, very friable, slightly sticky and slightly plastic, and weakly smeary; many coarse, medium, and fine roots; many medium tubular pores; 25 percent weakly cemented shotlike concretions; very strongly acid; clear wavy boundary. (18 to 30 cm thick)

A—28 to 53 cm (11 to 21 inches); dark brown (7.5YR 3/2) silty clay loam, dark brown (10YR 4/3) dry; moderate very fine subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; many coarse, medium, and fine roots; many medium tubular pores; few firm shotlike concretions; very strongly acid; clear wavy boundary. (0 to 25 cm thick)

2Bw1—53 to 99 cm (21 to 39 inches); dark brown (7.5YR 4/4) silty clay, yellowish brown (10YR 5/6) dry; weak fine subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; few fine roots; common medium tubular and interstitial pores; extremely acid; gradual wavy boundary.

2Bw2—99 to 140 cm (39 to 55 inches); strong brown (7.5YR 5/6) silty clay, strong brown (10YR 5/8) dry; weak very fine subangular blocky structure; very hard, friable, sticky and plastic, and weakly smeary; few fine tubular and common medium interstitial pores; extremely acid; clear wavy boundary. (Combined thickness of the 2Bw horizon: 50 to 100 cm)

2BC—140 to 157 cm (55 to 62 inches); strong brown (7.5YR 5/6) silty clay, yellowish brown (10YR 5/6) dry; weak very fine subangular blocky structure; very hard, friable, sticky and plastic, and weakly smeary; few fine tubular and common medium interstitial pores; extremely acid.

TYPE LOCATION: Thurston County, Washington; Capitol State Forest, about 5 miles northwest of Littlerock, 540 meters west and 180 meters north of the southeast corner of sec. 24, T. 17 N., R. 4 W.

RANGE IN CHARACTERISTICS: The thickness of the solum ranges from 100 to more than 150 cm, and the depth to basalt is more than 150 cm. The content of rock fragments averages less than 10 percent in the particle-size control section. The upper part of the particle-size control section, 5 to 105 cm, has an estimated moist bulk density of 0.65 to 0.90 g/cc, a volcanic glass content of 0 to 5 percent, acid-oxalate-extractable aluminum plus one-half iron of 2.0 to 3.0 percent, phosphate retention of 85 to 100 percent, and 15-bar water retention of 15 to 30 percent for air-dried samples. The content of organic carbon is less than 4 percent in some part between 50 and 75 cm. Under forest cover, the mean annual soil temperature is about 10 degrees C (50 degrees F) and ranges from 8 to 11 degrees C.

The A horizon has value and chroma of 2 or 3 when rubbed and moist and value and chroma of 2, 3, or 4 when dry. This horizon is moderately acid to very strongly acid.

Some pedons have AB and BA horizons.

The 2Bw horizon has hue of 5YR or 7.5YR and value and chroma of 4 through 6 moist, 5 through 8 dry. The apparent field texture averages clay loam, silty clay loam, or silty clay, but in some thin subhorizons it is gravelly or cobbly silty clay loam, gravelly or cobbly clay loam, or gravelly or cobbly silty clay. This horizon is moderately acid to extremely acid.

COMPETING SERIES: These are the Bunker soils. Bunker soils contain 15 to 35 percent rock fragments in the particle-size control section.

GEOGRAPHIC SETTING: Boistfort soils are in stable positions on foothills and mountains. Slopes are mostly less than 30 percent, but they range from 0 to 65 percent. The soils formed in material weathered from basalt and a component of volcanic ash in the upper part. Elevations range from 30 to 540 meters. These soils are in a marine climate with cool, wet winters and cool, dry summers. The average annual precipitation ranges from 1,800 to 3,000 mm. The average January temperature is about 3 degrees C, the average July temperature is about 16 degrees C, and the average annual temperature is about 10 degrees C. The growing season (-2 degrees C) is 200 to 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the competing Bunker soils and the Astoria, Elochoman, Katula, Lates, Lytell, Murnen, and Zenker soils. Astoria soils are in a fine class and are Udepts. Elochoman, Lytell, and Zenker soils are in a medial class. In addition, Lytell and Zenker soils average more than 35 percent pararock fragments, consisting of weathered sandstone or siltstone, in the particle-size control section. Katula soils are in a medial-skeletal class and have a lithic contact between 50 and 100 cm. Lates and Murnen soils are in a medial class and a frigid class.

DRAINAGE , RUNOFF, AND PERMEABILITY: Well drained; very low to medium runoff; moderate permeability.

USE AND VEGETATION: Forested. The vegetation is mainly Douglas-fir, western redcedar, and red alder with an understory of western swordfern, Oregongrape, red huckleberry, and vine maple.

DISTRIBUTION AND EXTENT: Southwestern Washington. The series is of moderate extent.

SERIES ESTABLISHED: Grays Harbor County (Grays Harbor County Area), Washington, 1970.

REMARKS: The diagnostic horizons and features recognized in this pedon are an umbric epipedon from the mineral soil surface (at 5 cm) to 53 cm and a cambic horizon from 53 to 157 cm. The upper 48 cm of the particle-size control section has andic soil properties.

ADDITIONAL DATA: Characterization data for this series are available; NSSL pedon numbers 84P0906 and 40A3303.

National Cooperative Soil Survey
U.S.A.

LOCATION BUNKER WA

Established Series
Rev. FG/RFP/RJE/TLA
08/98

BUNKER SERIES

The Bunker series consists of deep, well drained soils formed in colluvium weathered from basalt and a component of volcanic ash in the upper part. These soils are on foothills and mountains. Slopes are 1 to 90 percent. The average annual precipitation is about 2,300 mm, and the average annual temperature is about 10 degrees C.

TAXONOMIC CLASS: Medial over clayey, mixed over parasesquic, mesic Pachic Fulvudands

TYPICAL PEDON: Bunker loam - forested. (Colors are for moist soil unless otherwise stated. All textures are apparent field textures.)

Oi—0 to 3 cm (0 to 1 inch); loose, slightly decomposed Douglas-fir needles, twigs, and moss.

Oa—3 to 5 cm (1 to 2 inches); decomposed litter; dark red with many white mycelia.

A—5 to 29 cm (2 to 12 inches); dark reddish brown (5YR 3/3) loam, reddish brown (5YR 4/3) dry; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic, and weakly smeary; many roots; 15 percent angular basalt pebbles; moderately acid (pH 5.9); clear wavy boundary. (25 to 36 cm thick)

BA—29 to 47 cm (12 to 19 inches); dark reddish brown (5YR 3/4) gravelly clay loam, reddish brown (5YR 4/4) dry; moderate medium and fine subangular blocky structure; hard, friable, sticky and plastic, and weakly smeary; many roots; 30 percent angular basalt pebbles; few medium and fine shotlike concretions; moderately acid (pH 5.9); clear irregular boundary. (5 to 25 cm thick)

2Bw1—47 to 88 cm (19 to 35 inches); dark reddish brown (5YR 3/4) gravelly clay loam, reddish brown (5YR 4/4) dry; moderate medium and fine subangular blocky structure; hard, firm, sticky and plastic, and weakly smeary; common roots; many fine pores; 30 percent angular basalt pebbles; moderately acid (pH 5.8); gradual wavy boundary.

2Bw2—88 to 134 cm (35 to 53 inches); reddish brown (5YR 4/4) clay loam, reddish brown (5YR 5/4) dry; moderate medium subangular blocky structure; slightly hard, firm, sticky and plastic, and weakly smeary; many roots; many fine pores; 10 percent angular basalt pebbles; moderately acid (pH 6.0); clear irregular boundary. (Combined thickness of the 2Bw horizon: 50 to 90 cm)

2BC—134 to 156 cm (53 to 62 inches); dark brown (7.5YR 3/4) clay loam, reddish brown (5YR 4/4) dry; weak medium subangular blocky structure; slightly hard, friable, sticky and plastic, and weakly smeary; few roots; 10 percent angular basalt pebbles; moderately acid (pH 6.0); clear irregular boundary. (10 to 30 cm thick)

2R—156 cm (62 inches); fractured basalt.

TYPE LOCATION: Lewis County, Washington; on logging road number 5, Weyerhaeuser Company McDonald Tree Farm; approximately 570 meters south and 570 meters west of the northeast corner of sec. 11, T. 12 N., R. 5 W.

RANGE IN CHARACTERISTICS: The mean annual soil temperature ranges from 8 to 11 degrees C. The depth to fractured bedrock ranges from 100 to more than 150 cm from the mineral soil surface. The content of basalt fragments in the particle-size control section averages 15 to 35 percent. The upper part of the particle-size control section (4 to 104 cm) has an estimated moist bulk density of 0.65 to 0.90 g/cc, a volcanic glass content of 0 to 5 percent, acid-oxalate-extractable aluminum plus one-half iron of 2.0 to 3.0 percent, phosphate retention of 85 to 100 percent, and 15-bar water retention of 15 to 30 percent for air-dried samples. The content of organic carbon is less than 4 percent in some part of the upper 75 cm of the particle-size control section. Reaction ranges from very strongly acid to moderately acid.

The A horizon has hue of 5YR or 7.5YR, value of 2 or 3 moist, 4 or 5 dry, and chroma of 1 to 3 moist, 3 or 4 dry. It has 0 to 35 percent pebbles.

The BA horizon has hue of 5YR or 7.5YR, value of 3 or 4 moist, 4 or 5 dry, and chroma of 2 to 4 moist. It has 0 to 35 percent pebbles.

The 2B horizon has hue of 5YR through l0YR, value of 3 or 4 moist, 4 or 5 dry, and chroma of 3 or 4 moist. It ranges from loam to clay loam, silt loam, or silty clay loam with 10 to 35 percent rock fragments.

COMPETING SERIES: These are the Boistfort soils. Boistfort soils average 0 to 10 percent basalt fragments in the particle-size control section.

GEOGRAPHIC SETTING: Bunker soils are on metastable side slopes and foot slopes at elevations of 30 to 660 meters. Slopes are mostly 30 to 90 percent but range from 1 to 90 percent. These soils formed in colluvium weathered from basalt and a component of volcanic ash in the upper part. Winters are cool and moist, and summers are warm and dry. The average annual temperature is about 10 degrees C, the average January temperature is about 3 degrees C, and the average July temperature is about 16 degrees C. The annual precipitation ranges from 1,800 to 3,000 mm. The growing season (-2 degrees C) is 200 to 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Astoria, Katula, Lytell, Swem, Murnen, Squally, and Zenker soils and the competing Boistfort soils. Astoria soils are Udepts and are in a fine class. Katula and Squally soils are in a medial-skeletal class. Lytell and Zenker soils are in a medial class and average more than 35 percent sandstone or siltstone pararock fragments in the particle-size control section. Murnen soils are in a frigid temperature class. Swem soils are in a medial class and have grayish iron depletions in the particle-size control section.

DRAINAGE, RUNOFF, AND PERMEABILITY: Well drained; very low to high runoff; moderate permeability.

USE AND VEGETATION: Forested. Bunker soils are used for timber production, watershed, wildlife habitat, and recreation. The vegetation is mainly Douglas-fir and western hemlock with an understory of western swordfern, Oregongrape, red huckleberry, and vine maple.

DISTRIBUTION AND EXTENT: Southwestern Washington. The series is extensive.

SERIES ESTABLISHED: Wahkiakum County, Washington, 1976.

REMARKS: The diagnostic horizons and features recognized in this pedon are an umbric epipedon from the mineral soil surface to 29 cm and a cambic horizon from 29 to 156 cm. The upper 43 cm of the particle-size control section has andic soil properties.

ADDITIONAL DATA: The classification is based on laboratory data taken on the Boistfort series. These data are available at the National Soil Survey Laboratory, Lincoln, Nebraska: Pedon numbers 40A3303 and 84P0906.

National Cooperative Soil Survey
U.S.A.

CHAPTER 22

Soils of the United States

This chapter describes the geographic extent and pattern of the 12 soil orders and 64 suborders recognized in the current taxonomic system as these taxa occur in the United States. The geography of the orders and suborders, the nature of the topography on which they occur, the parent materials, and the principal uses of the soils are specified. More detailed descriptions of the soil orders and suborders and the lower categories of the taxonomic system are given in individual chapters on the soil orders.

The maps of the United States at the end of this publication show the geographic distribution of the soil orders and suborders in the United States and the territories, commonwealths, and island nations served by the United States Department of Agriculture, Natural Resources Conservation Service. The dominant order map and the dominant suborder maps are at scales of approximately 1:15,000,000 and 1:52,000,000, respectively, except in Alaska and the Pacific Basin islands.

The maps provide an illustration of the dominant soil orders and suborders derived from the State Soil Geographic Data Base, or STATSGO (USDA, NRCS, 1994, revised 1998; USDA, NRCS, 1996). The dominant soil orders and suborders represent the largest land area of each STATSGO map unit (summed component percentage) for each order and suborder category. The soil orders and suborders for the U.S. Virgin Islands and the Pacific Basin islands served by the Natural Resources Conservation Service were determined from published soil survey reports and from local information.

The soil order and suborder concepts for each STATSGO map unit were revised according to soil series name (118,568 component records for 10,872 map units) through use of the Soil Classification File (USDA, NRCS, 1997). These data records were further correlated to make them consistent with the current concepts of the taxonomic system.

The maps of the United States include 1 map showing the dominant orders and 12 maps showing the dominant suborders within each order. The dominant order map has a legend that includes 12 dominant order categories, 1 category of codominant orders, and 2 categories for miscellaneous lands, plus water. The codominant category is used only in Alaska, where the STATSGO scale is 1:1,000,000. Given this smaller scale, there is much greater uncertainty associated with this portion of the map and a multi-taxa unit was chosen.

During the correlation of the STATSGO component records, the following were included in the rock outcrop category: badlands, cinder land, lava flows, rock outcrop, rough mountainous land, and rubble land. Glacier ice fields in Alaska and continuously snow-covered areas at high elevations of the mountains in the Western States were included in the ice/tundra category. In addition, several miscellaneous land areas were included with the Entisol and Aridisol orders and suborders. Psamments included dune land, coastal dunes, and blown-out land. Salids included playas and salt flats. Orthents included dumps, pits, gullied land, and scoria land. Fluvents included riverwash and beaches; however, they excluded areas of riverwash and beaches with permafrost. Arents included urban land.

Gelisols did not occur in the Alaska STATSGO and Soil Classification File (USDA, NRCS, Soil Survey Staff, 1997) and were approximated through use of the pergelic subgroups for STATSGO components. Additional study and evaluation are needed to determine the proper placement and extent of these map units in Alaska.

The 12 dominant suborder maps each have legends that identify the possible suborders within a given order. The dominant suborder for each STATSGO map unit is the most extensive suborder of the dominant order in the map unit. The Gelisol suborders were approximated through use of local information that helped to correlate the Alaska STATSGO component soil series.

The table "Total Area of Soil Orders and Suborders in the United States" shows the approximate area, in square kilometers, and the percentages of the soil orders and suborders in the United States, based on a total area of 9,147,537 square kilometers. Some suborders are of very small extent or are not known to occur in the United States. These suborders are not shown on the map; however, the extent of all STATSGO map unit components is accounted for in the table.

Alfisols

Alfisols are extensive in the United States. They make up about 13.9 percent of the surface area. Typically, they have an ochric epipedon, an argillic horizon, and moderate or high base saturation. In normal years water is held at less than 1500 kPa tension in some or all parts of the moisture control section more than one-half of the time when the soils are warm enough

Total Area of Soil Orders and Suborders in the United States

Order/suborder	Square kilometers	Percent[1]
Alfisols	1,269,283	13.88
Aqualfs	215,497	2.36
Cryalfs	69,129	0.76
Udalfs	622,300	6.80
Ustalfs	281,586	3.08
Xeralfs	80,771	0.88
Andisols	155,812	1.69
Aquands	2,299	0.03
Cryands	87,531	0.95
Torrands	134	<.01
Udands	17,456	0.19
Ustands	1,149	0.01
Vitrands	17,319	0.18
Xerands	29,924	0.33
Aridisols	760,122	8.30
Argids	322,921	3.53
Calcids	221,716	2.42
Cambids	103,009	1.12
Cryids	562	0.01
Durids	74,371	0.81
Gypsids	14,061	0.15
Salids	23,482	0.26
Entisols	1,122,383	12.27
Aquents	124,331	1.36
Arents	21,232	0.23
Fluvents	178,579	1.95
Orthents	549,579	6.01
Psamments	248,662	2.72
Gelisols	792,945	8.68
Histels	87,440	0.96
Orthels	124,975	1.37
Turbels	580,530	6.35
Histosols	149,555	1.63
Fibrists	22,058	0.24
Folists	8,795	0.09
Hemists	29,159	0.32
Saprists	89,543	0.98
Inceptisols	889,441	9.71
Anthrepts	0	0
Aquepts	123,753	1.35
Cryepts	190,517	2.08
Udepts	348,528	3.81
Ustepts	149,122	1.62
Xerepts	77,521	0.85
Mollisols	1,966,457	21.49
Albolls	15,314	0.17
Aquolls	233,749	2.55
Cryolls	136,132	1.49
Rendolls	3,223	0.03
Udolls	356,064	3.89
Ustolls	884,688	9.67
Xerolls	337,287	3.69
Oxisols	1,666	0.02
Aquox	0	0
Perox	15	<.01
Torrox	0	0
Udox	1,048	0.01
Ustox	603	0.01
Spodosols	317,665	3.47
Aquods	55,269	0.60
Cryods	85,873	0.94
Humods	4,612	0.05
Orthods	171,911	1.88
Ultisols	842,259	9.20
Aquults	75,472	0.82
Humults	16,489	0.18
Udults	742,749	8.12
Ustults	823	0.01
Xerults	6,726	0.07
Vertisols	181,482	1.99
Aquerts	55,469	0.61
Cryerts	0	0
Torrerts	10,025	0.11
Uderts	30,934	0.34
Usterts	74,120	0.81
Xererts	10,934	0.12
Water[2]	118,973	1.30
Rock and ice	577,304	6.35
Rock	269,382	2.94
Rock and ice	307,922	3.41
Ice	1,108	0.01
Unclassified	1,082	0.01
Total surface area	9,147,537	100

[1] Percentage of the surface area of the United States and the territories, commonwealths, and island nations served by the Natural Resources Conservation Service.

[2] Water as represented in State Soil Geographic Data Base (USDA, NRCS, 1994 and 1996).

for plants to grow. Some Alfisols also have a fragipan, a duripan, a kandic horizon, a natric horizon, a petrocalcic horizon, plinthite, or other features.

Alfisols are divided into five suborders based on soil moisture or soil temperature. These properties tend to limit the suborders to specific regions of the country.

Aqualfs, which have aquic conditions, are of moderate extent in the United States. They make up about 2.4 percent of the surface area. They occur mostly in association with soils that have a udic moisture regime. The largest extent is in an area bordering the southern part of the Mississippi River, in southern Illinois, and in Indiana and Ohio. Most Aqualfs, except those that have a frigid or cryic temperature regime, have some artificial drainage or other water control and are used as cropland. Corn and soybeans are the most common crops. Rice also is a common crop on Aqualfs that have a thermic or warmer temperature regime. Before they were cultivated, some of the soils were under forest vegetation and others were under grass. Nearly all Aqualfs are believed to have supported forest vegetation at some time in the past.

Cryalfs, which have a cryic soil temperature regime, are of small extent in the United States. They make up about 0.8 percent of the surface area. They occur mostly in association with Inceptisols and Mollisols at high elevations, mainly in the Rocky Mountains in the Western United States. Most of the Cryalfs in the United States are used as forest because of their short, cool growing season.

Udalfs, which have a udic moisture regime, are of large extent in the United States. They make up about 6.8 percent of the surface area. They form a belt extending from Minnesota through Wisconsin, Michigan, Indiana, and Ohio and ending in New York State. This belt has mostly Spodosols and Inceptisols to the north, Mollisols to the west, and Ultisols to the south and east. Another large area of Udalfs begins in southern Iowa and extends through Missouri, Illinois, and the States to the south bordering the Mississippi River. Smaller areas of Udalfs are associated with the Ultisols in the Southeastern States. The Alfisols in the Southern States formed mostly in materials that are younger and/or have more bases than those of the associated Ultisols. All Udalfs are believed to have supported forest vegetation at some time during development. Most of the Udalfs with a mesic or warmer temperature regime currently support or formerly supported deciduous forest vegetation, and many with a frigid temperature regime currently support or formerly supported mixed coniferous and deciduous trees. Many Udalfs have been cleared of trees and are used intensively as cropland. As a result of erosion, some have only an argillic or kandic horizon below an Ap horizon. Others retain most of their eluvial horizons above the argillic or kandic horizon.

Ustalfs, which have an ustic soil moisture regime, are of large extent in the United States. They make up about 3.1 percent of the surface area. They tend to occur in association with Mollisols on the southern Great Plains, mostly in Texas and Oklahoma. They also occur in association with Aridisols, Inceptisols, and Mollisols throughout the Rocky Mountain States from Montana to Arizona and New Mexico and in association with Entisols in the Black Hills of South Dakota. The dry season or seasons are pronounced enough for the trees to be either deciduous or xerophytic. Many Ustalfs currently support or formerly supported savanna vegetation, and some supported grassland vegetation. Most are used as cropland or grazing land. Some are used as irrigated cropland. Wheat and sorghum are the most common crops. Cotton also is grown on the Ustalfs with a thermic or warmer temperature regime.

Xeralfs, which have a xeric soil moisture regime, are of small extent in the United States. They make up about 0.9 percent of the surface area. They occur mainly in association with Mollisols, Inceptisols, and Andisols. They are mostly in California, but small areas are in Oregon, Washington, Idaho, and Utah. The natural vegetation was a mixture of annual grasses, forbs, and woody shrubs on the warmest and driest Xeralfs and coniferous forest on the coolest and most moist Xeralfs. Xeralfs are used mostly as cropland, forest, or grazing land. Small grains, mostly winter wheat, are the most common crops. A wide variety of crops are grown on irrigated Xeralfs.

Andisols

Andisols are of small extent in the United States. They make up about 1.7 percent of the surface area. The colloidal fraction of these soils is dominated by short-range-order minerals or Al-humus complexes. Many Andisols developed in volcanic ejecta and/or in volcaniclastic materials. Some of the soils are dominated by short-range-order minerals that weathered from nonvolcanic primary alumino-silicates. The dominant process in the formation of Andisols is the transformation of minerals. Translocation within the soils and accumulation of the translocated compounds are normally minimal. The accumulation of organic matter, complexed with aluminum, however, is characteristic of some Andisols. Andisols may have any diagnostic epipedon, provided that the minimum requirements for the order are met in and/or below the epipedon. These soils commonly have an ochric or umbric epipedon and a cambic horizon. Some have buried diagnostic horizons. Andisols can have any soil moisture regime and any soil temperature regime, but they cannot have permafrost. They can occupy any position on the landscape and can occur at any elevation. One of the outstanding features of Andisols is their generally high natural productivity. The dominance of physical properties that favor the growth of most plants and the most common occurrence of the soils in areas of considerable rainfall have resulted in volcanic soils that generally are regarded as highly fertile.

Andisols are divided into seven suborders based on soil moisture and temperature regimes, soil wetness, and the amount of water held too tightly for plants to use.

Aquands, which have aquic conditions at or near the soil surface, are of very small extent in the United States. They make up less than 0.1 percent of the surface area and do not dominate any areas on the map. They commonly have dark colored surface horizons that meet the requirements for a histic, umbric, or mollic epipedon. They occur mostly in western Washington and Oregon, in the lower landscape positions and under forest or grass vegetation. Some of the soils have been drained and are used as cropland or pasture.

Cryands, which have a cryic temperature regime, are of moderate extent in the United States. They make up about 1.0 percent of the surface area. They dominate some areas in Alaska and in the mountains of the Pacific Northwest. Most of the soils formed under coniferous forest vegetation. Cryands commonly have a thin O horizon, an ochric or umbric epipedon, and a cambic horizon. They developed mostly in late-Pleistocene or Holocene deposits. Most are used as forest.

Torrands, which have an aridic (or torric) moisture regime and a temperature regime warmer than cryic, are of very small extent in the United States. They make up less than 0.1 percent of the surface area. The extent is too small for the soils to be shown on the map. A very few areas of these soils are in western Oregon and in Hawaii. Most of the soils formed under grassy or shrub vegetation. Commonly, Torrands have an ochric or mollic epipedon and a cambic horizon. Some have a duripan or a petrocalcic horizon. The Torrands in the United States generally developed in late-Pleistocene or Holocene deposits. They are used as rangeland or as irrigated cropland.

Udands, which have a udic moisture regime, a temperature regime warmer than cryic, and a relatively high content of water held too tightly for plants to use, are of small extent in the United States. They make up about 0.2 percent of the surface area. They dominate in some areas, mostly in western Washington and Oregon and in Hawaii. Most of the soils formed under forest vegetation. Characteristically, Udands have an ochric or umbric epipedon and a cambic horizon. Some have a cemented pan. Most developed in late-Pleistocene or Holocene deposits. Udands are used mostly as forest, but some have been cleared and are used as cropland or pasture.

Ustands, which have an ustic moisture regime, a temperature regime warmer than cryic, and a relatively high content of water held too tightly for plants to use, are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are mostly in Hawaii. They formed mostly under forest or savanna vegetation. Characteristically, Ustands have an ochric, mollic, or umbric epipedon and a cambic horizon. Most of the Ustands in the United States developed in late-Pleistocene or Holocene deposits. Ustands are used mostly as forest, cropland, or pasture or for urban development.

Vitrands, which are the more or less well drained, coarse textured Andisols that have a udic or ustic moisture regime, a temperature regime warmer than cryic, and a low content of water held too tightly for plants to use, are of small extent in the United States. They make up about 0.2 percent of the surface area. They occur mostly in Idaho, Oregon, and Washington. Most of the soils formed under coniferous forest vegetation, but some formed under grass and shrubs. Characteristically, Vitrands have an ochric or mollic epipedon and a cambic horizon. They are relatively young soils that developed mostly in Holocene deposits. They are used mostly as forest, but some are used as rangeland and some have been cleared and are used as cropland or pasture.

Xerands, which have a xeric moisture regime and a frigid, mesic, or thermic temperature regime, are of small extent in the United States. They make up about 0.3 percent of the surface area. They are mostly in Washington, California, Oregon, and Idaho. Most of the Xerands that have a frigid or mesic temperature regime formed under coniferous forest vegetation. Some Xerands, mostly those with a thermic temperature regime, formed under grass and shrub vegetation. Characteristically, Xerands have an ochric or mollic epipedon and a cambic horizon. They developed mostly in late-Pleistocene or Holocene deposits. They are used mostly as forest, but some have been cleared and are used as cropland or pasture.

Aridisols

Aridisols are moderately extensive in the United States. They make up about 8.3 percent of the surface area. They are in the Western States. For long periods, they are too dry for mesophytic plants to grow. During most of the time when they are warm enough for plants to grow, the soils are dry or salty, or both. There are no periods as long as 90 consecutive days when the soils are warm enough for plants to grow and soil moisture is continuously available for plant growth. The concept of Aridisols is based on the limited availability of soil moisture for sustained plant growth. In areas bordering deserts, the absolute precipitation may be high. Because of runoff or a very low storage capacity in the soils, or both, however, the actual soil moisture regime is aridic.

Soil moisture and, to a lesser extent, soil temperature regimes control processes in these soils. The soil moisture regime is used, in conjunction with diagnostic horizons, to define the Aridisol order. The soil moisture regime is the single most important limitation affecting the use of the soils. Because of an extreme imbalance between evapotranspiration and precipitation, many Aridisols in a sense are incipient evaporites. The dominant process in Aridisols is one of accumulation and concentration of weathering products. The redistribution and accumulation of soluble materials in some layer of the soils are common. The products of this process not only give special attributes that distinguish the soils but also limit the use of the soils. Four of the seven suborders are defined on the basis of the composition and accumulation of the soluble fraction. Weathering and clay and silica translocation also occur in Aridisols.

Aridisols are divided into seven suborders based on diagnostic horizons and soil temperature regimes.

Argids are the Aridisols that have an argillic or natric horizon, but not a duripan or a gypsic, petrocalcic, petrogypsic, or salic horizon, within 100 cm of the soil surface. They are of large extent in the United States and are the suborder with the largest extent on the map. They make up about 3.5 percent of the surface area. They have a temperature regime warmer than cryic. The presence of an argillic horizon is often attributed to a more moist paleoclimate, although there is evidence that clay illuviation has occurred during the Holocene in arid soils, especially where the soil moisture regime grades toward ustic or xeric. Most Argids are used as rangeland or wildlife habitat. Some are used as irrigated cropland.

Calcids are the Aridisols that have a calcic or petrocalcic horizon and have calcium carbonate in the layers above. They are of moderate extent in the United States. They make up about 2.4 percent of the surface area. They have a temperature regime warmer than cryic. The parent materials are high in content of carbonates, or carbonates were added as dust, or both. Precipitation has been insufficient to remove the carbonates or even move them to great depths. The upper boundary of the calcic or petrocalcic horizon is normally within 50 cm of the soil surface. These soils are in the Western States. Most are used as rangeland or wildlife habitat. Some are used as irrigated cropland. If the soils are used as cropland, micronutrient deficiencies are normal.

Cambids are the Aridisols that have a cambic horizon within 100 cm of the soil surface. They do not have other diagnostic horizons, such as petrocalcic, gypsic, or calcic horizons, unless the upper boundary of such horizons is 100 cm or more below the soil surface. The soils are characterized by the least degree of soil development. They are of moderate extent in the United States. They make up about 1.1 percent of the surface area. They are mostly in Washington State. These soils have a temperature regime warmer than cryic. Most are used as rangeland or wildlife habitat. Some are used as irrigated cropland.

Cryids are the Aridisols of cold areas. They have a cryic temperature regime. The growing season is short. The short growing season and arid conditions severely limit the use of these soils. The soils are of very small extent in the United States. They make up about 0.01 percent of the surface area. The extent is too small for the soils to be shown on the map. The soils are at high elevations in mountain valleys and basins in Idaho. They can have a duripan or an argillic, calcic, cambic, gypsic, natric, petrocalcic, petrogypsic, or salic horizon. Most of these soils are used as rangeland or wildlife habitat.

Durids are the Aridisols that have a duripan, but not a salic horizon, that has an upper boundary within 100 cm of the soil surface. Many duripans are within 50 cm of the soil surface. These soils have a temperature regime warmer than cryic. They are of small extent in the United States. They make up about 0.8 percent of the surface area. They are in the Western States. The largest extent is in Nevada and Idaho. These soils occur dominantly on gentle slopes. Many formed in sediments that contain pyroclastics. Most of the soils are used as rangeland or wildlife habitat. A few are used as irrigated cropland.

Gypsids are the Aridisols that have a gypsic or petrogypsic horizon, but not a duripan or a salic horizon, within 100 cm of the soil surface. They have a temperature regime warmer than cryic. They are of small extent in the United States. They make up about 0.15 percent of the surface area. They are mostly in the Southwestern States. They are on many segments of the landscape. Some of the soils have a calcic horizon or related horizons, which overlie the gypsic horizon. The gypsic horizon limits many soil uses. A petrogypsic horizon is an even greater limitation. Most of these soils are used as rangeland or wildlife habitat.

Salids are the Aridisols that have a salic horizon that has its upper boundary within 100 cm of the soil surface. They are commonly in depressions (playas). They are of small extent in the United States. They make up about 0.26 percent of the surface area. They are mostly in Utah and Nevada. In a warm, arid environment, salts commonly accumulate at or near the surface if there are both a supply of salts in the soils or in water and a net upward movement of water in the soils. In some areas salic horizons formed in salty parent materials without the presence of ground water. Silica can accumulate and form duripans if the ground water is sufficiently alkaline. As a rule, Salids are unsuitable for agricultural uses unless they are leached of salts. Leaching the salts is an expensive undertaking, particularly if there is no natural outlet for the drainage water. Most of these soils are used as rangeland or wildlife habitat.

Entisols

Entisols are extensive in the United States. They make up about 12 percent of the surface area. Most of the soils have no diagnostic horizons other than an ochric epipedon. Some have a cambic horizon with its base at a depth of less than 25 cm below the mineral soil surface. A few Entisols that have a sandy or sandy-skeletal particle-size class have a horizon that would be a cambic horizon were it not for the particle-size class exclusion, and a very few have an albic horizon. In coastal marshes some Entisols that have sulfidic materials within 50 cm of the mineral soil surface have a histic epipedon.

On many landscapes the soil material is too thin or has not been in place long enough for pedogenic processes to form diagnostic horizons. Some Entisols have steep, actively eroding slopes, and others are on flood plains or glacial outwash plains that receive new deposits of alluvium at frequent intervals. Some Entisols are old and deep enough to have formed diagnostic horizons, but they consist mostly of quartz or other minerals that are resistant to the weathering needed to form diagnostic horizons. Buried diagnostic horizons are permitted in Entisols if they meet the definition of “buried soil” in chapter 1.

Entisols may have any mineral parent material, vegetation, age, or moisture regime and any temperature regime, but they cannot have permafrost at a depth of less than 100 cm below the soil surface. The only features common to all Entisols are the virtual absence of diagnostic horizons and the mineral nature of the soils.

Entisols are divided into five suborders based on wetness and soil characteristics.

Aquents, or the wet Entisols, are of moderate extent in the United States. They make up about 1.4 percent of the surface area. They are widely distributed. They dominate some of the delineations along the southern Atlantic and gulf coasts and on the flood plains along the Mississippi River and along other rivers and streams. Some Aquents are forming, mostly in sandy deposits, in other parts of the country. Aquents can have any temperature regime, but they cannot have permafrost within 100 cm of the soil surface. Most of the soils are forming in recent sediments. They support vegetation that tolerates permanent or periodic wetness. They are used mostly as pasture, cropland, forest, or wildlife habitat.

Arents are of small extent in the United States. They make up about 0.2 percent of the surface area. They do not have diagnostic horizons because they have been deeply mixed by plowing, spading, or other methods of moving by humans. They are important soils for irrigated crop production in California. Small areas also occur throughout the country. Some are areas where the soil profile was removed and then replaced after strip-mining. Others are urban areas and resulted from cuts and fills made to shape or level the soils for development. Some were modified for use as irrigated cropland. Arents retain some fragments that can be identified as parts of a former spodic or argillic horizon, a duripan, or other feature, but the fragments do not themselves form diagnostic horizons, are not arranged in any discernible order, and are mixed with the materials of other horizons. Some of the soils are the result of deliberate soil modification intended to break up or remove a duripan or another root-restrictive layer. Arents are used mostly as cropland, urban land, or pasture. Some are used as wildlife habitat.

Fluvents are the more or less freely drained Entisols that formed in recent water-deposited sediments on flood plains, fans, and deltas along rivers and small streams throughout the country. They are of moderate extent in the United States. They make up about 2.0 percent of the surface area. Some of the largest areas are on the flood plains along the Mississippi River. The age of the sediments is commonly a few years or decades to a few hundred years in humid areas. It may be somewhat more in arid areas. Most Fluvents are frequently flooded, unless they are protected by dams or levees. Stratification of the materials is normal. These soils can have any kind of vegetation and any temperature regime, but they cannot have permafrost within 100 cm of the soil surface. They can have any moisture regime but cannot meet the criteria for Aquents. Most Fluvents are used as rangeland, forest, pasture, or wildlife habitat. Some are used as cropland.

Orthents are extensive in the United States. They make up about 6.0 percent of the surface area. They are mainly in the Western States. They are commonly on recent erosional surfaces. The erosion may be geologic or may have been induced by cultivation, mining, or other factors, but any soil that existed has been completely removed or so truncated that the diagnostic horizons are very thin or do not occur. Some of the soils, mostly those in the Rocky Mountain States, are less than 25 cm deep to a lithic or paralithic contact. Some of the soils, mostly those in the Western States, are deep, have an aridic moisture regime, and are characterized by little horizon development. A few Orthents are forming in recent volcanic deposits, loamy or fine textured eolian deposits, solifluction or glacial deposits, landslide debris, or mudflows. Orthents can have any kind of vegetation and any temperature regime, but they cannot have permafrost within 100 cm of the soil surface. They cannot have aquic conditions, a high water table, and the colors defined for Aquents. Orthents are used mostly as rangeland, pasture, or wildlife habitat.

Psamments are moderately extensive in the United States. They make up about 2.7 percent of the surface area. They occur throughout the country. Some of the largest areas are in Nebraska, California, Minnesota, Wisconsin, Michigan, Arizona, and Florida. These soils are sandy in all layers within the particle-size control section. Because Psamments store less water than other deep soils, they have lower yields than most other soils in humid climates. Because they lose little precipitation to runoff and store the moisture deeply, they are among the most productive rangeland soils in some arid and semiarid climates. Some Psamments are forming in poorly graded (well sorted) sands on shifting or stabilized sand dunes, in cover sands, or in sandy parent materials that were sorted in an earlier geologic cycle. Some are forming in sands that were sorted by water and are on outwash plains, lake plains, natural levees, or beaches. Psamments occur under any climate, but they cannot have permafrost within 100 cm of the soil surface. They can have any vegetation and are on surfaces of virtually any age from recent historic to Pliocene or older. The Psamments on old stable surfaces commonly consist of quartz sand, which cannot form diagnostic horizons that involve the accumulation of clays or sesquioxides. Ground water is typically deeper than 50 cm and commonly is much deeper. Some Psamments that are nearly bare are subject to soil blowing and drifting and provide poor support for wheeled vehicles. Because very gravelly sands do not have these two qualities, they are excluded from Psamments and are grouped with Orthents. Psamments are used mostly as rangeland, pasture, or wildlife habitat.

Gelisols

Gelisols are moderately extensive in the United States. They make up about 8.7 percent of the surface area. They are known to occur only in Alaska. Most of the soils have a layer of gelic materials that is underlain by permafrost within 100 cm of the soil surface. Diagnostic horizons may or may not be present. Permafrost influences pedogenesis through its effect on the downward movement of the soil solution and on the soil-forming processes. Cryoturbation (frost mixing) is an important process in many Gelisols and results in irregular or broken horizons, involutions, organic matter accumulation on the permafrost table, oriented rock fragments, and silt caps on rock fragments. Cryoturbation occurs when two freezing fronts, one from the surface and the other from the permafrost, merge during freeze-back in autumn. Ice segregation is an important property of gelic materials and occurs when the soil solution migrates toward ice, increasing the volume of ice. Volume changes also occur as the water freezes. In the drier areas cryoturbation is less pronounced or does not occur, but the soils still have gelic materials, as manifested by structure that results from segregated ice. The importance of any diagnostic horizons is overshadowed by the properties of the gelic materials and the associated permafrost.

Gelisols are divided into three suborders based on the kind of soil materials (organic or mineral) and expression of cryoturbation in the mineral soil materials. The delineation Gelisols/Inceptisols is a mosaic of Gelisols with a subgelic temperature class and Cryepts.

Histels are the Gelisols with large amounts of organic carbon that commonly accumulate under anaerobic conditions, or the organic matter at least partially fills voids in fragmental, cindery, or pumiceous materials. Cold temperatures contribute to the accumulation of organic matter. These soils are of small extent in the United States. They make up about 0.96 percent of the surface area. They are in Alaska. The vegetation is mostly mosses, sedges, and shrubs. The soils are used as wildlife habitat.

Orthels are the Gelisols that show little or no evidence of cryoturbation. These soils are of moderate extent in the United States. They make up about 1.4 percent of the surface area. They occur throughout the Gelisol area in Alaska. Orthels are generally drier than Turbels and Histels. The vegetation is mostly lichens, mosses, sedges, shrubs, black spruce, and white spruce. The soils are used mostly as wildlife habitat. A small amount of the acreage is used as cropland or for urban development.

Turbels are the Gelisols that have one or more horizons showing cryoturbation in the form of irregular, broken, or distorted horizon boundaries, involutions, an accumulation of organic matter on top of the permafrost, ice or sand wedges, or oriented rock fragments. These soils are of large extent in the United States. They make up about 6.4 percent of the surface area. They occur throughout the Gelisol area in Alaska. The vegetation is mostly mosses, sedges, shrubs, and black spruce. The soils are used mostly as wildlife habitat. A small amount of the acreage is used as cropland or for urban development.

The Gelisols in the Gelisols/Inceptisols delineation include Turbels, Orthels, and Histels in a mosaic with Cryepts. The Gelisols generally have a subgelic temperature class. The Cryepts occur on slopes that receive more solar radiation or in areas where fire or land clearing has changed the thermal properties of the soils enough to allow the permafrost to thaw to a depth of 2 meters or more.

Histosols

Histosols are of small extent in the United States. They make up about 1.6 percent of the surface area. They are forming in organic soil materials that do not have permafrost within 100 cm of the soil surface. The general rule is that a soil is classified as a Histosol if half or more of the upper 80 cm is organic. A soil also is classified as a Histosol without regard to the thickness of organic materials if the organic materials rest on rock or fill or partially fill voids in fragmental, cindery, or pumiceous materials. If the bulk density is very low (less than 0.1 gram per cubic centimeter), three-fourths or more of the upper 80 cm must be organic.

Histosols are divided into four suborders based on soil wetness and the degree of decomposition of the organic materials.

Fibrists are the wet, slightly decomposed Histosols. They are of small extent in the United States. They make up about 0.24 percent of the surface area. The largest extent is in southern Alaska. More than two-thirds of these soils consists of fiber that is not destroyed by rubbing between the thumb and fingers. The botanic origin of much of the materials can be readily determined. The bulk density generally is less than 0.1 gram per cubic centimeter. These soils commonly are in closed depressions or on broad flats, such as coastal plains. Many have ground water near the soil surface nearly all the time. The level of the ground water fluctuates, but it seldom drops much below the bottom of the surface tier. Most of the soils support natural vegetation of widely spaced, small trees, shrubs, forbs, and grasses and grasslike plants.

Folists are the more or less freely drained Histosols that consist primarily of O horizons derived from leaf litter, twigs, and branches resting on bedrock or on fragmental materials in which the interstices are partly or completely filled with organic materials. These soils are of very small extent in the United States. They make up about 0.09 percent of the surface area. The largest extent is in Hawaii and Alaska. Some Folists developed in the mountains and the most humid parts of the conterminous United States. Most of these soils support forest vegetation. Some of the soils in Hawaii mainly support grass. A few of the soils in Hawaii are used for specialty crops or for urban or recreational development.

Hemists are the wet Histosols in which the organic materials are moderately decomposed. These soils are of small extent in the United States. They make up about 0.3 percent of the surface area. The largest extent is in Minnesota and Alaska. The soils are mainly in closed depressions and on broad flats, such as coastal plains and outwash plains. The botanic origin of much of the organic material cannot be readily determined. The fiber content of the organic material is mostly between one-sixth and two-thirds after rubbing between the thumb and fingers. The bulk density commonly is between 0.1 and 0.2 gram per cubic centimeter. Ground water is at or very close to the surface much of the time unless artificial drainage has been provided. The level of ground water may fluctuate but seldom drops much below the bottom of the surface tier. Most Hemists support natural vegetation and are used as woodland, rangeland, or wildlife habitat. Some have been cleared and drained and are used as cropland.

Saprists are the wet Histosols in which the organic materials are well decomposed. These soils are of moderate extent in the United States. They make up about 1.0 percent of the surface area. The largest extent is in Michigan, Florida, Wisconsin, Minnesota, and Alaska. Small areas are common on the Atlantic and gulf coasts. The soils are mainly in closed depressions and on broad flats, such as coastal plains and outwash plains. The botanic origin of the organic material is difficult to determine in most of these soils. The fiber content of the organic material is mostly less than one-sixth after rubbing between the thumb and fingers. Most of the soils have a bulk density of more than 0.2 gram per cubic centimeter. The water table tends to fluctuate within the soils, or the soils were aerobic during drier periods in the past. Many Saprists support natural vegetation and are used as woodland, rangeland, or wildlife habitat. Some of the soils, mostly those with a mesic or warmer temperature regime, have been cleared and drained and are used as cropland.

Inceptisols

Inceptisols are soils of cool to very warm, humid and subhumid regions. They are moderately extensive and widely distributed in the United States. They make up about 9.7 percent of the surface area. The largest area is one that includes the southern New England States and the Appalachian Mountains. Other areas are on the southern Great Plains; in the Rocky Mountains; in eastern Montana; in the coastal and Cascade Mountains of California, Oregon, and Washington; and in northeastern Minnesota.

Inceptisols have many kinds of diagnostic horizons and epipedons. They cannot have an argillic, kandic, or natric horizon unless it is buried. Spodic and oxic horizons also are excluded unless the top of the horizon is deep. Inceptisols can have an anthropic, histic, mollic, ochric, plaggen, or umbric epipedon. The most common diagnostic horizons in the Inceptisols in the United States are an ochric epipedon and a cambic horizon. An umbric epipedon and a fragipan also are common. Most Inceptisols do not have sandy texture throughout. They are largely forming on late- or post-Pleistocene surfaces if evapotranspiration normally exceeds precipitation at some time of the year. If precipitation exceeds potential evapotranspiration in most months, Inceptisols occur in areas of old as well as young surfaces or deposits. If the soil temperature regime is frigid or cryic in these humid regions, Inceptisols form mainly in the more clayey parent materials and Spodosols form in the materials that have little clay. Inceptisols range from very poorly drained to excessively drained. A cambic horizon is not required if there is an umbric, histic, or plaggen epipedon or if there is a fragipan or duripan or a placic, calcic, petrocalcic, gypsic, petrogypsic, salic, or sulfuric horizon.

Inceptisols may have any moisture regime except aridic and any temperature regime, but they cannot have permafrost at a depth of less than 100 cm below the soil surface.

Inceptisols are divided into four suborders based on soil moisture and temperature regimes, soil wetness, and the kind of epipedon.

Anthrepts are the more or less freely drained Inceptisols that have either an anthropic or plaggen epipedon. They can have almost any temperature regime and almost any vegetation. These soils are not known to occur in the United States.

Aquepts are the wet Inceptisols. They are of moderate extent and are widely distributed in the United States. They make up about 1.4 percent of the surface area. Their natural drainage is poor or very poor, and, if the soils have not been artificially drained, ground water is at or near the soil surface at some time during normal years but typically not in all seasons. The soils generally have a gray to black surface horizon and a gray subsurface horizon that has redox concentrations and begins at a depth of less than 50 cm. Most Aquepts formed in late-Pleistocene or younger deposits in depressions, on nearly level plains, or on flood plains. They can have almost any particle-size class except fragmental and any temperature regime, but they cannot have permafrost. Many formed under forest vegetation, but they can have almost any kind of vegetation. Most of the soils have a cambic horizon, and some have a fragipan. Aquepts are used mostly as cropland, pasture, forest, or wildlife habitat.

Cryepts are the cold Inceptisols of high mountains or high latitudes. They cannot have permafrost. They are of moderate extent in the United States. They make up about 2.1 percent of the surface area. They are mostly in the high mountains of the West as well as southern Alaska. The vegetation is mostly conifers or mixed conifers and hardwoods. These soils formed mostly in loess, drift, or alluvium or in solifluction deposits of late-Pleistocene or Holocene age. They commonly have a thin ochric epipedon and a brownish cambic horizon. Some have bedrock within 100 cm of the surface. Most are used as forest or wildlife habitat. Some of the soils, mostly those in Alaska, are used as cropland.

Udepts are mainly the more or less freely drained Inceptisols that have a udic or perudic moisture regime. They are of large extent in the United States. They make up about 3.8 percent of the surface area. They are most extensive in the Appalachian Mountains, on the Allegheny Plateau, in northeastern Minnesota, and in Oregon. They formed on nearly level to steep surfaces, mostly of late-Pleistocene or Holocene age. Where the soil moisture regime is perudic, some of the soils formed in older deposits. Most of the soils currently support or formerly supported forest vegetation, but some support shrub or grass vegetation. The vegetation was mostly coniferous forest in the Northwest and mixed or hardwood forest in the Eastern States. A few Udepts have been formed from Mollisols through truncation of the mollic epipedon, mostly under cultivation. Most Udepts have an ochric or umbric epipedon and a cambic horizon. Some also have a fragipan, a duripan, or a sulfuric horizon. Most are used as forest or have been cleared and are used as cropland or pasture.

Ustepts are the more or less freely drained Inceptisols that have an ustic moisture regime. They are of moderate extent in the United States. They make up about 1.6 percent of the surface area. They are most common on the Great Plains, mostly in Montana, Texas, and Oklahoma. They receive dominantly summer precipitation. They formed mostly in Pleistocene or Holocene deposits or on steep slopes. Many of these soils are calcareous at a shallow depth and have a Bk or calcic horizon. A few have formed from Mollisols through truncation of the mollic epipedon, mostly under cultivation. Most of the soils have an ochric or umbric epipedon and a cambic horizon. Some have a duripan. The native vegetation commonly was grass, but some of the soils supported trees. Most Ustepts are used as cropland or pasture. Some are used as rangeland, forest, or wildlife habitat.

Xerepts are mainly the more or less freely drained Inceptisols that have a xeric moisture regime. They are of small extent in the United States. They make up about 0.85 percent of the surface area. They are in the western part of the United States, mostly in California, Oregon, and Washington. They receive dominantly winter precipitation and have a frigid, mesic, or thermic temperature regime. Most Xerepts formed in Pleistocene or Holocene deposits or on steep slopes. Many are calcareous at a shallow depth and have a Bk or calcic horizon. Most have an ochric or umbric epipedon and a cambic horizon. Some have a duripan, and a few have a fragipan. The native vegetation commonly was coniferous forest on the soils with a frigid or mesic temperature regime and shrubs, grasses, and widely spaced trees on the soils with a thermic temperature regime. Most Xerepts are used as forest, cropland, or pasture. Some are used as rangeland or wildlife habitat.

Mollisols

Mollisols are very extensive in the United States. They make up about 21.5 percent of the surface area. Most are on the Great Plains and in the Western States. Nearly all Mollisols have a mollic epipedon. Many also have an argillic or natric horizon or a calcic horizon. A few have an albic horizon. Some also have a duripan or a petrocalcic horizon. Most have supported grass vegetation at some time, although many apparently have been forested at times. Some of the soils, mostly those in the mountains, formed in base-rich materials under forest vegetation. Mollisols may have any of the defined temperature regimes but do not have permafrost. They can have any moisture regime, but enough available moisture to support perennial grasses seems to be essential. Where the temperature is frigid or warmer and slopes are not too steep, Mollisols are used mainly as cropland. Generally, grains and sorghum are grown in the drier regions and maize (corn) and soybeans in the warmer, humid regions.

Mollisols are divided into seven suborders based on soil moisture, soil temperature, and diagnostic horizons.

Albolls are the Mollisols that have both an albic horizon and fluctuating ground water. They are of small extent in the United States. They make up about 0.2 percent of the surface area. They are mostly on the Great Plains, in eastern Washington, and in Oregon and Idaho. Most are saturated with water at or near the soil surface at some time during winter or spring in normal years. In summer ground water is commonly deeper than 200 cm. Below the albic horizon, there is either an argillic horizon or, less commonly, a natric horizon. Albolls developed mostly on broad, nearly level to sloping ridges and back slopes or in closed depressions. Most have a perched water table. Most formed in late-Pleistocene deposits. Most supported grass or grass and shrub vegetation. In early stages of development, some are thought to have supported forest vegetation that was later succeeded by grass. Most of the soils have gentle slopes and are used as cropland.

Aquolls are the wet Mollisols that do not have an albic horizon and that have dominantly low-chroma and high-contrast redox depletions or concentrations in or below the epipedon. These soils are of moderate extent in the United States. They make up about 2.6 percent of the surface area. They occur in all areas where there are Mollisols, but they are most extensive in glaciated areas of the Midwestern States, mainly Iowa, Minnesota, North Dakota, and Indiana. They also occur in Florida. Commonly, they are in low areas where water collects and stands, but some are on broad flats or on seepy hillsides. Most have supported a vegetation of grasses, sedges, and forbs, but some supported forest vegetation. Aquolls can have any temperature regime, but they cannot have permafrost. Most have a mesic or frigid temperature regime, have been artificially drained, and are used as cropland.

Cryolls are the cool or cold, more or less freely drained Mollisols. They are of moderate extent in the United States. They make up about 1.5 percent of the surface area. Most are in the high mountains of the Western States. Some are in Alaska. Cryolls have a cryic temperature regime and a udic or xeric moisture regime. They support forest, grass, or grass and shrub vegetation. In Alaska forests of spruce, birch, and aspen trees are common. Cryolls are used mostly as rangeland. Some are used as forest and some as pasture.

Rendolls are the Mollisols that are of humid regions and formed in highly calcareous parent materials, such as limestone, chalk, and drift composed mainly of limestone, or on shell bars. These soils are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are in Florida, on tropical islands, and in a few areas in the mountains of the Western States. They formed mostly under forest vegetation or under grass and shrubs. They have a mollic epipedon that rests on the calcareous parent materials or on a cambic horizon that is rich in carbonates. A few of the soils are so rich in finely divided lime that the mollic epipedon has a color lighter than normal but is nevertheless rich in dark-colored humus and is within the limits of a mollic epipedon. Rendolls have a cryic soil temperature regime or a udic moisture regime, or both. Most are used as cropland or pasture, but some are used as rangeland or forest.

Udolls are the more or less freely drained Mollisols of humid climates. They are of large extent in the United States. They make up about 3.9 percent of the surface area. They are in the eastern part of the Great Plains and east of the Great Plains. They are most extensive in Minnesota, Illinois, Iowa, and North Dakota. In addition to the mollic epipedon, most of the soils have a cambic, calcic, natric, or argillic horizon. The soils formed mainly in late-Pleistocene or Holocene deposits or on surfaces of comparable age. The vegetation at the time of settlement was dominantly tall grass prairie. The temperature regime is frigid or warmer, and the moisture regime is udic. Where slopes are not too steep, nearly all of these soils are used as cropland. Some are used as pasture or rangeland.

Ustolls are the more or less freely drained Mollisols of subhumid to semiarid climates. They are of large extent in the United States. They make up about 9.7 percent of the surface area. They are mostly on the western Great Plains. They also are common throughout the Rocky Mountain States. In addition to the mollic epipedon, most Ustolls have a Bk horizon that has identifiable secondary carbonates or have a calcic horizon, but a few that formed in noncalcareous materials do not have secondary lime. Ustolls may also have a cambic, argillic, kandic, or natric horizon. Most of the Ustolls on the Great Plains supported grass vegetation when the country was settled. Some Ustolls, mostly those in the mountains of the Western States, supported forest vegetation. On the Great Plains, the most moist Ustolls supported mostly tall grasses, the drier ones supported mostly short grasses, and the others supported mixtures of short and tall grasses. Ustolls have a frigid or warmer temperature regime. They generally have an ustic moisture regime, but a few that are marginal to Aridisols have an aridic moisture regime. Rainfall comes mainly during a growing season, often in heavy showers, but is erratic. Drought is frequent and may be severe. Without irrigation, the low supply of moisture usually limits crop yields. During a drought, soil blowing can be a problem. Most of these soils are used as cropland or rangeland.

Xerolls are the more or less freely drained Mollisols of regions that have Mediterranean climates. These soils are of large extent in the United States. They make up about 3.7 percent of the surface area. They are in the Pacific Northwest, California, Idaho, Nevada, and western Utah. They generally have a xeric moisture regime, but some that are marginal to Aridisols have an aridic moisture regime. Xerolls are dry for extended periods in summer, but moisture moves through most of the soils in winter and is stored above the deep layers or above bedrock in normal years. Characteristically, Xerolls have a relatively thick mollic epipedon and a cambic or argillic horizon. Any accumulation of carbonates is in the lower part of the B horizon. These soils are neutral in most horizons. The vegetation at the time of settlement was dominantly bunchgrass and shrubs or trees in the areas that have a mesic or frigid temperature regime, a savanna of perennial grasses and oak and Douglas-fir in the Willamette Valley of Oregon, and a savanna of annual grasses and oak species on the Xerolls in California that have a thermic temperature regime. Many irrigated crops are grown on the Xerolls in the United States, especially where the temperature regime is thermic or mesic. Most of the soils that have gentle or moderate slopes are used as cropland. The very steep soils are used mainly as rangeland, but some are used as forest.

Oxisols

Oxisols are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are only on tropical and subtropical islands. They are most common on the gentle slopes of geologically old surfaces on the tropical and subtropical islands. Their profiles are distinctive because of a lack of obvious horizons. Both the structure and “feel” of Oxisols are deceptive. Upon first examination, they appear structureless and have the feel of a loamy texture. While some are loamy or even coarser textured, many are in a fine or very-fine particle-size class, but the clay is aggregated in a strong grade of fine and very fine granular structure. Oxisols have a very low cation-exchange capacity and have very few weatherable minerals. Most are infertile. The natural vegetation ranges from tropical rain forests to desert savannas.

Oxisols are divided into five suborders based on the moisture regime and soil wetness.

Aquox are the wet Oxisols. They are rare in the United States and are known to occur only in Puerto Rico. They are in shallow depressions and in seepage areas at the base of slopes. Most areas of these soils are small.

Perox are the well drained Oxisols with a perudic soil moisture regime. They are rare in the United States and are known to occur only in Hawaii. Curing many seed crops and storage of produce are difficult on these soils.

Torrox are the Oxisols of arid regions. They have an aridic moisture regime. Many have a higher base saturation than that in other Oxisols. Torrox are very rare in the United States.

Udox are well drained Oxisols with a udic soil moisture regime. They are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are known to occur only in Hawaii, Puerto Rico, and Guam. They have a year-round growing season. They are moist because of rainfall in normal years and are dry in some parts for less than 90 days. The dry period is short enough for rain-fed crops to be grown continuously in normal years.

Ustox are the Oxisols that have an ustic moisture regime. They are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are known to occur only in Hawaii, Puerto Rico, and Guam. Because of natural rainfall, they are moist for at least 90 but not more than 270 days in normal years, a period that is usually long enough for one rain-fed crop. Crops are not grown continuously on these soils because there is inadequate moisture for at least 90 days in normal years.

Spodosols

Spodosols are of small extent in the United States. They make up about 3.5 percent of the surface area. They have a spodic horizon or spodic materials, both of which consist of accumulated amorphous mixtures of organic matter and aluminum, with or without iron. The moisture regime generally is udic, but some of the soils have aquic conditions. Spodosols may have any soil temperature regime, but they cannot have permafrost. In undisturbed soils there is commonly an overlying eluvial horizon, generally with a gray or light gray color similar to that of uncoated quartz. The spodic horizon may be destroyed by cultivation. Yet, spodic materials may still be present. Below the spodic horizon, there may be a fragipan or another sequum that has an argillic horizon. In some Spodosols spodic materials are cemented by sesquioxides and organic matter (ortstein) that are thicker than a placic horizon. Most Spodosols are forming in late-Pleistocene or Holocene deposits. Most have few clay-sized phyllosilicates and have a sandy, sandy-skeletal, coarse-loamy, loamy-skeletal, or coarse-silty particle-size class.

Spodosols are most extensive in areas of cool, humid or perhumid climates in the Northeastern States, southern Alaska, the Great Lakes States, and the high mountains of the Northwestern States. These soils also formed in warm, humid subtropical and tropical regions, mainly Florida and the southern Atlantic coast, where they occur mostly in areas of quartz-rich sands that have a fluctuating level of ground water. In many of the latter soils, the silt and sand fractions contain very little iron and very few weatherable minerals and the albic horizons tend to be thick. The chemical and physical properties of many Spodosols and Andisols are very similar. The definition of spodic materials, however, is based on the concept of organic matter and aluminum, with or without iron, accumulating through illuviation. Spodosols are naturally infertile soils, but they can be highly responsive to good management. Under cultivation, particularly if lime and nitrogen are applied, the spodic horizon may be destroyed.

Spodosols are divided into four suborders based on soil wetness, soil temperature regime, or content of organic matter in the spodic horizon.

Aquods are the wet Spodosols. They are characterized by a shallow fluctuating water table. They are of small extent in the United States. They make up about 0.6 percent of the surface area. They dominate the Spodosol delineations in Florida and along the Atlantic coast. They are a component of many of the delineations in the Northeastern and Great Lakes States. Aquods formed mainly in materials of Pleistocene age. They can have any temperature regime, but they cannot have permafrost. In the warmer areas most of the soils have a nearly white albic horizon thick enough to persist under cultivation or, in the wettest Aquods, a black surface horizon resting on a dark reddish brown spodic horizon that is virtually free of iron. Some Aquods have ortstein that is cemented by an amorphous mixture of sesquioxides and organic matter. The vegetation is water-loving plants, ranging from moss, shrubs, and trees in cold areas to mixed forests and palms in the warmest areas. Most Aquods are used as forest or wildlife habitat. Some, mostly in Florida and New Jersey, have been cleared and are used as cropland or pasture. Aquods are naturally infertile, but they can be highly responsive to good management. The spodic horizon can be destroyed under cultivation, particularly if lime and nitrogen are applied.

Cryods are the cold Spodosols of high latitudes and/or high elevations. They are of small extent in the United States. They make up about 0.9 percent of the surface area. They are mostly in southern Alaska and in the mountains of Washington and Oregon. Some are in the high mountains of New York and northern New England. Most Cryods formed in glacial drift and some in residuum or colluvium. Those in Alaska, Washington, and Oregon commonly formed at least partially in volcanic ash. Cryods commonly have an O horizon over a very thin or intermittent albic horizon, which overlies a well developed spodic horizon. Some have ortstein or another cemented soil layer within 100 cm of the mineral soil surface. In many Cryods the content of organic carbon in the upper part of the spodic horizon is relatively high. The vegetation is mostly coniferous forest. Most Cryods are used as forest or wildlife habitat.

Humods are the relatively freely drained Spodosols that have a large accumulation of organic carbon in the spodic horizon. They are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They are mostly in Washington State, but a few are known to occur on tropical islands and in the Northeastern and Southeastern States. Humods formed dominantly in Pleistocene or Holocene sediments. The undisturbed soils may have either a thin, intermittent or a distinct, continuous albic horizon over a spodic horizon. The upper part of the spodic horizon commonly is nearly black and has a reddish hue. The hue normally becomes less red with increasing depth. Most Humods formed under coniferous forest vegetation. These soils are used mainly as forest.

Orthods are the relatively freely drained Spodosols that have a moderate accumulation of organic carbon in the spodic horizon. They are of moderate extent in the United States. They make up about 1.9 percent of the surface area. They occur in all of the Spodosol delineations, except for those in Alaska. They are most extensive in the Northeastern United States and the Great Lakes States. Most Orthods formed in coarse textured, acid Pleistocene or Holocene deposits under coniferous forest vegetation. If undisturbed, Orthods normally have thin O and albic horizons over a spodic horizon. A few have a fragipan below the spodic horizon. Under cultivation, the albic horizon is very commonly mixed with part of the spodic horizon. The Orthods in the United States generally have a udic moisture regime, but a few have a xeric moisture regime. The soil temperature regime ranges from frigid to hyperthermic. Most Orthods are used as forest or have been cleared and are used as cropland or pasture. Orthods are naturally infertile, but they can be highly responsive to good management. The spodic horizon can be destroyed under cultivation, particularly if lime and nitrogen are applied.

Ultisols

Ultisols are moderately extensive in the United States. They make up about 9.2 percent of the surface area. Typically, they have an ochric epipedon and an argillic or kandic horizon that has few bases and commonly is calcium deficient. The base saturation in most Ultisols decreases with increasing depth, probably because the vegetation has added recycled bases at the surface. Ultisols can have any soil moisture regime except aridic and any soil temperature regime, but they cannot have permafrost. Most of the Ultisols in the United States have a udic moisture regime and a mesic or thermic temperature regime. Ultisols are extensive in the warm, humid parts of the country. They formed in a wide variety of parent materials, mainly on Pleistocene or older surfaces. Most of these soils supported mixed coniferous and hardwood forest vegetation at the time of settlement. Some are now used as cropland or pasture.

Ultisols are divided into five suborders based on the soil moisture regime, soil wetness, and content of organic carbon in the upper part of the profile.

Aquults are the Ultisols in wet areas where ground water is very close to the surface during part of each year, usually in winter and spring, and is deep at other times. These soils are of small extent in the United States. They make up about 0.8 percent of the surface area. They are on the coastal plains, particularly along the Atlantic Ocean and the Gulf of Mexico. The soils are mostly grayish or olive in the subsoil and formed mainly in alluvium and marine deposits that are of Pleistocene age or older. They have an ochric or umbric epipedon and an argillic or kandic horizon. Some have a fragipan. Slopes are gentle. Most of the soils formerly supported forest vegetation. Many still support forest vegetation.

Humults are the more or less freely drained, humus-rich Ultisols. They are of small extent in the United States. They make up about 0.2 percent of the surface area. They dominate most of the Ultisol delineations in Oregon and Washington and also occur in California and Puerto Rico. They commonly receive high rainfall but also have a moisture deficit during some season. Most of the Humults in the United States formed in material weathered from basic country rock on late-Pleistocene or older surfaces. Slopes are commonly steep. If the soils are cultivated, the argillic or kandic horizon may be near the surface. Humults generally have a dark colored epipedon. The vegetation was mostly coniferous forest in the Northwest and rain forest in the tropics. Most of these soils are used as forest or have been cleared and are used as cropland or pasture.

Udults are the more or less freely drained, relatively humus-poor Ultisols that have a udic moisture regime. They are of large extent in the United States. They make up about 8.1 percent of the surface area. They dominate most of the Ultisol delineations in the southern and eastern parts of the country. Most of these soils receive well distributed rainfall. Most have light colored upper horizons, commonly including a grayish horizon that rests on a yellowish brown to reddish argillic or kandic horizon. A few of the Udults that formed in material weathered from basic rocks have a dark brown or reddish brown surface horizon that rests on a dark red or dusky red argillic or kandic horizon. Some Udults have a fragipan or plinthite, or both, in or below the argillic or kandic horizon. Udults developed in sediments and on surfaces that range from late Pleistocene to Pliocene or possibly older. Most of these soils currently support or formerly supported mixed forest vegetation. Many have been cleared and are used as cropland, mostly with the use of soil amendments.

Ustults are the more or less freely drained Ultisols that have an ustic soil moisture regime and have a relatively low content of organic carbon. They are of very small extent in the United States. They make up less than 0.1 percent of the surface area. They occur in the extreme western part of the Ultisol delineation in Texas. Some are in California and on tropical islands. Ustults formed in regions where rainfall is moderately low to high but where evapotranspiration exceeds precipitation. Some Ustults, mostly those in California, have a single dry season each year, and others have alternating moist and dry periods throughout the growing season. Most Ustults have a thermic or warmer temperature regime. The vegetation is commonly forest or savanna. Some of the soils have been cleared and are used as cropland or pasture.

Xerults are the more or less freely drained Ultisols of

Mediterranean climates. They are of moderate extent in the United States. They make up about 0.1 percent of the surface area. They dominate some Ultisol delineations in California and Oregon. They have a xeric moisture regime and a moderate amount of organic matter. Most Xerults have an ochric or umbric epipedon and a brownish to reddish argillic horizon. They are generally on gentle to very steep mountain slopes. The vegetation formerly was and currently is mostly coniferous forest. Most of these soils are used as forest, but some have been cleared and are used as cropland or pasture.

Vertisols

Vertisols are of small extent in the United States. They make up about 2.0 percent of the surface area. They are clayey soils that have deep, wide cracks for some time during the year and have slickensides within 100 cm of the mineral soil surface. They shrink as they dry and swell as they become moist. They are a relatively homogeneous order because of the kinds and amounts of clay common to them, but their microvariability within a pedon is great. Vertisols can have any soil temperature regime but cannot have permafrost, and they can have any moisture regime. Although the process of shrinking and swelling is important in Vertisols, it does not preclude the formation of diagnostic horizons and features. For example, Vertisols commonly have a mollic epipedon and a cambic horizon and can have a calcic, gypsic, or salic horizon. They generally have gentle slopes, although a few are strongly sloping. The natural vegetation is predominantly grass, savanna, open forest, or desert shrub. Most Vertisols are well suited to mechanized frming if there is plenty of rainfall or irrigation water. Vertisols are well known among engineers because their unique properties limit engineering uses.

Vertisols are divided into six suborders based on soil wetness, soil temperature, and soil moisture. These properties tend to limit the suborders to specific regions of the country.

Aquerts are of small extent in the United States. They make up about 0.6 percent of the surface area. They are the wet Vertisols. They have aquic conditions at or near the soil surface for extended periods during the year but also are dry enough in normal years for cracks to open during some periods. These soils are mostly in Texas, the lower Mississippi River Valley, and the valley of the Red River of the North. They typically are nearly level and are in low areas, such as glacial lake plains, flood plains, stream terraces, and coastal lowlands. The natural vegetation is predominantly forest, grass, or savanna. These soils are used mostly as rangeland, cropland, or forest. Drainage of cropland presents special problems since the saturated hydraulic conductivity of these soils is very low. Because the permeability of these soils is so slow, a surface drainage system commonly is installed in areas used as cropland or pasture. Rice is grown on some Aquerts that have a thermic or warmer temperature regime.

Cryerts are not known to occur in the United States. They are the Vertisols that have a cryic temperature regime. They are cold, but they periodically shrink and swell, forming the diagnostic characteristics of Vertisols. Cracks commonly open once a year, late in summer.

Torrerts are of small extent in the United States. They make up about 0.1 percent of the surface area. They are in areas too small to be shown on the map. They are the Vertisols of arid climates. They are in western Texas and in Arizona and New Mexico. The cracks in these soils commonly stay open for most of the year but close for at least part of the winter in normal years. Many of the soils are in closed depressions that may be ponded from time to time. Some areas of Torrerts are more continuous and are commonly underlain by basalt or other parent materials that tend to weather to smectitic clays. Torrerts commonly have an ochric epipedon and a cambic, salic, gypsic, or calcic horizon. The native vegetation is mostly grasses and forbs. These soils are used mainly as rangeland. The use of Torrerts as irrigated cropland presents special problems since the saturated hydraulic conductivity is very low. Bypass flow through open cracks is common. Because the permeability of these soils is so slow, irrigation may result in water-logging and a buildup of salinity unless an adequate artificial drainage system can be installed.

Uderts are of small extent in the United States. They make up about 0.3 percent of the surface area. They are the Vertisols of humid areas. They have cracks that open and close, depending on the amount of precipitation. In some years the cracks may not open completely. These soils are mostly in Texas, in the lower Mississippi River Valley, in the valley of the Red River of the North, and in Alabama and Mississippi. They typically are nearly level or gently sloping and are mostly on coastal plains, flood plains, stream terraces, and glacial lake plains. Most Uderts occur on gentle slopes and are derived from marine shales, marl, and alluvium. At one time many of these soils supported grass and widely spaced trees, although some supported hardwood forest vegetation. Uderts are used mostly as pasture, cropland, or forest. Because the saturated hydraulic conductivity of these soils is very low, a surface drainage system is commonly used to remove excess water from cropland. Rice is grown on some Uderts that have a thermic or warmer temperature regime.

Usterts are of small extent in the United States. They make up about 0.8 percent of the surface area. They are mostly in Texas, South Dakota, and Montana. They receive low amounts of rainfall during the summer, and cracks open and close once or twice during normal years. A few of these soils are on tropical and subtropical islands. Many Usterts formed in nearly level or gently sloping areas of fine textured marine deposits, shale, or alluvium. Some formed in material weathered from basic igneous rocks. The native vegetation is mostly grasses and forbs. Usterts are used mainly as rangeland or cropland. The use of Usterts as irrigated cropland presents special problems since the saturated hydraulic conductivity is very low. Bypass flow through open cracks is common. Because the permeability of these soils is so slow, irrigation may result in water-logging and a buildup of salinity unless an adequate artificial drainage system can be installed.

Xererts are of small extent in the United States. They make up about 0.1 percent of the surface area. They are the Vertisols of Mediterranean climates, which are typified by cool, wet winters and warm, dry summers. Xererts are mostly in California, Oregon, and Idaho. They have cracks that regularly close and open each year. Because these soils become dry every summer and moisten in winter, damage to structures and roads is very significant. Many Xererts are nearly level to sloping. Most formed in material weathered from basic igneous rocks or shale or in alluvium. The native vegetation is mostly grasses and forbs. Xererts are used mainly as rangeland or cropland. Irrigated rice is grown on some Xererts that have a thermic temperature regime. Bypass flow through open cracks is a concern. The use of Xererts as irrigated cropland presents some special problems. Because the permeability of these soils is so slow, irrigation may result in water-logging and a buildup of salinity unless an adequate artificial drainage system can be installed.

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CHAPTER 23

World Distribution of Orders and Suborders

The only comprehensive and international effort to develop an assessment of the soil resources of the world was undertaken in the 1960's by the Food and Agriculture Organization of the United Nations (FAO-UNESCO). After World War II, many Western countries undertook systematic soil surveys and similar activities were initiated in developing countries through bilateral programs. FAO also had ongoing national assessments in some developing countries and to enable these assessments developed a legend for the eventual Soil Map of the World at a scale of 1:5,000,000. The maps of the different regions of the world were published at different periods during the 1970's. No information was available for many countries or regions within these countries. For these reasons, there is a high degree of variability in the quality of information from country to country. Despite this variability, the maps are the only reference base available on a global scale. In 1992, the maps were digitized by FAO. The digital copy was used for the world map in this publication.

Soil Taxonomy has been subject to many changes since its first edition was published in 1975. Though the translation of the FAO legend to the most recent version of *Soil Taxonomy* presents only minor problems, converting the FAO soil map results in important errors. The conversion was done by assigning terms in *Soil Taxonomy* to FAO terms, taking into consideration the soil moisture and temperature regimes (SMR and STR). All polygons with the same FAO class term have an equivalent term in *Soil Taxonomy*. The errors introduced by this process are illustrated by the case of the soils in the western Amazon Basin. On the FAO map, these are shown as Orthic Ferralsols, which are equivalent to Typic Hapludox in *Soil Taxonomy*. A recent soil map of Brazil depicts these soils as Acrisols, or Ultisols in *Soil Taxonomy*. Consequently, though every effort was made to incorporate recent information, in some cases the process of manipulating rastorized digital data made it impossible to make the changes.

The map of the world at the end of this publication shows the distribution of the major soil orders. The table "World Distribution of Orders and Suborders" provides estimates of the area of different orders and suborders on a global basis and also the area of climatic environments, or major eco-regions. Only the suborders that are extensive enough to be shown on the world map are listed. Soil patterns are distinct and show the role of soil moisture and temperature regimes interacting with parent materials. In Europe, the soil moisture regimes show a north-south trend and the consequent effect on soil formation is illustrated by horizontal patterns of the soils. In North America and particularly in the United States, the soil moisture regimes show an east-west trend and the soil patterns reflect this trend. On the eastern seaboard, the soils are Ultisols, and as one proceeds westward, they give way to Mollisols, Alfisols, and Aridisols. Finally, in the Rocky Mountains, the soils are Inceptisols and some Andisols. Farther north in North America, the soils are dominantly Inceptisols and Spodosols, which give way to Histosols and Gelisols in the northern tundra zone.

Gelisols, the most recent soil order introduced into the system of soil taxonomy, occupy about 8.6 percent of the ice-free land surface. Few detailed soil maps depict these soils, as previous classification systems did not differentiate the soils based on permafrost. The lower geographic limit of Gelisols for this map is defined by a mean annual soil temperature of less than 0 ^{o}C and by a mean summer soil temperature of less than 10 ^{o}C. The northern part of the Gelisol zone grades to ice.

Organic soils, or Histosols, occupy about 1.2 percent of the land surface. This percentage does not include the 0.8 percent of Histels, which are present in the Gelisol region and which form the largest contiguous extent of organic soils. The next largest area of organic soils is adjacent to the tundra soils in the boreal belt. These organic soils are the "Cryo" great groups of Fibrists, Hemists, and Saprists. Tropical Histosols are dominantly in Southeast Asia, mainly in Sumatra and Kalimantan. Many of the tropical Histosols are on coastal plains and have very low pH because of the presence of acid sulfate materials. Unlike the temperate and boreal Histosols, which formed in areas of moss and grassy vegetation, tropical Histosols are woody and frequently contain large trunks of undecomposed trees. These woody materials make cultivation of such soils difficult.

Spodosols are dominantly in the colder regions of the world where STR is mesic or colder and SMR is udic or perudic. These boreal Spodosols occupy about 2.7 percent of the land surface. Podsolization results from release of large quantities of organic acids in the organic-rich surface soil horizons. Characteristically, these soils form in sandy materials or in materials with only small amounts of weatherable minerals that have the potential to alter and release bases. In the Tropics, soils with similar morphology are in areas of coastal beach deposits. The largest contiguous extent of such soils is on the coastal plains of the Amazon Basin. The soils are described and classified as Spodosols but frequently are not the result of

World Distribution of Orders and Suborders

Order	Suborder	Area ice-free land		Area tropical		Area temperate		Area boreal		Area tundra	
		10^6 km^2	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*
	Histels	1.01	0.77	0	0	0	0	0	0	1.011	0.77
	Turbels	6.33	4.84	0	0	0	0	0	0	6.316	4.83
	Orthels	3.91	2.99	0	0	0	0	0	0	3.903	2.98
Gelisols		11.26	8.61	0	0	0	0	0	0	11.230	8.59
	Fibrists	0.20	0.15	0	0	0	0	0.194	0.15	0	0
	Saprists	0.34	0.26	0.317	0.24	0.022	0.02	0	0	0	0
	Hemists	0.99	0.76	0	0	0.099	0.08	0.884	0.68	0	0
Histosols		1.53	1.17	0.317	0.24	0.121	0.09	1.078	0.82	0	0
	Aquods	0.17	0.13	0.013	0.01	0.055	0.04	0.099	0.08	0	0
	Cryods	2.46	1.88	0	0	0	0	2.455	1.88	0	0
	Humods	0.06	0.04	0.029	0.02	0.028	0.02	0.000078	0	0	0
	Orthods	0.67	0.51	0.018	0.01	0.508	0.39	0.138	0.11	0	0
Spodosols		3.35	2.56	0.060	0.05	0.592	0.45	2.693	2.06	0	0
	Cryands	0.26	0.2	0	0	0	0	0.254	0.19	0	0
	Torrands	0.001	0	0.001	0	0	0	0	0	0	0
	Xerands	0.032	0.02	0	0	0.032	0.02	0	0	0	0
	Vitrands	0.28	0.21	0.202	0.15	0.077	0.06	0.000605	0	0	0
	Ustands	0.62	0.05	0.058	0.04	0.003	0	0	0	0	0
	Udands	0.28	0.21	0.185	0.14	0.089	0.07	0.001	0	0	0
Andisols		0.91	0.7	0.448	0.34	0.202	0.16	0.256	0.2	0	0
	Aquox	0.32	0.24	0.320	0.24	0	0	0	0	0	0
	Torrox	0.031	0.02	0.027	0.02	0.004	0	0	0	0	0
	Ustox	3.10	2.37	3.086	2.36	0.009	0.01	0	0	0	0
	Perox	1.16	0.89	1.010	0.77	0.151	0.12	0	0	0	0
	Udox	5.20	3.98	5.166	3.95	0.032	0.02	0	0	0	0
Oxisols		9.81	7.5	9.610	7.35	0.197	0.15	0	0	0	0

World Distribution of Orders and Suborders--Continued

Order	Suborder	Area ice-free land		Area tropical		Area temperate		Area boreal		Area tundra	
		10⁶ km²	*%*	*10⁶ km²*	*%*	*10⁶ km²*	*%*	*10⁶ km²*	*%*	*10⁶ km²*	*%*
	Aquerts	0.054	0	0.000763	0	0.004	0	0	0	0	0
	Cryerts	0.014	0.01	0	0	0	0	0.014	0.01	0	0
	Xererts	0.098	0.08	0	0	0.098	0.08	0	0	0	0
	Torrerts	0.889	0.68	0.238	0.18	0.647	0.5	0	0	0	0
	Usterts	1.767	1.35	1.169	0.89	0.594	0.45	0.002	0	0	0
	Uderts	0.384	0.29	0.086	0.07	0.297	0.23	0	0	0	0
Vertisols		3.160	2.42	1.494	1.14	1.642	1.26	0.017	0.01	0	0
	Cryids	0.943	0.72	0	0	0	0	0.940	0.72	0	0
	Salids	0.890	0.68	0.052	0.04	0.632	0.48	0.195	0.15	0.000691	0
	Gypsids	0.682	0.52	0.228	0.17	0.429	0.33	0.024	0.02	0	0
	Argids	5.407	4.13	0.573	0.44	4.035	3.09	0.782	0.6	0	0
	Calcids	4.872	3.73	0.451	0.34	4.400	3.36	0.013	0.01	0	0
	Cambids	2.931	2.24	0.561	0.43	2.063	1.58	0.302	0.23	0	0
Aridisols		15.728	12.02	1.867	1.43	11.560	8.84	2.258	1.73	0.000691	0
	Aquults	1.280	0.98	1.042	0.8	0.235	0.18	0.000058	0	0	0
	Humults	0.343	0.26	0.277	0.21	0.061	0.05	0.004	0	0	0
	Udults	5.539	4.24	2.654	2.03	2.872	2.2	0.009	0.01	0	0
	Ustults	3.869	2.96	3.630	2.78	0.234	0.18	0.001	0	0	0
	Xerults	0.018	0.01	0	0	0.0009	0	0.017	0.01	0	0
Ultisols		11.052	8.45	7.605	5.81	3.405	2.6	0.033	0.03	0	0
	Albolls	0.027	0.02	0	0	0.001	0	0.026	0.02	0	0
	Aquolls	0.118	0.09	0.001	0	0.084	0.06	0.031	0.02	0	0
	Rendolls	0.265	0.2	0.120	0.09	0.103	0.08	0.040	0.03	0	0
	Cryolls	1.163	0.89	0	0	0	0	1.160	0.89	0	0
	Xerolls	0.924	0.71	0	0	0.873	0.67	0.050	0.04	0	0
	Ustolls	5.244	4.01	0.184	0.14	2.370	1.81	2.682	2.05	0	0
	Udolls	1.261	0.96	0.054	0.04	1.058	0.81	0.146	0.11	0	0
Mollisols		9.005	6.89	0.361	0.28	4.491	3.43	4.139	3.16	0	0

World Distribution of Orders and Suborders--Continued

Order	Suborder	Area ice-free land		Area tropical		Area temperate		Area boreal		Area tundra	
		10^6 km^2	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*	*10^6 km^2*	*%*
	Aqualfs	0.836	0.64	0.407	0.31	0.373	0.29	0.054	0.04	0	0
	Cryalfs	2.517	1.92	0	0	0	0	2.509	1.92	0	0
	Ustalfs	5.663	4.33	3.773	2.88	1.719	1.31	0.165	0.13	0	0
	Xeralfs	0.896	0.69	0	0	0.848	0.65	0.046	0.04	0	0
	Udalfs	2.706	2.07	0.616	0.47	1.926	1.47	0.158	0.12	0	0
Alfisols		12.620	9.65	4.797	3.67	4.868	3.72	2.933	2.24	0	0
	Aquepts	3.199	2.45	1.498	1.15	1.183	0.9	0.502	0.38	0	0
	Cryepts	0.456	0.35	0	0	0	0	0.456	0.35	0	0
	Ustepts	4.241	3.24	2.804	2.14	1.372	1.05	0.060	0.05	0	0
	Xerepts	0.685	0.52	0	0	0.674	0.52	0.009	0.01	0	0
	Udepts	4.247	3.25	1.755	1.34	2.153	1.65	0.333	0.26	0	0
Inceptisols		12.829	9.81	6.058	4.63	5.383	4.12	1.362	1.04	0	0
	Aquents	0.116	0.09	0.105	0.08	0.010	0.01	0	0	0	0
	Psamments	4.428	3.39	2.799	2.14	1.625	1.24	0.001	0	0	0
	Fluvents	2.860	2.19	1.017	0.78	1.455	1.11	0.368	0.28	0	0
	Orthents	13.733	10.5	2.095	1.6	11.264	8.61	0.363	0.28	0	0
Entisols		21.137	16.16	6.019	4.6	14.355	10.98	0.732	0.56	0	0
Total		130.796	100	39.193	29.97	51.865	39.65	19.327	14.78	20.188	15.43
	Ocean	364.654									
	Shifting sands	5.321	4.07	0.545	0.42	4.680	3.58	0.092	0.07	0	0
	Rock	13.076	10	0.007	0.01	0.363	0.28	3.727	2.85	8.956	6.85
	Ice	14.640									
Miscellaneous		397.692									

the podsolization process that operates in the temperate or boreal climates. The sandy levee deposits or stranded beach deposits occur in association with Aquepts and Saprists. The dissolved organic colloids seep up the sands (capillary effect) and precipitate at the capillary fringe of the ground water table. The resulting morphology is that of a spodic horizon.

Andisols dominate the circum-Pacific belt, or the Ring of Fire. They are frequently associated with current or former volcanic activity. Depending on the intensity and periodicity of the volcanic activity, deposits of several ages may characterize a soil. In the colder and moister parts of the world, Andisols are characterized by dark mollic-like or umbric-like epipedons. Buried horizons with similar organic-rich horizons may be typical. In the Tropics, organic accumulation is not so rapid. In addition, weathering and mineral alteration lead to the formation of a clay fraction dominated by halloysite and kaolinite. A normal toposequence in the Tropics is Andisols on the upper slopes, in association with Inceptisols, which give way to Ultisols and Oxisols on the gentler topography. In some Andisols in which the content of organic matter is low and short-range-order minerals dominate the colloids, the soils may have a net positive charge. These Andisols are counterparts of the suborder Anionic Acrudox in terms of mineral-chemical composition.

Oxisols are confined to the intertropical regions, which by definition have an *iso* STR. Most of the Oxisols occur between the Tropics of Cancer and Capricorn. The largest extent is in Brazil, followed by the Congo Basin in Central Africa. Characteristically, Oxisols formed in preweathered and transported deposits. Weathering may continue in the postdepositional phase. Other pedogenic processes are slow unless there is a fluctuating water table. On the volcanic islands of the Pacific and in Southeast Asia, basic or ultrabasic rocks may weather to form Oxisols. Although there is always the possibility of admixture with alluvial or colluvial products, these soils are generally thought to have formed directly on the rocks, unlike the Oxisols of the Amazon or Congo Basins.

Vertisols occupy about 2.4 percent of the land surface and are about equally distributed in tropical and temperate areas. They are among the soils in which soil properties are a function of the mineralogical composition of the clay fraction. For the smectites to form and persist in the soils, one of the requirements is that the soil solution have a high pH, which results in high amounts of bases and soluble silica. Thus, most of the Vertisols occur in semiarid or arid environments. The countries with large areas of Vertisols are Sudan, India, Australia, and the United States. In semiarid southern Africa, large contiguous areas of Vertisols are in Zambia, Zimbabwe, and South Africa. In other areas Vertisols occur sporadically in basins adjoining Andisols.

Although about a third of the land mass of the world is arid, Aridisols occupy only about 12 percent of the land surface. By definition, Aridisols must have a diagnostic horizon; the remaining soils in arid regions are Entisols with associated unstabilized dunes and rocky land. About 60 percent of the Aridisols are in the temperate parts of the world. The rest have tropical and boreal climates. Argids are the most extensive Aridisols and are frequently in areas where the aridic SMR borders on the ustic or xeric SMR. Calcids, which occupy about 3.7 percent of the land area, are associated with the Argids. Translocation and subsurface accumulation of carbonates, gypsum, and salts require some moisture. Formation of the horizons diagnostic for these suborders may be a current process or may have taken place in historic or geologic periods. Because of the current aridity of the sites where these soils occur, it is generally assumed that many of the diagnostic features may have a "paleo" origin.

Ultisols and Alfisols occupy 8.5 and 9.7 percent of the land surface, respectively. Ultisols are more common in the intertropical areas, while Alfisols are in the temperate areas. Also, there is greater proportion of Alfisols than of Ultisols in the semiarid parts of the world. The dominant feature of both Ultisols and Alfisols is the presence of an argillic horizon. Other diagnostic horizons or properties define the subclasses. A lighter textured surface soil, which makes tillage easy, and a heavier textured underlying argillic horizon, which enables greater storage of water and nutrients, favor crop production. Many of these soils occur on flat to gently undulating landscapes and have been used by farmers since the beginning of civilization.

Mollisols, which have a thick, organic-rich surface horizon, are among the most productive soils in the world. Some of the world's record yields have been obtained on these soils. Mollisols occupy about 6.9 percent of the land mass and are concentrated in the temperate and boreal regions of the world. They are important soils in the semiarid parts of the world, particularly in the regions with a Mediterranean climate. The cool climate permits a slow accumulation of the humified organic matter. Because of the excellent quality of the soils and the very favorable climate, these soils are very productive and make up the breadbasket of modern times. Large areas of such soils characterize the Midwest in the United States, the steppes of the former Soviet Union, the northern part of Argentina, and part of Uruguay.

Inceptisols and Entisols together occupy about 25 percent of the land surface. Generally on young surfaces, they occur in association with rock outcrops and sand dunes. These soils formed in recent coastal and riverine deposits. They formed in marine alluvium under brackish water conditions. Entisols are potential acid sulfate soils, and Inceptisols are actual acid sulfate soils. When drained, potential acid sulfate soils (Sulfaquents) are converted to actual acid sulfate soils (Sulfaquepts). The process results in release of a considerable amount of sulfuric acid, making these soils and the soils adjacent to them extremely acid.

Because of different data sets, the map of the world and the map of the United States in this publication do not always exactly match.

APPENDIX

Laboratory Methods for Soil Taxonomy

The standard laboratory methods upon which the operational definitions of this edition of *Soil Taxonomy* are based are described in the *Soil Survey Laboratory Methods Manual* (USDA, NRCS, 1996). Copies of standard laboratory data sheets are included with the typifying pedons in the chapters on soil orders in this edition of *Soil Taxonomy*. For specific information about an analytical procedure, these data sheets should be checked and reference should be made to the *Soil Survey Laboratory Methods Manual*. Much of the information included in this appendix is derived from "Soil Survey Laboratory Methods for Characterizing Physical and Chemical Properties and Mineralology of Soils" (Kimble, Knox, and Holzhey, 1993). Also, the information is summarized in the *Soil Survey Laboratory Information Manual* (USDA, NRCS, 1995).

Pedon characterization data, or any soil survey data, are most useful when the operations for collecting the data are well understood. The mental pictures and conceptual definitions that aid in visualizing properties and processes often differ from the information supplied by an analysis. Also, results differ by method, even though two methods may carry the same name or the same concept. There is uncertainty in comparing one bit of data with another without knowledge of how both bits were gathered. Operational definitions, definitions tied to a specific method, are needed. This soil taxonomy has many class limits (at all levels) that are based on chemical or physical properties determined in the laboratory. One can question a given limit, but that is not the purpose of this appendix. This appendix is written to show what procedures are used for given class limits. By using specific class limits, everyone will come to the same classification if they follow the same procedures.

This taxonomy is based almost entirely on criteria that are defined operationally. One example is the definition of particle-size classes. There is no one definition of clay that works well for all soils. Hence, an operation for testing the validity of a clay measurement and a default operation for those situations where the clay measurement is not valid are defined. The default method is based on a water content at 1500 kPa and on content of organic carbon.

Data Elements Used in Classifying Soils

Detailed explanations of laboratory methods are given in the *Soil Survey Laboratory Methods Manual* (USDA, NRCS, 1996). Each method is listed by code on the data sheet at the beginning of the chapters describing soil orders. On the data sheets presented with each order, the method code is shown for each determination made. These data sheets should be consulted for reference to the *Soil Survey Laboratory Methods Manual*. This manual specifies method codes for pedon sampling, sample handling, site selection, sample collection, and sample preparation.

The units of measure reported on the data sheets are not SI units. Following are SI conversions:

1 meq/100 g = 1 cmol(+)/kg
1 mmho/cm = 1 dS/m
15 bar = 1500 kPa
$^{1}/_{3}$ bar = 33 kPa
$^{1}/_{10}$ bar = 10 kPa

In this taxonomy the terms (1) particle-size analysis (size separates), (2) texture, and (3) particle-size classes are all used. Particle-size analysis is needed to determine texture and particle-size classes. Texture differs from particle-size class in that texture includes only the fine-earth fraction (less than 2 mm), while particle size includes both the fraction less than 2 mm in size and the fraction equal to or more than 2 mm.

Atterberg limits are determined on the fraction less than 0.4 mm in size. Plasticity index is the difference in water content between liquid limit and plastic limit. It is the range of water content over which a soil paste can be deformed without breaking, but it does not include flow as a liquid under operationally defined conditions. Liquid limit is the minimum water content at which the paste begins to flow as a liquid. Samples that do not deform without breaking at any water content are reported as NP, nonplastic. Operational definitions are in the *Annual Book of ASTM Standards* (ASTM, 1998).

Bulk density is obtained typically by equilibration of Saran-coated natural fabric clods at designated pressure differentials. Bulk densities are determined at two or more water contents. For coarse textured and moderately coarse textured soils, they are determined when the sample is at 10 kPa suction and when ovendry. For soils of medium and finer texture, the bulk densities are determined when the sample is at 33 kPa suction and when ovendry.

Bulk density determined at 33 kPa suction is used to convert other analytical results to a volumetric basis (for example, kg of organic carbon per m^3).

Coefficient of linear extensibility (COLE) is a derived value. It is computed from the difference in bulk density between a moist clod and an ovendry clod. It is based on the shrinkage of a natural soil clod between a water content of 33 kPa (10 kPa for sandier soils) and ovendry.

Linear extensibility (LE) of a soil layer is the product of the thickness, in centimeters, multiplied by the COLE of the layer in question. The LE of a soil is the sum of these products for all soil horizons. COLE multiplied by 100 is called linear extensibility percent (LEP).

Water retention difference (WRD) is computed from water retentions at 33 kPa (10 kPa for sandier soils) and 1500 kPa suction. It is converted to cm of water per cm of soil through use of the bulk density. The 33 or 10 kPa water is determined by desorption of the natural fabric clods, and the 1500 kPa water is determined by desorption of crushed soil.

Organic carbon data in the National Soil Survey Laboratory (NSSL) data base have been determined mostly by wet digestion (Walkley, 1935). Because of environmental concerns about waste products, however, that procedure is no longer in use. The only procedure that is currently used to determine organic carbon is a dry combustion procedure that determines the percent of total carbon. The content of organic carbon is determined by subtracting the amount of carbon contributed by carbonates from total carbon data. The content of organic carbon determined by this computation is very close to the content determined by the wet digestion procedure.

Nitrogen in the NSSL data base is reported as a percentage of the total dry weight. A soil sample is combusted at high temperature with oxygen to release NOx, and the N2 is measured by thermal conductivity detection.

Iron and aluminum extracted by citrate dithionite are removed in a single extraction. They are measured by atomic absorption and reported as a percentage of the total dry weight. The iron is primarily from ferric oxides (hematite, magnetite) and iron oxyhydroxides (goethite). Aluminum substituted into these minerals is extracted simultaneously. The dithionite reduces the ferric iron, and the citrate stabilizes the iron by chelation. Iron and aluminum bound in organic matter are extracted if the citrate is a stronger chelator than the organic molecules. Manganese extracted by this procedure also is recorded. The iron extracted is commonly related to the clay distribution within a pedon.

Extractable bases (calcium, magnesium, sodium, and potassium) are extracted with ammonium acetate buffered at pH 7. They are equilibrated, filtered in an auto-extractor, and measured by atomic absorption. They are reported as meq/100 g soil. The bases are extracted from the cation-exchange complex by displacement with ammonium ions. The term “extractable bases” is used instead of “exchangeable bases” because soluble salts and some bases from carbonates can be included in the extract.

Sum of bases is the sum of the calcium, magnesium, sodium, and potassium described in the previous paragraph.

Extractable acidity is the acidity released from the soil by a barium chloride-triethanolamine solution buffered at pH 8.2. It includes all the acidity generated by replacement of the hydrogen and aluminum from permanent and pH-dependent exchange sites. It is reported as meq/100 g soil. Extractable acidity data are reported on some data sheets as exchangeable acidity and on others as exchangeable H^+.

Extractable aluminum is exchangeable aluminum extracted by 1N KCl. It is a major constituent only in strongly acid soils (pH of less than 5.0). Aluminum will precipitate if the pH rises above 4.5 to 5.0 during analysis. The extractant KCl usually affects the soil pH 1 unit or less. Extractable aluminum is measured at the NSSL by atomic absorption. Many laboratories measure the aluminum by titration with a base to the phenopthalein end point. Titration measures exchangeable acidity as well as extractable aluminum. Soils with a pH below 4.0 or 4.5 are likely to have values determined by atomic absorption similar to values determined by titration because very little hydrogen is typically on the exchange complex. If there is a large percentage of organic matter, however, some hydrogen may be present. For some soils it is important to know which procedure was used. Extractable aluminum is reported as meq/100 g soil.

Aluminum saturation is the amount of KCl-extractable Al divided by extractable bases (extracted by ammonium acetate) plus the KCl-extractable Al. It is expressed as percent. A general rule of thumb is that if there is more than 50 percent Al saturation, Al problems in the soil are likely. The problems may not be related to Al toxicity but to a deficiency of calcium and/or magnesium.

Cation-exchange capacity (CEC) by ammonium acetate (at pH 7), by sum of cations (at pH 8.2), and by bases plus aluminum is given on the data sheets in the chapters on soil orders. The CEC depends on the method of analysis as well as the nature of the exchange complex. CEC by sum of cations at pH 8.2 is calculated by adding the sum of bases and the extractable acidity. CEC by ammonium acetate is measured at pH 7. CEC by bases plus aluminum, or effective cation-exchange capacity (ECEC), is derived by adding the sum of bases and KCl-extractable Al. Aluminum extracted by 1N KCl is negligible if the extractant pH rises toward 5.5. ECEC then is equal to extractable bases. CEC and ECEC are reported on the data sheets as meq/100 g soil.

The reported CEC may differ from the CEC of the soil at its natural pH. The standard methods allow the comparison of one soil with another even though the pH of the extractant differs from the pH of the natural soil. Cation-exchange capacity by ammonium acetate and by sum of cations applies to all soils.

CEC at pH 8.2 is not reported if the soil contains free carbonates because bases are extracted from the carbonates. The effective CEC (ECEC) is reported only for acid soils. ECEC is not reported for soils having soluble salts, although it can be calculated by subtracting the soluble components from the extractable components. ECEC also may be defined as bases plus aluminum plus hydrogen. That is the more common definition for agronomic interpretations. This taxonomy specifies bases plus aluminum.

Generally, the ECEC is less than the CEC at pH 7, which in turn is less than the CEC at pH 8.2. If the soil is dominated by positively charged colloids (e.g., iron oxides), however, the trend is reversed. Most soils have negatively charged colloids, which cause the CEC to increase with increasing pH. This difference in CEC is commonly called the pH-dependent or variable charge. The CEC at the soil pH can be estimated by plotting the CEC of the soil vs. the pH of the extractant on a graph and reading the CEC at the soil pH.

CEC measurements at pH levels other than those described in the paragraphs above and CEC derived by use of other cations will yield somewhat different results. It is important to know the procedure, pH, and cation used before evaluating CEC data or comparing data from different sources.

Base saturation is reported on the data sheets as percent of the CEC. It is reported as CEC by sum of cations at pH 8.2 and by ammonium acetate at pH 7. Base saturation by ammonium acetate is equal to the sum of the bases extracted by ammonium acetate, divided by the CEC (by ammonium acetate), and multiplied by 100. If extractable calcium is not reported on the data sheet because of free carbonates or salts in the sample, then the base saturation is assumed to be 100 percent.

Base saturation percentage by sum of cations is equal to the sum of bases extracted by ammonium acetate, divided by the CEC (by sum of cations), and multiplied by 100. This value is not reported if either extractable calcium or extractable acidity is omitted.

Differences between the two methods of determining base saturation reflect the amount of the pH-dependent CEC. Class definitions in this taxonomy specify which method is used.

The sum of exchangeable cations is considered equal to the sum of bases extracted by ammonium acetate unless carbonates, gypsum, or other salts are present. When these salts are present, the sum of the bases extracted by ammonium acetate typically exceeds 100 percent of the CEC. Therefore, a base saturation of 100 percent is assumed. The amount of calcium from carbonates is usually much larger than the amount of magnesium from the carbonates. Extractable calcium is not shown on the data sheet if more than a trace (more than 0.4 percent) of carbonates (reported as calcium carbonate) is present or if calculated base saturation exceeds 110 percent, based on CEC by ammonium acetate at pH 7.

Calcium carbonate equivalent is the amount of carbonates in the soil as measured by treating the sample with HCl. The evolved carbon dioxide is measured manometrically. The amount of carbonate is then calculated as a calcium carbonate equivalent regardless of the form of carbonates (dolomite, sodium carbonate, magnesium carbonate, etc.) in the sample. Calcium carbonate equivalent is reported as a percentage of the total dry weight of the sample. It can be reported on material that is less than 2 mm or less than 20 mm in size.

Calcium sulfate as gypsum is determined by extraction in water and precipitation in acetone. The amount of gypsum is reported as a percentage of the total dry weight of the fraction less than 2 mm in size and the fraction less than 20 mm in size. Drying soils to oven-dryness, the standard base for reporting the data, removes part of the water of hydration from the gypsum. Many measured values, particularly water retention values, must be recalculated to compensate for the weight of the water of hydration lost during drying.

pH is measured in water and in salts. The pH measured in water is determined in distilled water typically mixed 1:1 with dry soil. The pH measured in potassium chloride is determined in 1N KCl solution mixed 1:1 with soil. The pH measured in calcium chloride is determined in 0.01M $CaCl_2$ solution mixed 2:1 with soil.

The pH is measured by a pH meter in a soil-water or soil-salt solution. The extent of the dilution is shown in the heading on the data sheets. A ratio of 1:1 means one part dry soil and one part water, by weight.

Measurement of pH in a dilute salt solution is common because it tends to mask seasonal variations in pH. Readings in 0.01M $CaCl_2$ tend to be uniform regardless of the time of year. Readings in 1N KCl also tend to be uniform. The former are more popular in regions with less acid soils. The latter are more popular in regions with more acid soils. If KCl is used to extract exchangeable aluminum, the pH reading (in KCl) shows the pH at which the aluminum was extracted.

The pH may also be measured in 1N sodium fluoride. This measurement is usually used to identify soils that are dominated by short-range-order minerals, such as Andisols and Spodosols. In soils that have a significant component of poorly ordered minerals, such as the soils in the isotic mineralogy class, the pH in NaF will be greater than 8.5. Soils with free carbonates also have high pH values in NaF. Therefore, care must be taken in interpreting these data.

Water-soluble cations and anions are determined in water extracted from a saturated paste. The cations include calcium, magnesium, sodium, and potassium, and the anions include carbonate, bicarbonate, sulfate, chloride, nitrate, fluoride, phosphate, silicate, and borate. The cations and anions can be reported as cmol(+)/l.

Exchangeable sodium percentage (ESP) is reported as a percentage of the CEC by ammonium acetate at pH 7. Water-soluble sodium is converted to meq/100 g soil. This value is subtracted from extractable sodium, divided by the CEC (by ammonium acetate), and multiplied by 100. An ESP of more than 15 percent is used in this taxonomy as a criterion for the natric horizon.

Sodium adsorption ratio (SAR) was developed as a measure of irrigation water quality. Water-soluble sodium is divided by water-soluble calcium and magnesium. The formula is SAR = $Na/[(Ca+Mg)/2]^{0.5}$. An SAR of 13 or more is used as an alternate to the ESP criterion for the natric horizon.

Electrical conductivity (EC) is the conductivity of the water extracted from saturated paste. The EC is used to determine the total content of salts. It is reported as mmhos/cm, which is equal to dS/m.

Total salts is calculated from the electrical conductivity of the saturation extract. It is reported as a weight percentage of the total water-soluble salts in the soil.

Phosphate retention (P ret.) refers to the percent phosphorus retained by soil after equilibration with 1,000 mg/kg phosphorus solution for 24 hours. This procedure is used in the classification of andic soil materials. It identifies soils in which phosphorus fixation may be a problem affecting agronomic uses.

Acid-oxalate-extractable aluminum, iron, and silicon are determined by a single extraction made in the dark with 0.2 molar ammonium oxalate at a pH of 3.5. The amount of aluminum, iron, and silicon is measured by atomic absorption and reported as a percentage of the total dry weight. These values are used as criteria in identifying soils in the Andisol and Spodosol orders and in the andic and spodic subgroups in other orders. The procedure extracts iron, aluminum, and silicon from organic matter and from amorphous mineral material. It is used in conjunction with dithionite-citrate and pyrophosphate extractions to identify the sources of iron and aluminum in the soil. Pyrophosphate extracts iron and aluminum from organic matter. Dithionite citrate extracts iron from iron oxides and oxyhydroxides as well as from organic matter.

Sodium-pyrophosphate-extractable iron and aluminum are determined by a single extraction and measured by atomic absorption. Results are reported as a percentage of the total dry weight. This procedure has been used widely to extract iron and aluminum from organic matter. It successfully removes much of the organo-metal accumulations in spodic horizons but extracts little of the inorganically bound iron and aluminum.

Potassium-hydroxide-extractable aluminum is determined by atomic absorption spectrophotometry. This procedure has been used in the past but is not used in this taxonomy. The data can be used in the field to estimate the amount of acid-oxalate-extractable aluminum.

Melanic index is used in the identification of the melanic epipedon. The index is a ratio of the humic and fulvic acids in the organic fraction of the soil (Honna, Yamamoto, and Matsui, 1988). About 0.50 gram of air-dried soil material that is less than 2 mm in size is shaken with 25 ml of 0.5 percent NaOH solution in a 50-ml centrifuge tube for 1 hour at room temperature. One drop of a flocculating agent is added, and the mixture is centrifuged at 4,000 rpm for 10 minutes. The melanic index is the ratio of the absorbance at 450 nm over that at 520 nm.

Citric-acid-extractable phosphorus (acid-soluble phosphate) is used to separate the mollic epipedon (less than 1,500 mg/kg P_2O_5) from the anthropic epipedon (equal to or more than 1,500 mg/kg).

Exchangeable manganese and calcium plus exchangeable acidity (at pH 8.2) is used as a criterion for the natric horizon. The exchangeable acidity is measured at pH 8.2, and the manganese and calcium are extracted at pH 7.0 with ammonium acetate. See the paragraphs about extractable acidity and exchangeable bases.

Color of sodium-pyrophosphate extract is used as a criterion in the separation of different types of organic materials. A saturated solution is made by adding 1 g of sodium pyrophosphate to 4 ml of distilled water, and a moist organic matter sample is added to the solution. The sample is mixed and allowed to stand overnight, chromatographic paper is dipped in the solution, and the color of the paper is ascertained through use of a Munsell color chart.

Water-soluble sulfate is used in the definition of the sulfuric horizon. The sulfate is determined in the saturation extract and is reported as one of the anions.

Mineralogy of the clay, silt, and sand fractions is required in some taxa. The different techniques employed are X-ray diffraction analysis, thermal analysis, and petrographic analysis.

X-ray diffraction analysis (XRD) is reported in a five-class system based mostly on relative peak intensities. It is useful in determining relative amounts of clay minerals. It is used to differentiate between the smectitic and vermiculitic mineralogy classes.

Thermal analysis is reported as weight percent of the clay fraction. It helps to determine kaolinitic, gibbsitic, and other mineralogy classes.

Petrographic analysis is reported as percent of grains counted. Minerals are identified by use of a petrographic microscope. At least 300 grains of a coarse silt, very fine sand, or fine sand separate are identified and counted. Weatherable minerals, resistant minerals, and volcanic glass are identified by this procedure. A complete list of these is in Appendix XXI of the *Soil Survey Laboratory Methods Manual* (USDA, NRCS, 1996).

Other Information Useful in Classifying Soils

Volumetric amounts of organic carbon are used in some taxonomic criteria. The following calculation is used: (Datum [percent] times bulk density [at 33 or 10 kPa] times thickness [cm]) divided by 10. This calculation is normally used for organic carbon, but it can be used for some other measurements. Each horizon is calculated separately, and the product of the calculations can be summed to any desired depth, commonly 100 cm.

Ratios that can be developed from the data are useful in making internal checks of the data, in making management-related interpretations, and in answering taxonomic questions. Some of the ratios are used as criteria in determining argillic, kandic, or oxic horizons.

The ratio of 1500 kPa water to clay is used to indicate the relevancy of the particle-size determination. If the ratio is greater than 0.6 and the soil does not have andic soil properties, incomplete dispersion of the clay is assumed and clay is estimated by the following formula: Clay % = 2.5(% water retained at 1500 kPa tension - % organic carbon). For a typical soil with well dispersed clays, the ratio is 0.4. Some soil-related factors that can cause deviation from the 0.4 value are: (1) low-activity clays (kaolinites, chlorites, and some micas), which tend to have a ratio of 0.35 or below; (2) iron oxides and clay-size carbonates, which tend to decrease the ratio; (3) organic matter, which increases the ratio because it increases the water content at 1500 kPa; (4) andic and spodic materials and materials with an isotic mineralogy class, which increase the ratio because they do not disperse well; (5) large amounts of gypsum; and (6) clay minerals within grains of sand and silt. These clay minerals hold water at 1500 kPa and thus increase the ratio. They are most common in shale and in pseudomorphs of primary minerals in saprolite.

The ratio of CEC by ammonium acetate at pH 7 to clay can be used to estimate clay mineralogy and clay dispersion. If the ratio is multiplied by 100, the product is cmol(+)/kg clay. The following ratios are typical for the following classes of clay mineralogy: less than 0.2, kaolinitic; 0.2-0.3, kaolinitic or mixed; 0.3-0.5, mixed or illitic; 0.5-0.7, mixed or smectitic; and more than 0.7, smectitic. These ratios are most valid when some detailed mineralogy data are available. If the ratio of 1500 kPa water to clay is less than 0.3 or more than 0.6, the ratio of CEC by ammonium acetate to clay is not valid. Ratios of 1500 kPa water to clay of 0.6 or more are typical of poorly dispersed clays, andic and spodic materials, and materials with an isotic mineralogy class, and ratios of less than 0.3 are common in some soils that contain large amounts of gypsum.

A ratio of CEC at pH 8.2 to 1500 kPa water of more than 1.5 and more exchange acidity than the sum of bases plus KCl-extractable Al imply a soil with a high pH-dependent charge. Along with bulk density data, they help to distinguish soils that have andic and spodic materials or soils that have materials with an isotic mineralogy class from soils with minerals that are more crystalline.

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Errata

Soil Taxonomy

Second Edition, 1999

The date that changes were posted to the PDF file is indicated at the end of each item on this list of corrections.

Page 28, column 1, umbric epipedon, required characteristics, item 2b: Add the word "moist" after "3 or less" (8/02).

Page 49, column 2, salic horizon, required characteristics, item 1, line 2: Add "the water extracted from" after "dS/m in" (5/00).

Page 57, caption for photo 11: Change "Umbrept" to "Xerept" (5/00).

Page 88, column 1, top of diagram: Change "Fibric soil materials that have a rubbed fiber content of four-tenths to six-tenths by volume" to "Fibric soil materials that have a fiber content, after rubbing, of two-fifths to three-fourths by volume" (8/02).

Page 88, column 1, lower right of diagram: Change "Sapric soil materials" to "Sapric soil colors" (8/02).

Page 126, the table "Formative Elements in Names of Soil Orders," the column "Derivation of formative element," Ultisols: Change *ultumus* to *ultimus* (8/02).

Page 127, the table "Formative Elements in Names of Suborders," the "Derivation" column: For the element "Fol," change "leaf" to "leaves," and for the element "Turb," change *turbidis* to *turbidu*s (8/02).

Page 129, the table "Formative Elements in Names of Great Groups," the "Derivation" column: For the element "Verm," change "worm" to "worms" (8/02).

Page 156, the table "Adjectives in Names of Extragrades and Their Meaning," the "Derivation" column: For the adjective "Abruptic," change *abruptum* to *abruptus* (8/02).

Page 159, column 2, third full paragraph, last line: Add "and family criteria" (8/02).

Pages 331-388: Change the first letter of the symbols for all Aridisols from "F" to "G" (5/00).

Page 331, column 2, key to suborders, GE, line 2: Delete "that has its upper boundary within 100 cm of the soil surface" (5/00).

Page 333, column 1, definition of Argids, item 1: Delete "that has its upper boundary within 100 cm of the soil surface" (5/00).

Page 352, column 2, Petronodic Ustic Haplocalcids: Change the symbol FEBL to GFBL (5/00).

Page 361, column 1, Petronodic Ustic Haplocambids: Change the symbol FEDJ to GGDJ (5/00).

Page 393, column 1, LC, Psamments, line 3: Add "(sandy loam lamellae are permitted)" after "in all layers" (8/02).

Page 394, column 1, LAD, Psammaquents, line 3: Add "(sandy loam lamellae are permitted)" after "in all layers" (8/02).

Page 399, definition of Typic Fluvaquents, item 1: Change “Have, in one or more horizons” to “Have, in all horizons” (8/02).

Page 403, description of Thapto-Histic Sulfaquents, sentence 2: Change “These soils do not have *n* values above 0.7” to “These soils have both *n* values of more than 0.7 and 8 or more percent clay in the fine-earth fraction” (8/02).

Page 406, column 1, LBAA: Change “Utarents” to Ustarents” (8/02).

Page 474, column 2, description Fibrists, paragraph 1, sentence 2: Change “More than two-thirds of the soil consists of fibers” to “More than two-fifths or more than three-fourths (depending on solubility in a sodium-pyrophosphate solution) of the soil consists of fibers” (8/02).

Page 614, column 1, IFGE , Pachic Udertic Haplustolls, item 1, lines 1 and 2: Change “A mollic epipedon with a texture finer than loamy fine sand; *and either* ” to “A mollic epipedon 50 cm or more thick with a texture finer than loamy fine sand; *and* ” and delete items a and b (5/00).

Page 727, column 1, HAC, line 2: Change “(low or very low)” to “(moderately low or lower)” (8/02).

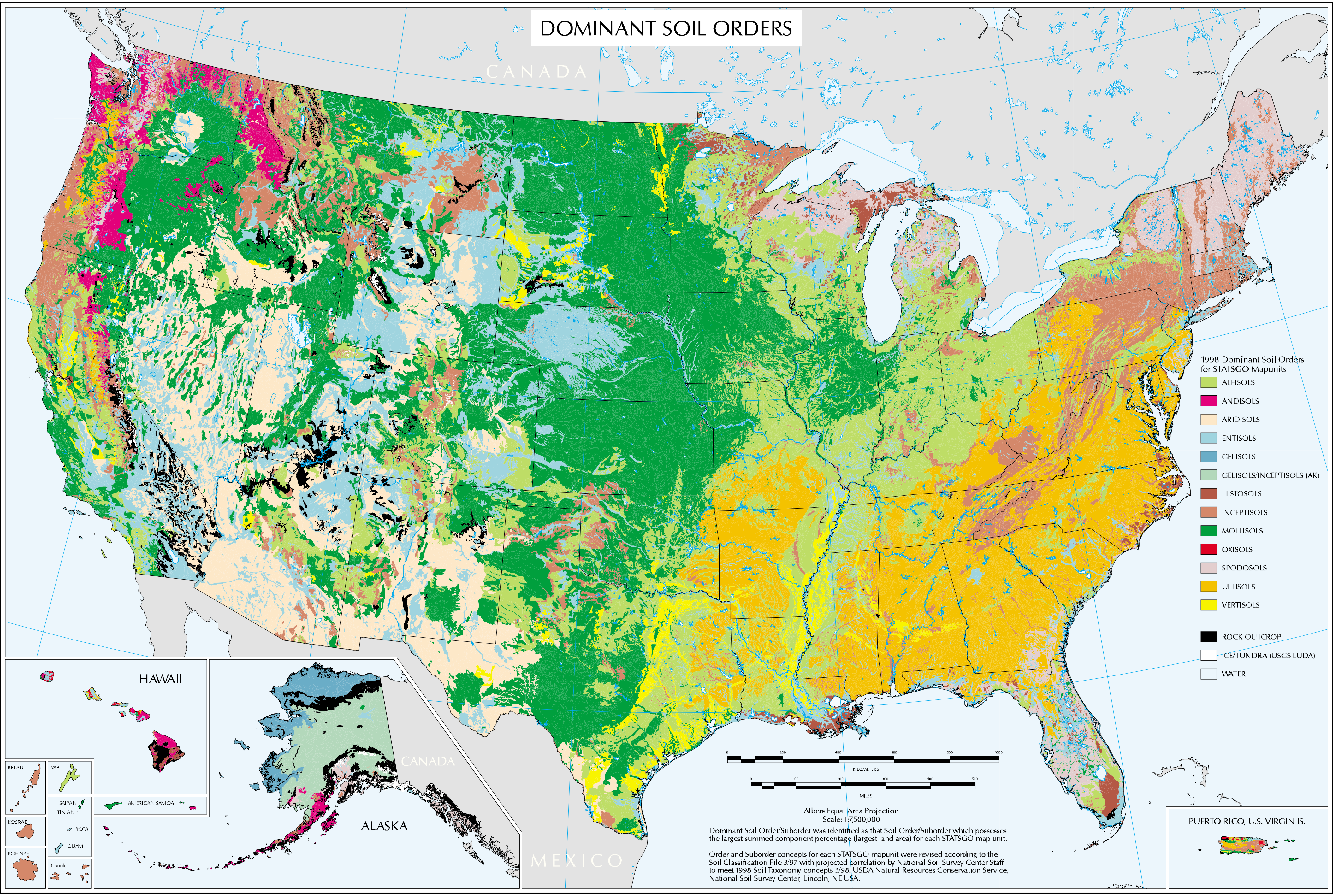
Page 727, column 2, description of Albaquults, sentence 2: Change “low or very low hydraulic conductivity” to “moderately low or lower hydraulic conductivity” (8/02).

Page 825, column 2, and page 826, column 1, key to mineralogy classes, item B, lines 2 and 3: Change “that replaces the particle-size class and that” to “that replaces the particle-size class, other than fragmental, and that” (5/00).

Page 828, column 2, key to calcareous and reaction classes, last sentence: Change “following the mineralogy class” to “following the mineralogy and cation-exchange activity classes” (5/00).

Maps

Click here to go to Table of Contents.


DOMINANT SOIL ORDERS
CANADA
1998 Dominant Soil Orders
for STATSGO Mapunits
ALFISOLS
ANDISOLS
ARIDISOLS
ENTISOLS
GELISOLS
GELISOLS/INCEPTISOLS (AK)
HISTOSOLS
INCEPTISOLS
MOLLISOLS
OXISOLS
SPODOSOLS
ULTISOLS
VERTISOLS
ROCK OUTCROP
ICE/TUNDRA (USGS LUDA)
WATER
HAWAII
BELAU
YAP
SAIPAN
TINIAN
AMERICAN SAMOA
ROTA
GUAM
KOSRAE
POHNPEI
Chuuk
CANADA
ALASKA
MEXICO
0 200 400 600 800 1000
KILOMETERS
0 100 200 300 400 500
MILES
Albers Equal Area Projection
Scale: 1:7,500,000
Dominant Soil Order/Suborder was identified as that Soil Order/Suborder which possesses the largest summed component percentage (largest land area) for each STATSGO map unit.
Order and Suborder concepts for each STATSGO mapunit were revised according to the Soil Classification File 3/97 with projected correlation by National Soil Survey Center Staff to meet 1998 Soil Taxonomy concepts 3/98. USDA Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE USA.
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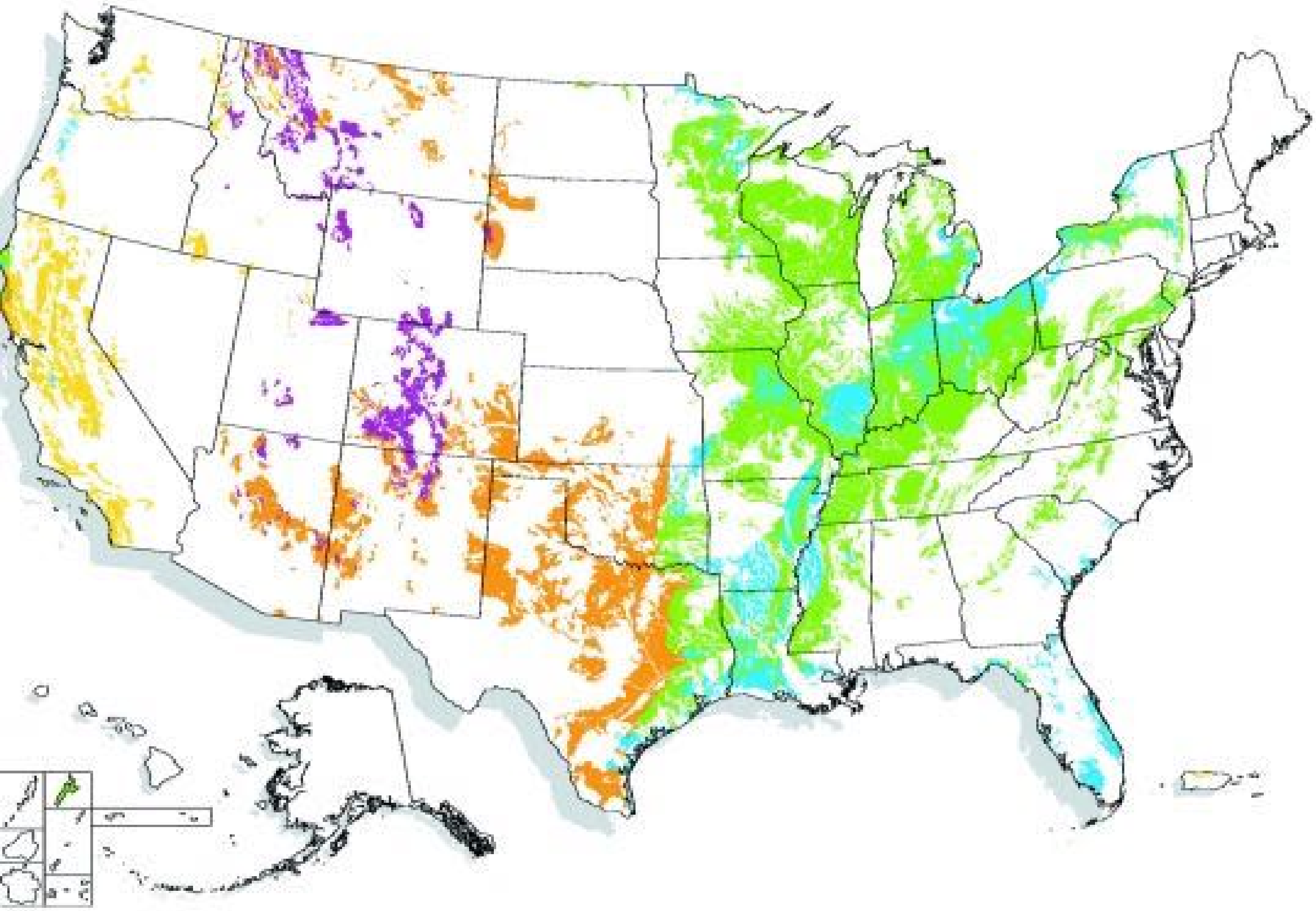
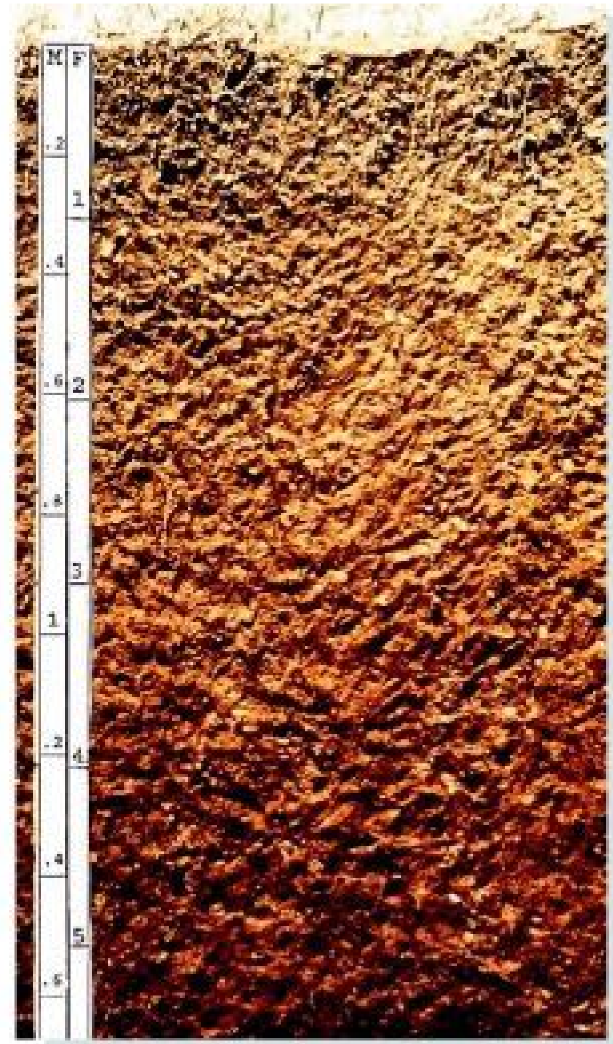
ALFISOLS



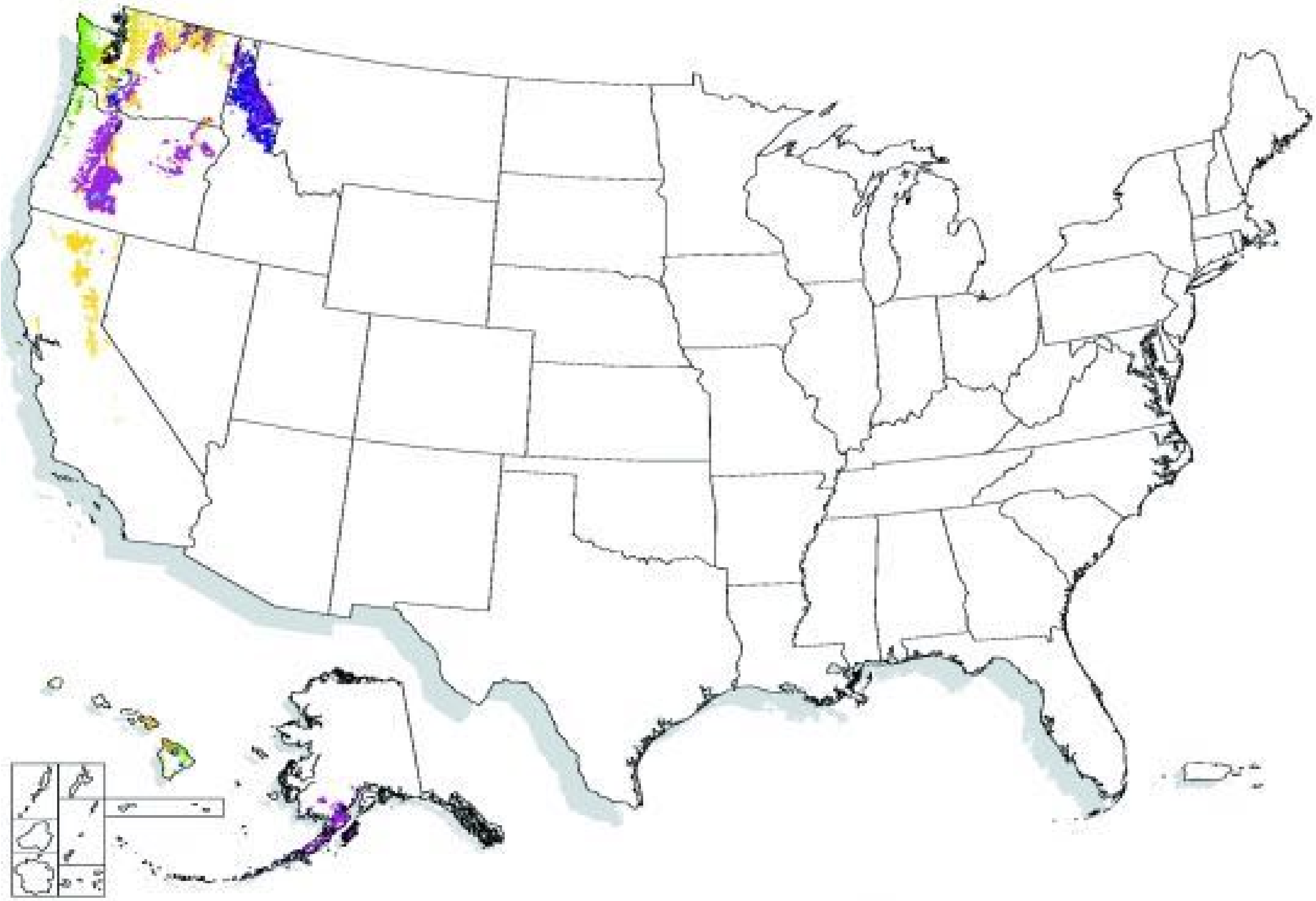
DOMINANT SUBORDERS

- Aqualfs
- Cryalfs
- Udalfs
- Ustalfs
- Xeralfs



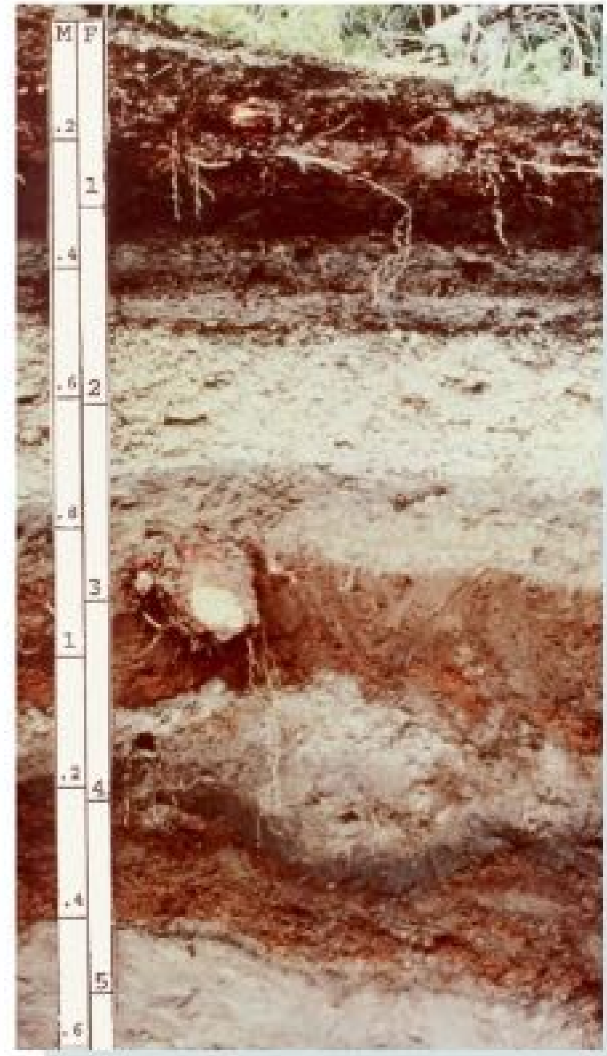
Alfisols have an argillic, kandic, or natric horizon and a relatively high content of bases. They typically have an ochric epipedon. Some also have a duripan, a fragipan, or a petrocalcic horizon. Most formed under forest or savanna vegetation.

ANDISOLS



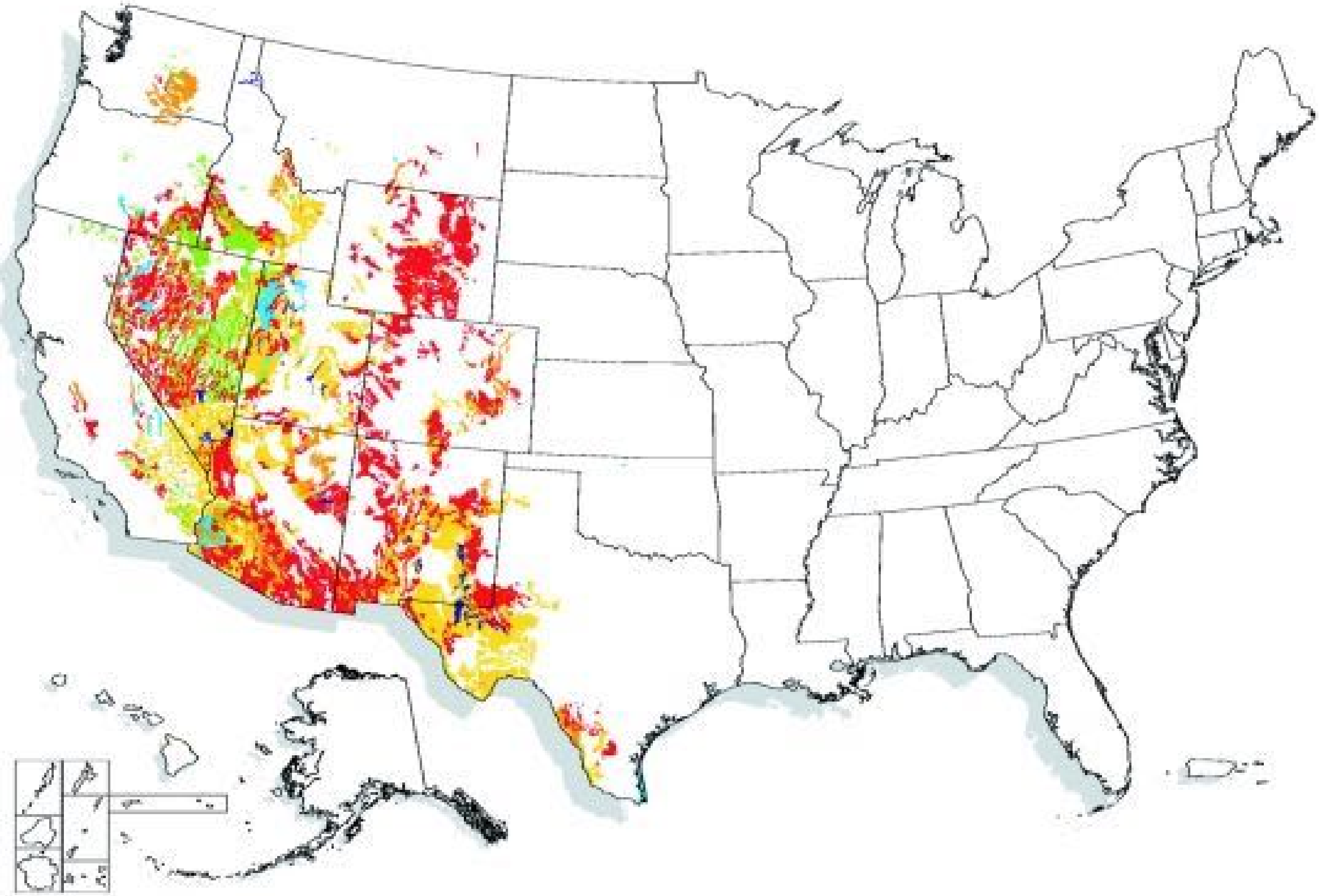
DOMINANT SUBORDERS

Aquands · Udands · Xerands
Cryands · Ustands
Torrands · Vitrands



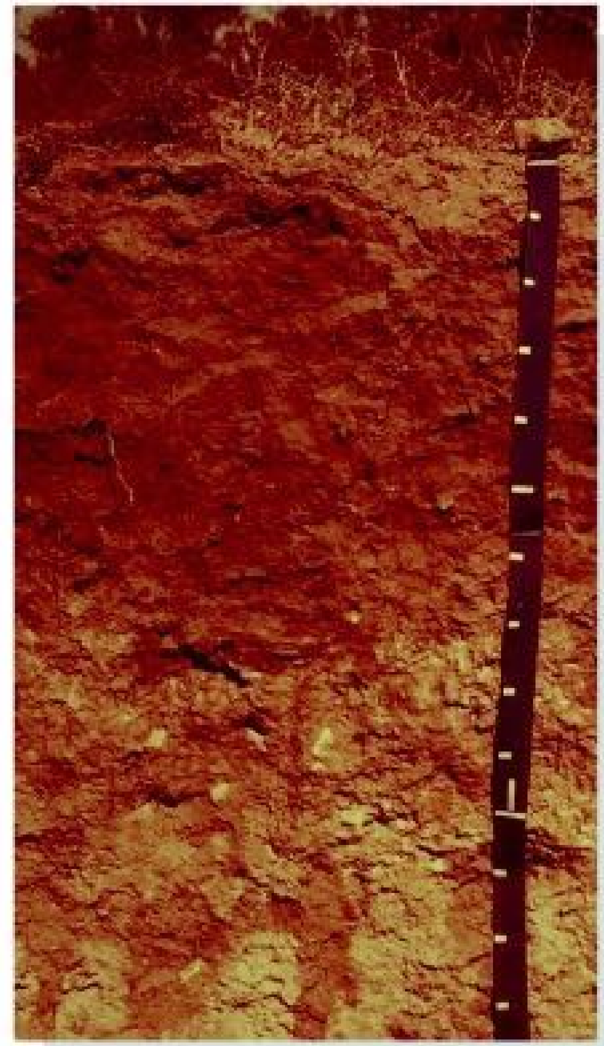
Andisols are dominated by short-range-order minerals or Al-humus complexes, and many have a large content of volcanic materials. The dominant soil-forming process is *in situ* mineral transformation. These soils commonly have a cambic horizon and can have any diagnostic epipedon.

ARIDISOLS



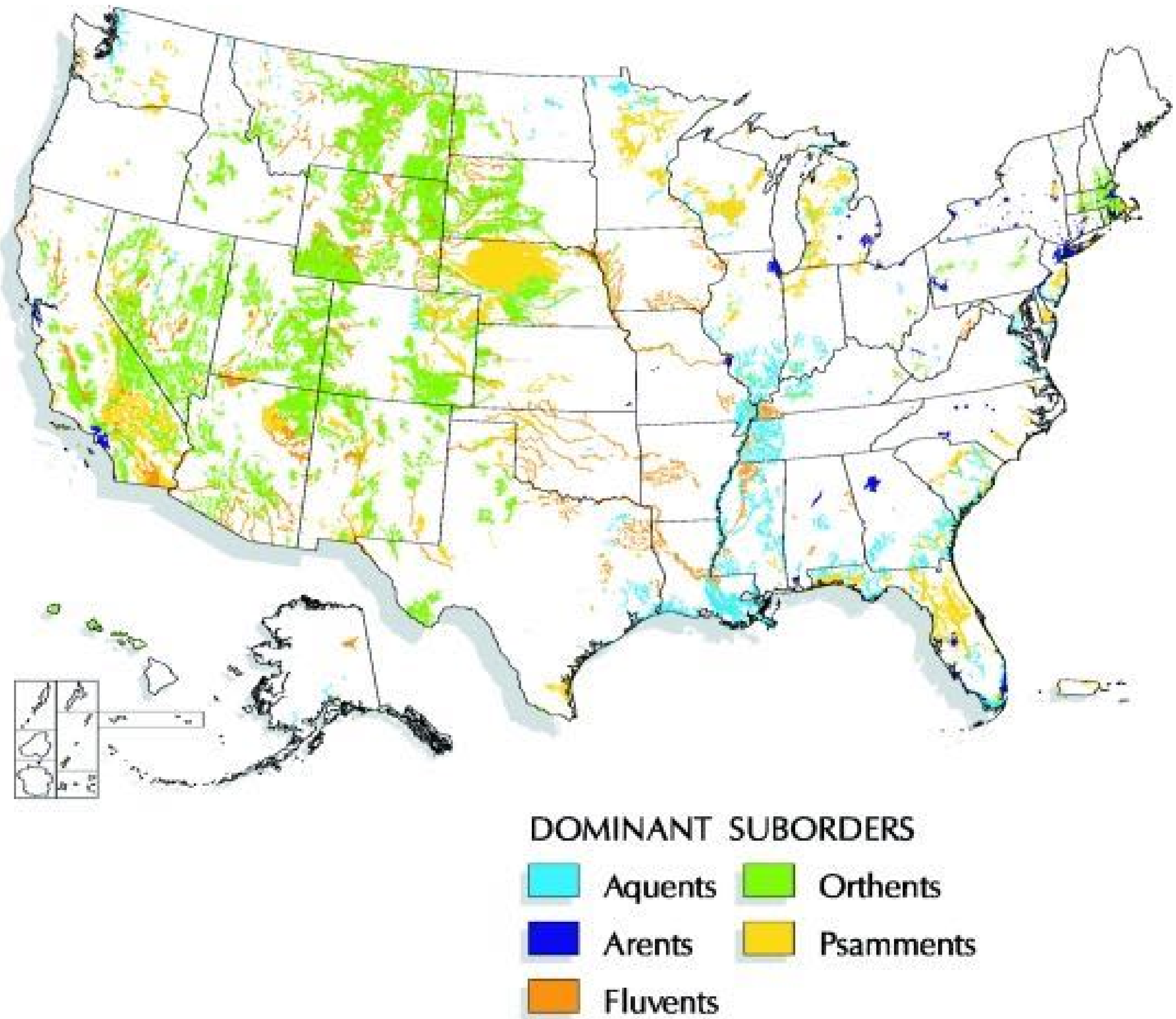
DOMINANT SUBORDERS

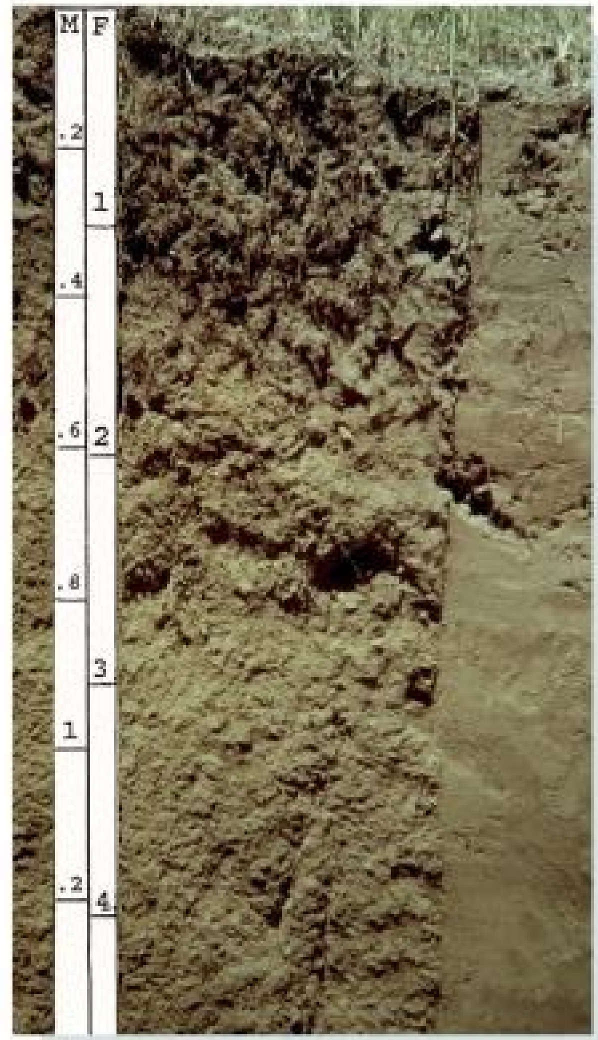
- Argids
- Cryids
- Salids
- Calcids
- Durids
- Cambids
- Gypsids



Aridisols have an aridic moisture regime. They also have one or more of the following diagnostic horizons: an argillic, calcic, cambic, gypsic, natric, petrocalcic, petrogypsic, or salic horizon or a duripan. These soils typically have an ochric epipdon.

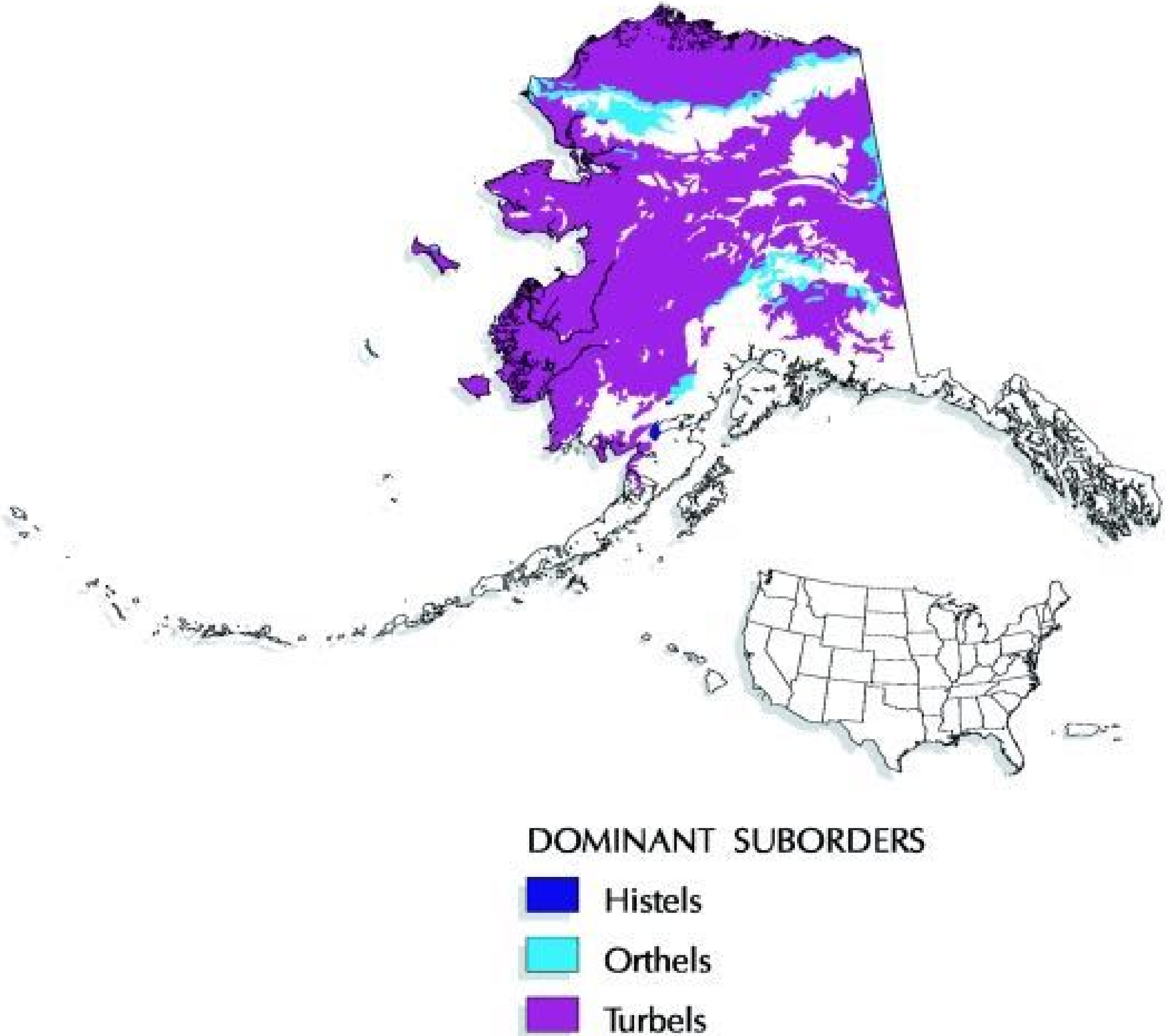
ENTISOLS

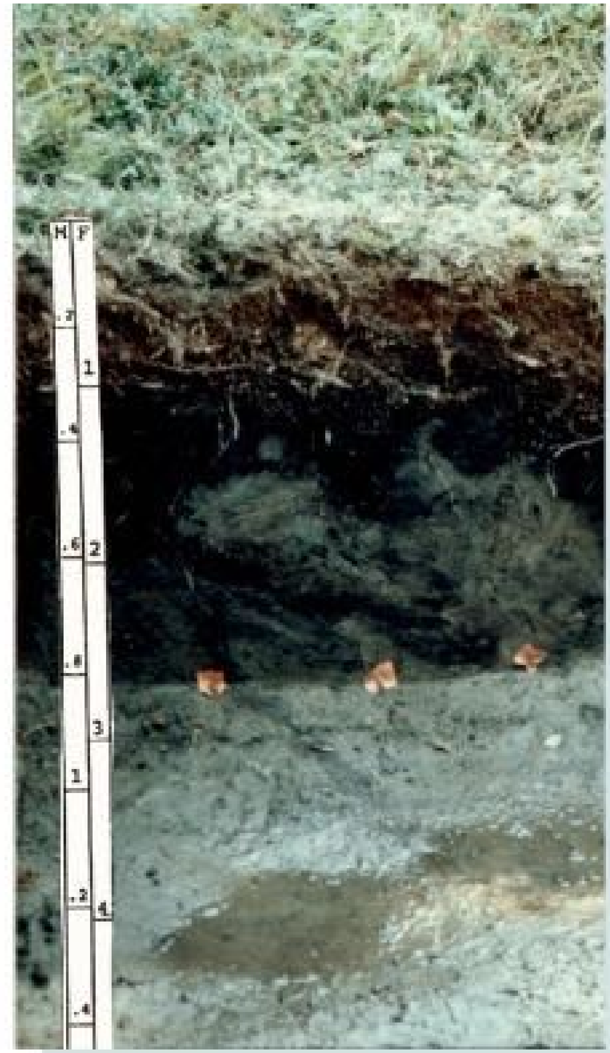




Entisols have little or no evidence of the development of diagnostic horizons. Many have an ochric epipedon. Many are sandy or very shallow.

GELISOLS





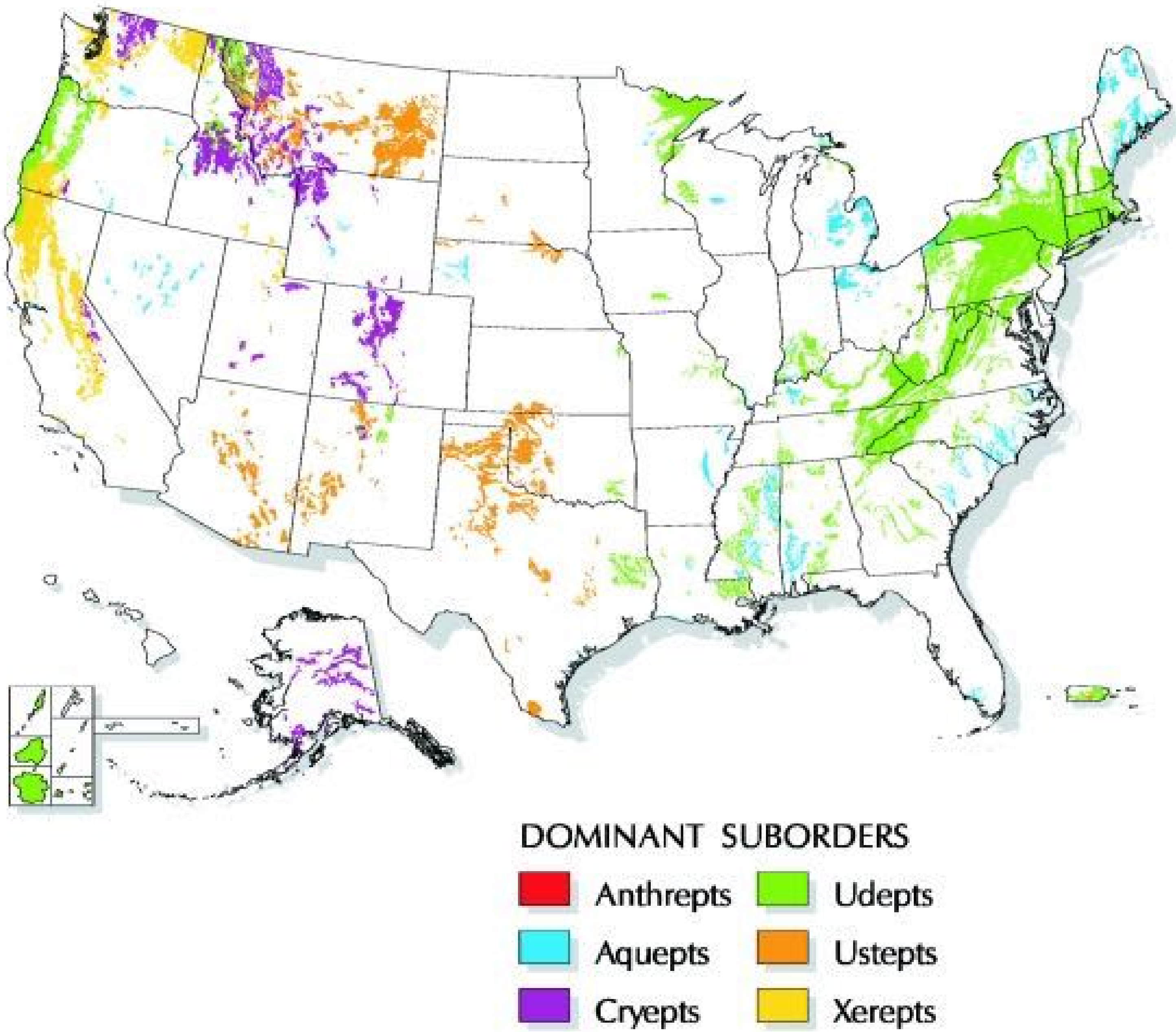
Gelisols have permafrost, and many are cryoturbated. These soils consist of mineral or organic soil materials, or both. They commonly have layers of gelic materials and a histic or ochric epipedon.

HISTOSOLS

Histosols are dominated by organic soil materials. They are mostly soils commonly called bogs, moors, peats, or mucks. Some consist of a thin layer of organic materials over a root-limiting layer or fragmental materials.

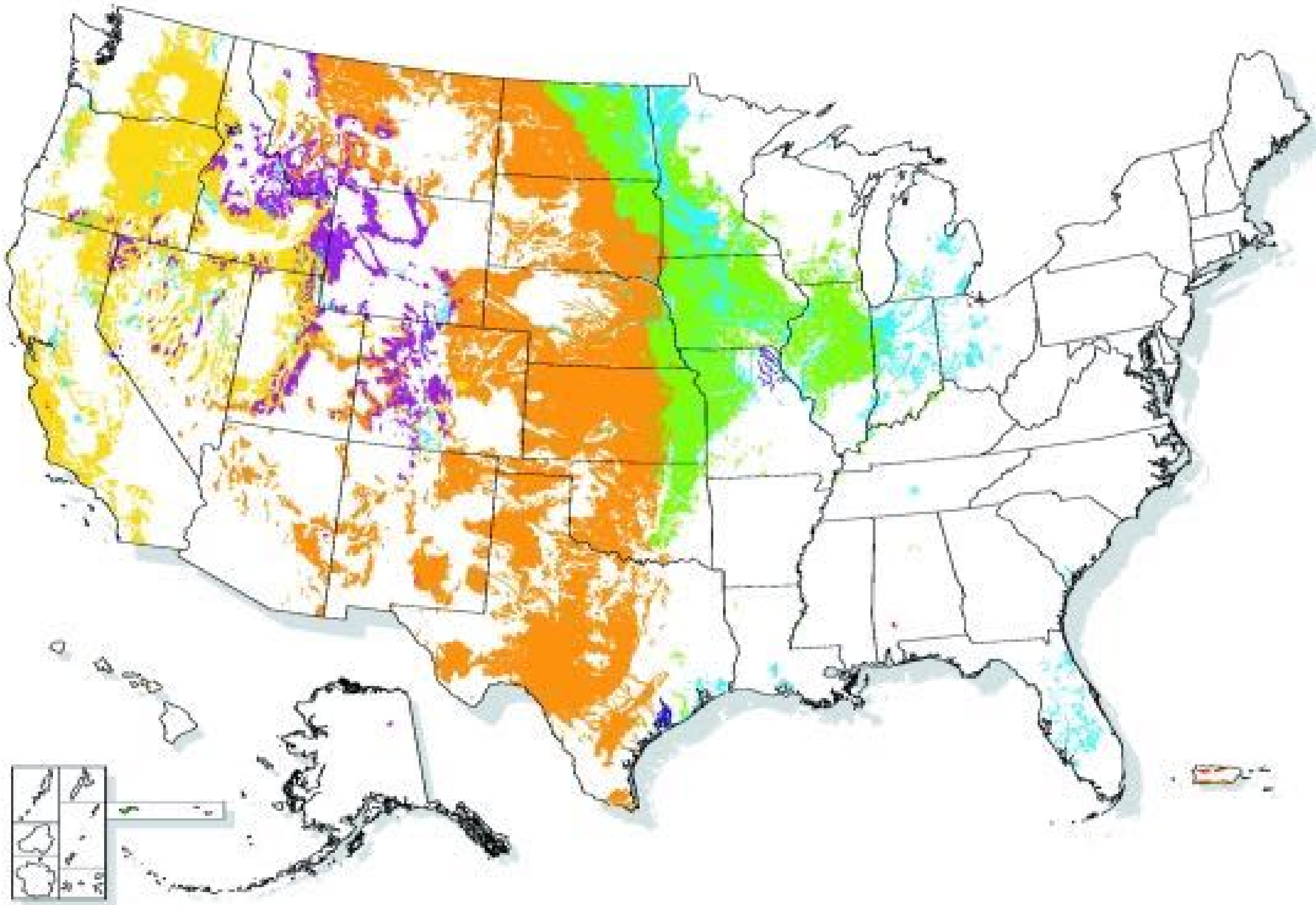
Inceptisols have many kinds of diagnostic horizons but cannot have an argillic, kandic, natric, oxic, or spodic horizon. They commonly have a cambic horizon and an ochric or umbric epipedon.

INCEPTISOLS

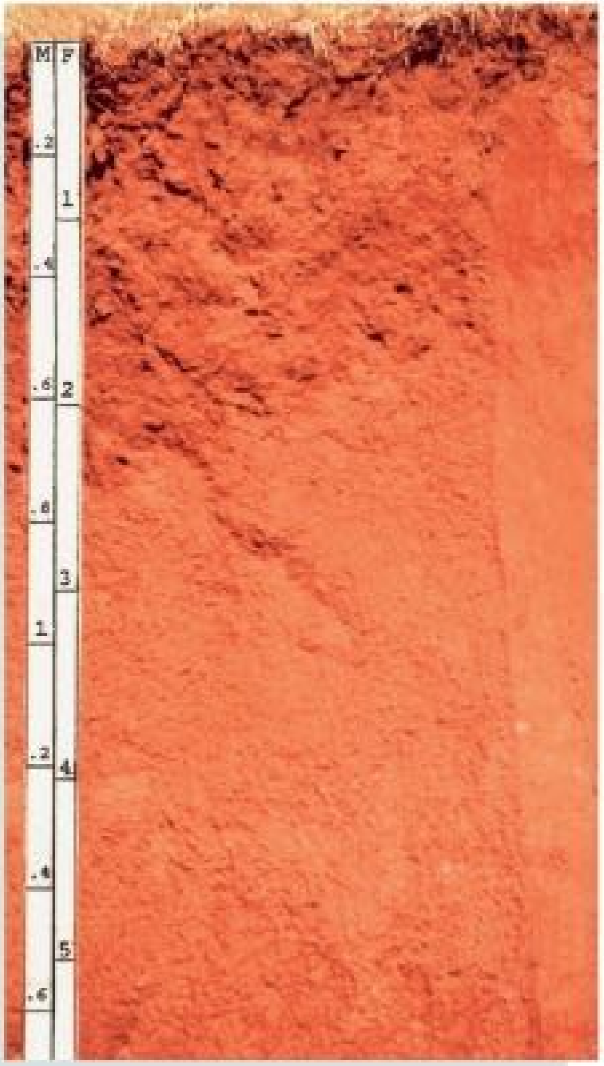


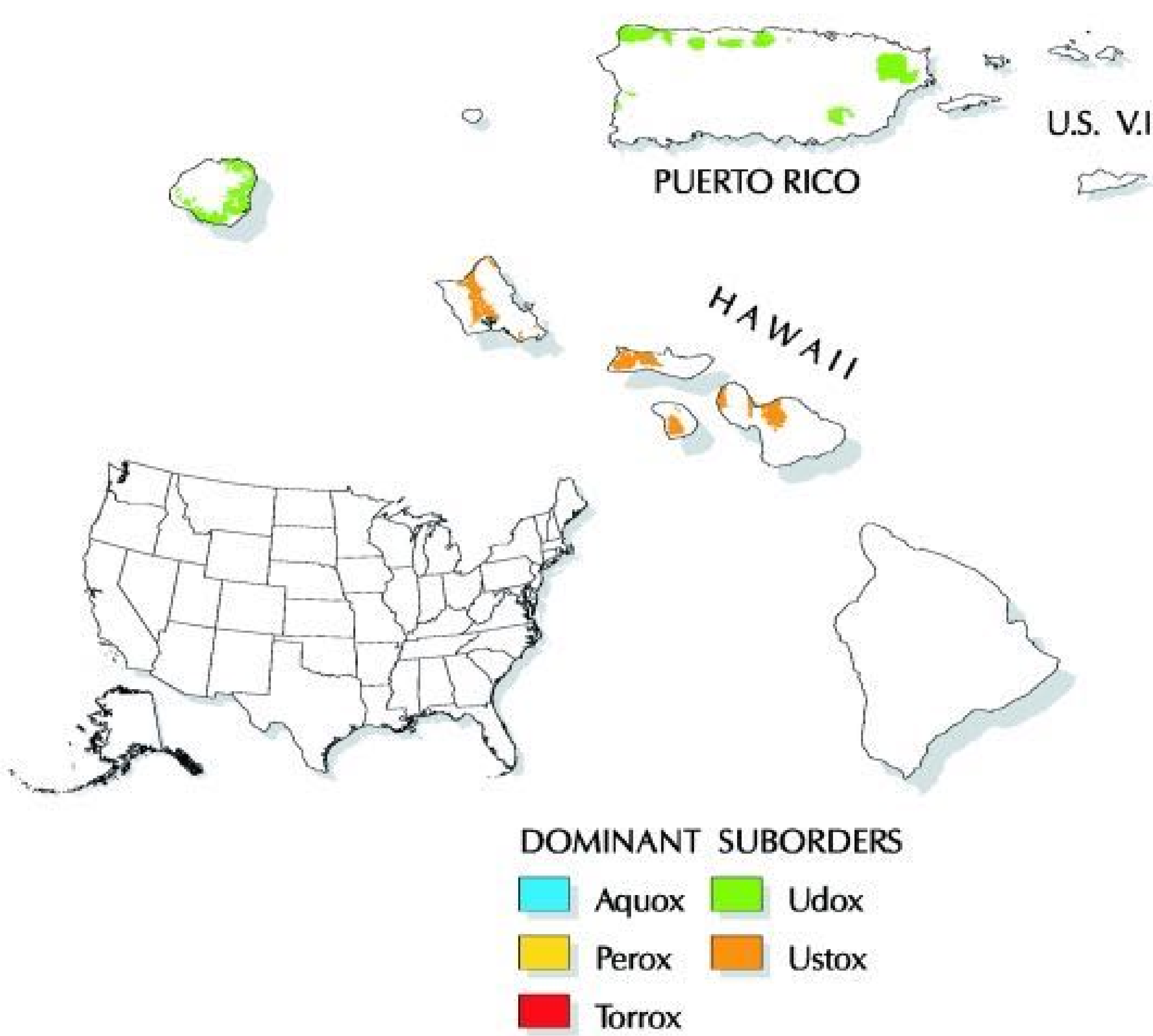
MOLLISOLS

Mollisols have a mollic epipedon and a relatively high content of bases. Many also have an argillic, natric, or calcic horizon. Some have a duripan or a petrocalcic horizon. Most formed under grass or savanna vegetation.

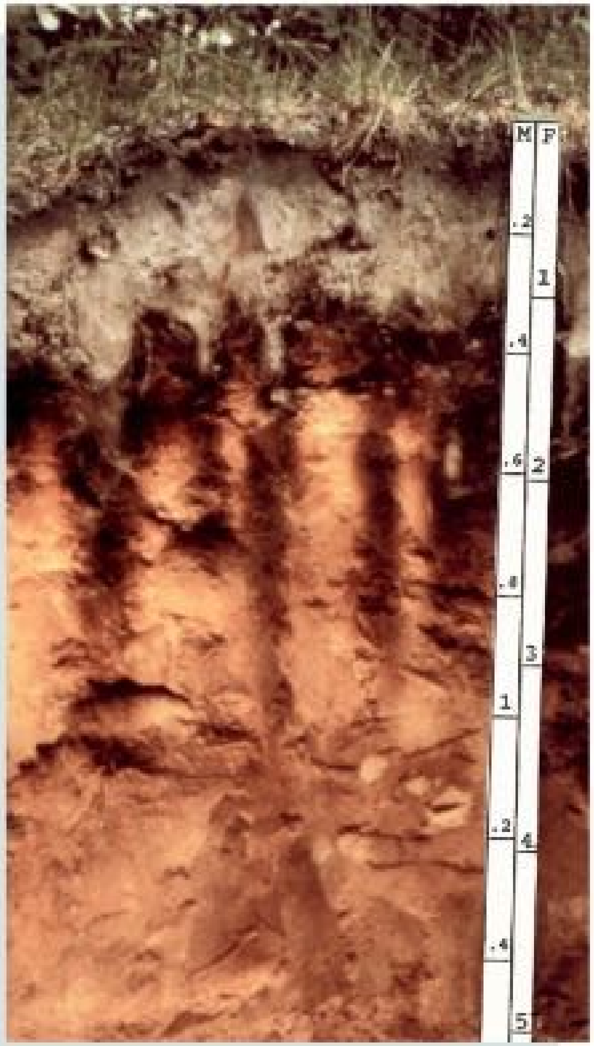


OXISOLS



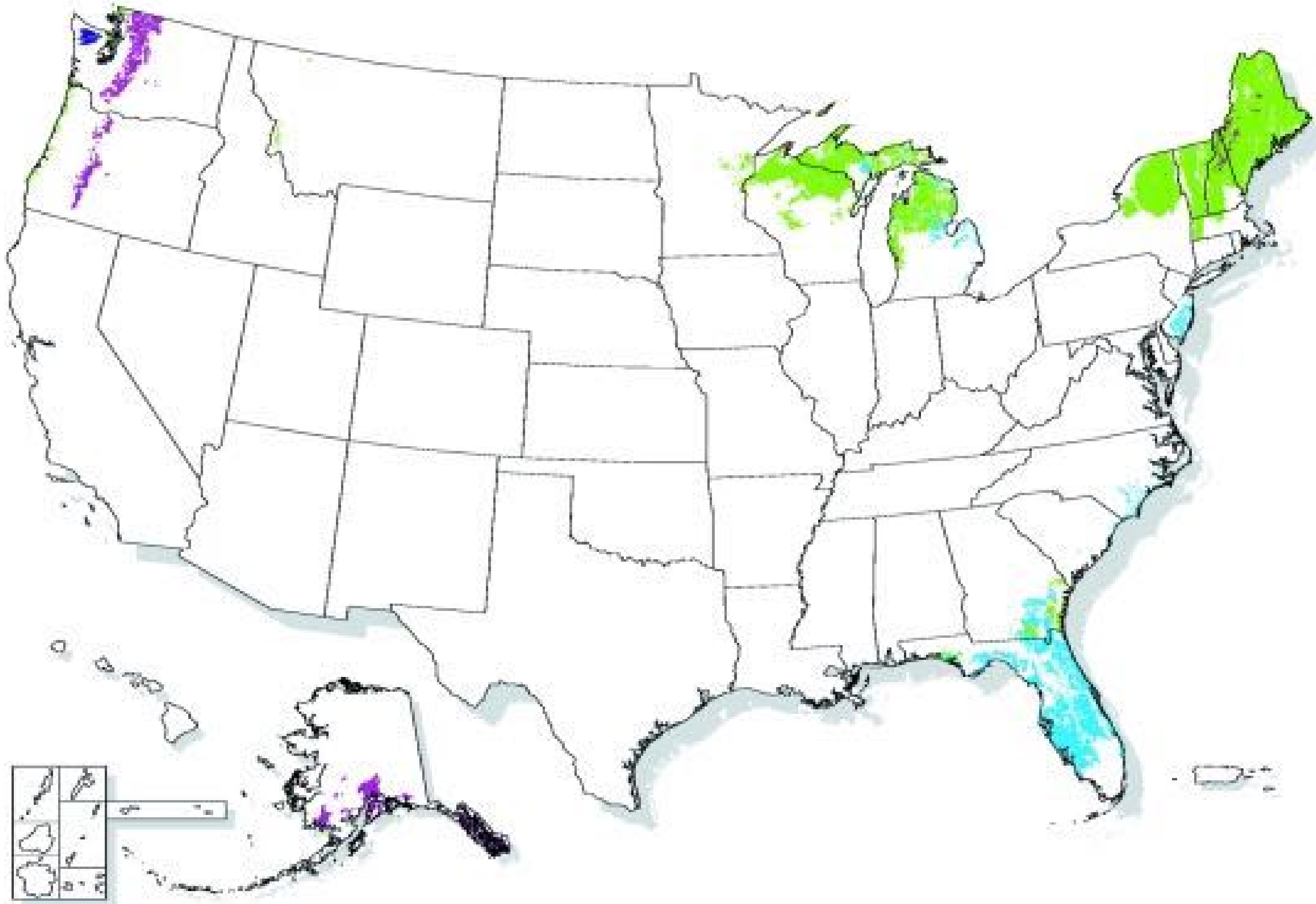


Oxisols have a clay fraction with a low cation-exchange capacity and have very few weatherable minerals. They have an oxic or kandic horizon and commonly have an ochric epipedon. Most formed under tropical forest vegetation.



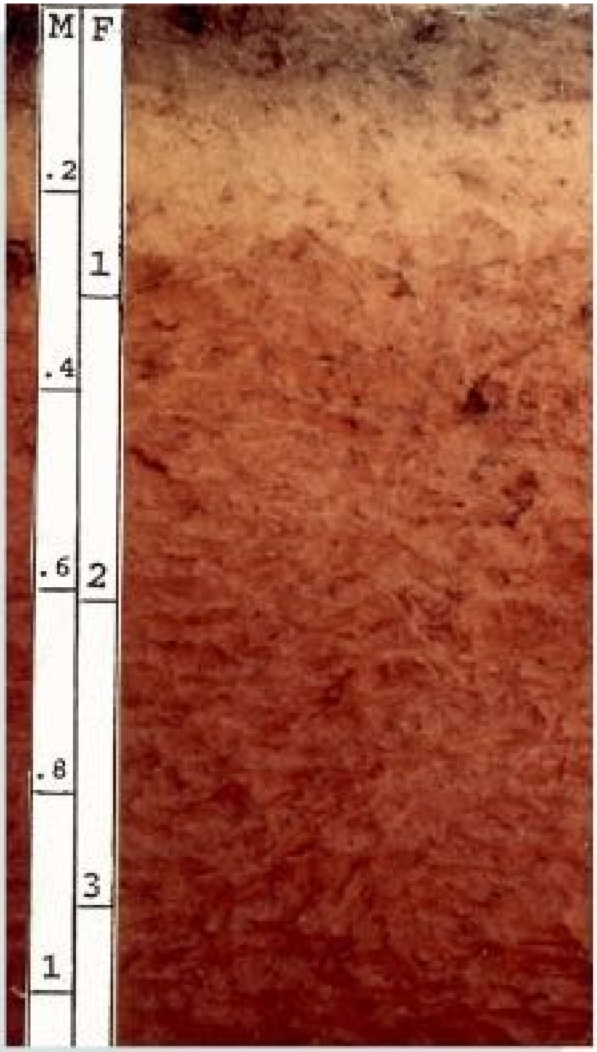
Spodosols have a spodic horizon and commonly an albic horizon and an ochric epipedon. Most formed under forest vegetation. Dominant processes are weathering and translocation of minerals. The colloidal fraction is dominated by Al-humus complexes and short-range-order minerals.

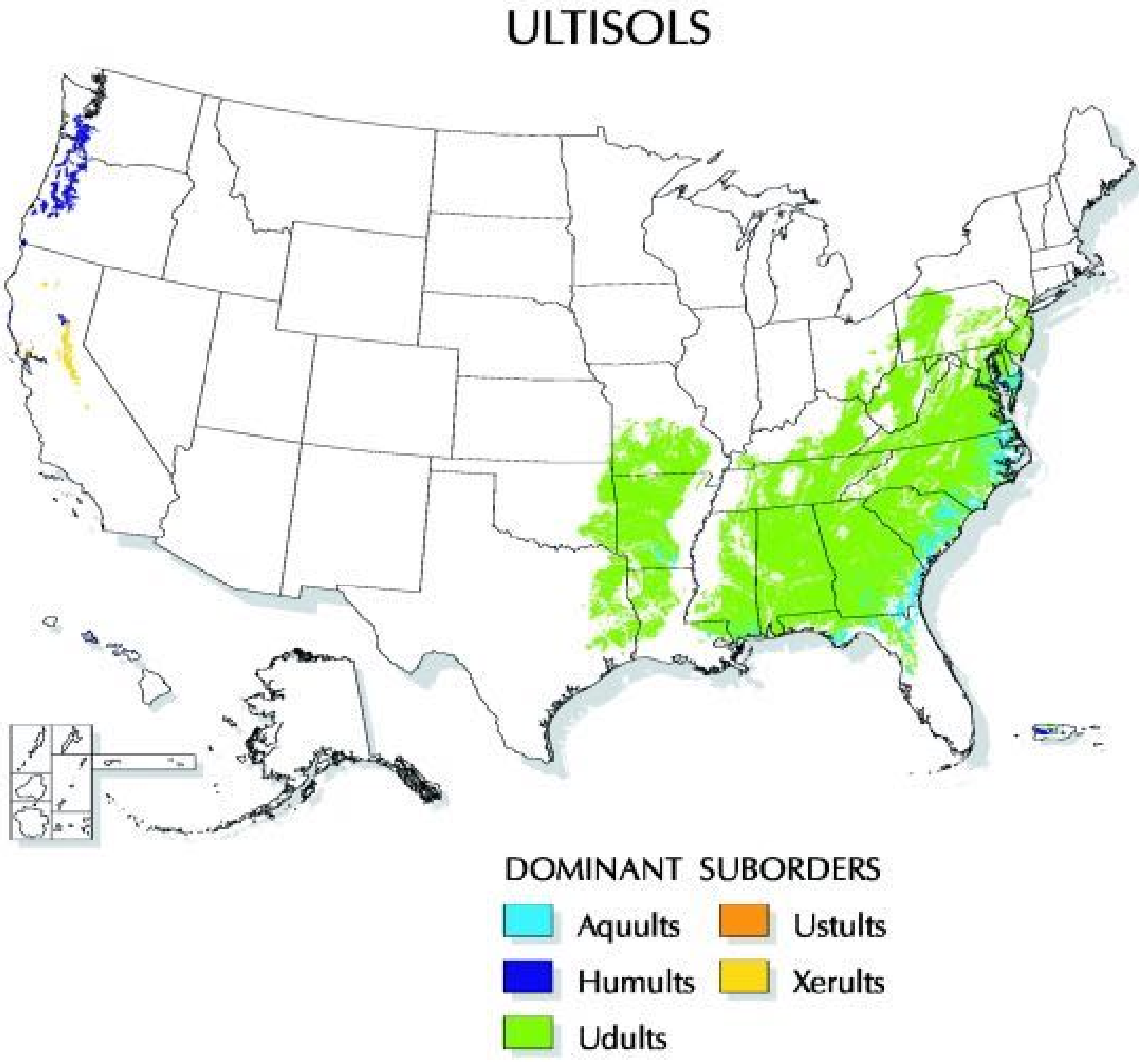
SPODOSOLS



DOMINANT SUBORDERS

- Aquods
- Orthods
- Cryods
- Humods

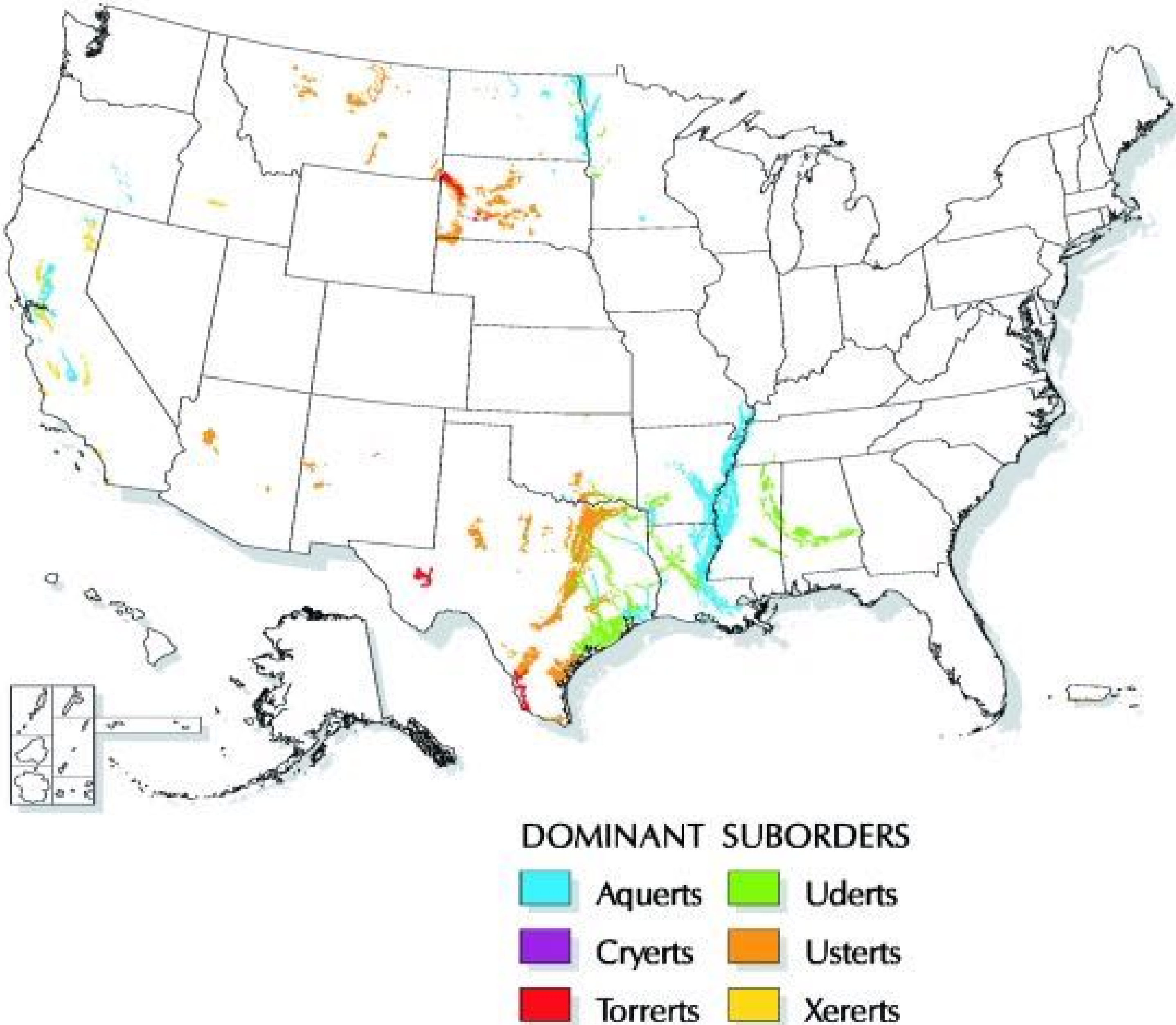




Ultisols have an argillic or kandic horizon and a relatively low content of bases. They typically have an ochric epipdon. Some also have a fragipan. Most formed under forest vegetation.

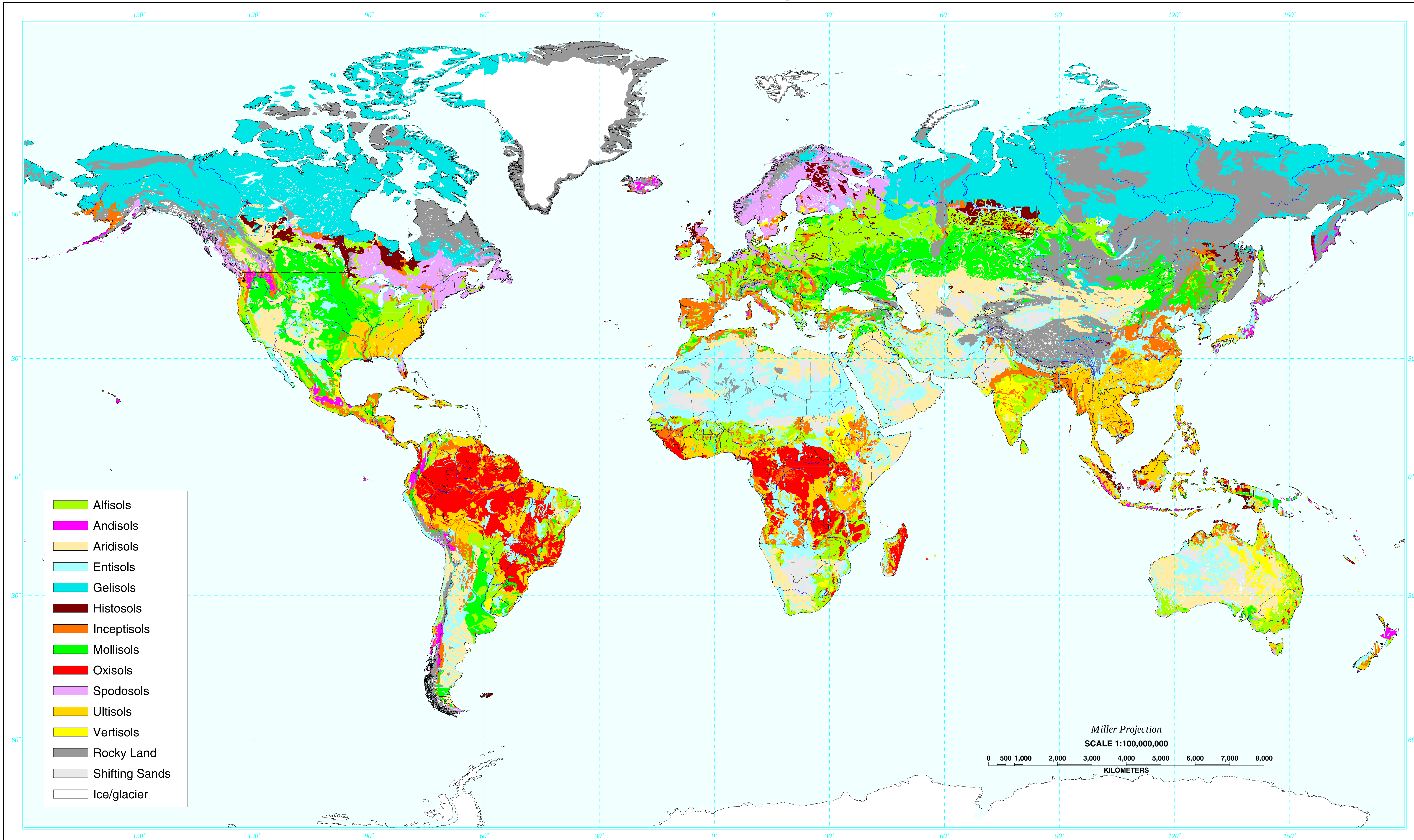
Vertisols are high in expanding clays that shrink when the soils become dry and swell when they become moist. Vertisols commonly have slickensides and develop deep, wide cracks when dry.

VERTISOLS



U.S. Dept. of Agriculture
Natural Resources Conservation Service
Soil Survey Division
World Soil Resources

Global Soil Regions



Country boundaries are not authoritative.

November 1998