Williams, Arthur Edward, Dagenham Dock, Romford, Essex.

Wood, Walter C., care of Messrs. Buchheister and Co., Ningpo-road, Shanghai, China.

The following candidates were balloted for and duly elected members of the Society:—

Bowen, Horace George, Bank of England, E.C.

Chalmers, George, St. John del Rey Mines, Morro Velho, Brazil.

Elliott, George, 10, Oceanic-avenue, Belfast.

Fortlage, H., Breakspeare-house, College-road. South Dulwich, S.E.

Rabbidge, Richard, 32, Poultry, E.C.

The paper read was—

ASBESTOS AND ASBESTIC: WITH SOME ACCOUNT OF THE RECENT DISCOVERY OF THE LATTER AT DANVILLE, IN LOWER CANADA.

By Robert H. Jones.

When the Canadian form of asbestos, which is technically named chrysotile, was first discovered, about a score of years ago, I had occasion to go over to Quebec to examine what, to all intents and purposes, was a new mineral, and report upon its qualifications and capabilities. I then became so impressed with its manifest importance, that I determined to make a special study of it, as well as of asbestos generally.

My inquiries after, and searches for, asbestos have naturally led me into many remote and untravelled parts of the world; and some few years ago I published a book on the subject, since which time, whenever any new discovery has been made, I am frequently sent for to advise on the special quality found, the best mode of working it, and the proper channels in which to dispose of its produce.

First, I will say a few words on its nature and historical relations.

Asbestos is one of the most marvellous productions of inorganic nature. It is a physical paradox: a mineralogical vegetable, both fibrous and crystalline, elastic yet brittle, a floating stone, which is as capable of being carded, spun, and woven as wool, flax, or silk.

Occupying the apparent position of a connecting link between the animal and vegetable kingdoms, it would appear to possess some of the characteristics of both, while being strangely different from either. In appearance, it is as light and feathery as thistle or eider down, while, in its crude state, it is as dense and heavy as the rock which carries it. Ostensibly as perishable as grass, it is older than any animal or vegetable life on earth. So little, indeed, is it affected by the dissolving influences of time, that the action of unnumbered centuries, by which the hardest rocks are worn away, has had no perceptible effect on the asbestos found embedded in them. While some portion of its bulk is composed of the roughest and most gritty materials known, it is as smooth to the touch as soap or oil. Apparently as combustible as tow, the fiercest heat cannot consume it, and no combination of acids will affect the strength of its fibre, even after days of exposure to its influence. Yet, notwithstanding its extreme delicacy, a single strand of it can be spun to weigh less than an ounce to one hundred yards of thread, and a cloth may be manufactured from its fibres which shall weigh less than eight ounces to the square yard, and still retain a fair tensile strength.

Perhaps, not the least remarkable of its many inconsistencies, is that, while in some form or other, it occurs in nearly every country in the world, it is never found to repeat itself. It nowhere appears, even in strata of the same age, in any two countries precisely alike, in appearance, texture, or general character, or in any two parts of the same country, or even of the same district. It varies greatly in accordance with different conditions of climate and locality, as well as of the nature and surroundings of the rock in which it is found. One remarkable difference, occasioned by variations of constituents, is shown in the sample of fibre from South Africa; and another, almost as startling, appears in one of the Australian varieties, which is of a bluish eucalyptus green. In some other cases, the variation may be the result of formation under different temperatures, or different rates of cooling.

Under the Romans, it was believed to be of vegetable origin, the silky appearance and unctuous feel of the fibre contributing to the idea that it was an organic substance. Herodotus tells us that his countrymen made a kind of cremation cloth of it, in which they enwrapped the bodies to be consumed on the funeral pyre, in order that the ashes and unconsumed particles of bone might be kept separate from the remains of the fuel, so as to be preserved in vases, or in the family urn. Pliny took it to be of vegetable origin, calling it *linum vivum*, but he says these were rare and costly cloths, the funeral dress of kings.

One of these shrouds was found in a sarcophagus in the Via Praenestina in 1702, perfectly intact, and can be seen to this day in the library of the Vatican, where it was placed by order of Pope Clement XI.

The religious care also with which the Romans guarded the sacred fires in the temples of the gods from extinction, caused them to make use of asbestos as an auxiliary, the flame having been first enkindled by means of a crystal sphere.

The lamps of the Vestal Virgins were furnished with asbestos wick, the fine fibres of which, by their contiguity, form small tubes or channels, which serve to draw up and feed the flame with oil, themselves remaining unconsumed.

Kircher, the German philosopher, formerly made a wick of this kind, which he says he used for two years without injury, until at last it was destroyed by accident; but Pontoppidan tells us he made one, but was obliged to discontinue its use, because he found he could not get so clear a light from it as from the common wick. The Greenlanders use them, and so do the Labrador Esquimaux. I have seen these last using them in Labrador, in their soapstone lamps. Asbestos wicks are used in England in some of the lighthouse lanterns, and are now being arranged for more general use.

A very interesting account of the mining for and use of asbestos is given in Marco Polo's "Travels in Great Tartary" (A.D. 1280), which is too long for quotation here, but the matter is so faithfully described that the account of it might have been written yesterday.

The late Prof. Ansted, of King's College, in his little work, "Rambles in Search of Minerals," tells us that certain tribes of Indians make dresses of asbestos, which they cleanse by throwing them into fire; but, unfortunately, he says nothing as to the whereabouts of these unknown tribes. When speaking of "tribes of Indians," one's thoughts seem naturally to turn to the Red men, dwellers on the American continent, but it is absolutely certain that those spoken of could have been none of these. Even the bare supposition that any tribe of savages could have accomplished the extraordinarily difficult process of spinning and weaving this refractory mineral fibre into a cloth, is just as wildly improbable as to imagine that any human being could have dreamt of using it as a covering for his bare skin. The difficulty of doing this—that is, of spinning it—is seen by placing a single fibre under the microscopic lens, where it looks as firm and rigid as a bar of steel, and shows none of the callosities or other irregularities of silk—and none of the imbrications, which make the spinning of wool so easy and natural. It is curious also that none of the old authors who speak on this subject attempt to describe the weaving process. We have now, however, ample proof that it was managed by intermingling some organic fibre, probably flax, with the asbestos fibre, and then, with a liberal supply of oil, weaving the two together, after which they burned out both the vegetable fibre and the oil. Naturally, the cloth so made must have been but a poor skeleton of what such a cloth should have been; and what is a little extraordinary is that this was precisely the process by which asbestos cloth was woven in modern days until, after long and repeated experiment, a more effectual way was found of accomplishing the operation by means of very ingenious and intricate machinery.

All these historical matters are very interesting, but asbestos to-day is of more importance to the human race than ever it has been before in the whole range of history.

In modern times—little more than five-and-twenty or, perhaps, thirty years ago—it was scarcely known, except in the cabinets of the curious, but now it finds its way into every workshop where steam is employed.

In recent times it was intended, in the first instance, to be applied in Italy for the manufacture of a special clothing for the protection of firemen; and afterwards, Paris set an example, which was followed by London after conclusive evidence of its feasibility. Captain Shaw says that there are certain cases in which it may be indispensable to traverse the flames in order to reach some particular spot, and it was for the purpose of preserving persons who find themselves in such circumstances that the Italian experiments were made.

In the general application of asbestos in modern times to the several branches of practical mechanics and industrial manufactures, it is to Italy that we are indebted for leading the way. Previous isolated experiments are recorded, but these do not seem to have been followed up until long afterwards. In the last century, for instance, Professor Bruckmann of Brunswick was successful in the manufacture of paper, on which he caused to be printed a natural history of the mineral,

some copies of which book are said still to be preserved in the museum of Wolfenbuttel; and early in the present century, a Madame Perpenti of Cone successfully employed asbestos, not only in the manufacture of paper, but of cloth also, and a kind of coarse lace, with many other articles of a useful character. It is specially noteworthy in regard to this cloth that in her make Madame Perpenti used no other fibrous ingredient as an admixture. Her process simply consisted in softening the asbestos in water, beating and rubbing it, and finally separating the fibres by means of a comb furnished with fine steel points.

I have only been able to refer to a few of the earliest adaptions of this mineral fibre, because it would take far too long to explain or give any attempt to enumerate them, or even give more than a general mention of some few of its uses in steam, hydraulic and electrical machinery, in which a multiplicity of packings, &c., now find a place. The various coverings also designed for the protection of boilers and pipes and for the economy of fuel are specially important and very numerous, as well as its varied applications to engineering and electrical purposes. It is also of great importance in many matters connected with warfare, and in medical and hospital practice, though in the latter it is, fortunately for us, not used as it is said to be in China, as a medicine. In regard to its use as lint, the editor of the *Engineer* remarked, some time ago, that although we may never reach the time when our undergarments shall be purified by fire, instead of by the laundress's art, yet, short of this, many uses now fulfilled by materials—the thorough cleansing of which cannot be secured without their destruction — may possibly be better served by asbestos. Of these, the cleansing of lint is one, with medical bandages, operating cloths, &c.

In these days of high pressure and liner records across the ocean, asbestos is of supreme importance to the marine engineer, to enable him to obtain jointing and packing materials upon which absolute reliance can be placed. The natural properties of the mineral admirably adapt it for such purposes as these, its native lubricity rendering it additionally valuable; by its use a perfectly pure packing can now be produced through which the rod slides with a minimum of friction.

Its numerous uses for building purposes may also be referred to, many of which are rendered compulsory in the United States, where asbestos is far more largely used than it is here. Its usefulness in the form of drop curtains is generally understood there, and in New York and elsewhere is made compulsory, as, it is to be hoped, it will be some day so rendered here. A part of one of these curtains which withstood the fire at the Queen's Theatre, Manchester, in August, 1890, I will show you. This was made by the United Asbestos Company of London, and was given to me by the secretary and manager of that company.

For cold storage buildings and refrigerating chambers, it is simply invaluable. For the preservation of meat and other provisions, brought from distant lands, specially constructed ships containing the necessary refrigerating apparatus and chambers are now in universal use.

In beetroot sugar refineries in France, Germany, and Austria, fine asbestos cloth is in universal use for filtering the saccharine juices. It is necessary also in chemical laboratories for straining and filtering acids and alkalies, which would quickly destroy any ordinary filtering paper; and it is specially useful when the liquid to be filtered is of a caustic or strongly acid nature, or where it may be desirable that the filter, with the residue, should be ignited without consuming the filter, or where the residuum is to be dissolved off the filter by acids or other solvents. Asbestos filter bags are better fitted for this purpose than those made of any other material; they last longer, retain the heat better, and are more easily purified. For filtration purposes generally, asbestos has proved to be so eminently adapted that it forms a material adjunct to the filtering media in all the more important filters now in use.

Being one of the most refractory substances known, asbestos is in use in a variety of ways for the lining of furnaces and the backing of stoves.

For insulation purposes, it is much in use by electrical engineers in the form of millboard in the construction of dynamos.

A special quality of asbestos paper is also made for wrapping battery plates in, and gloves are made of asbestos cloth for holding red-hot crucibles, and to enable the engineer to handle the wires with comparative impunity.

As already mentioned, asbestos in modern times was first brought into experimental use in Italy, and soon afterwards the United Asbestos Company, having acquired the

Italian works and mines, started the manufacturing business in England.

It was not long afterwards that there appeared amongst us a totally distinct variety of the mineral, which had not long before been discovered in a wild and unpopulous part of the province of Quebec, in Lower Canada; and though it was not very favourably received at first, its economic value could not long be ignored, and experience has shown that while the two varieties are totally and curiously unlike, each has certain special uses and advantages, and, indeed, a combination of both is occasionally to be preferred to the use of either one of them separately.

The difference between the two forms of mineral is remarkable. The asbestos of Italy is asbestos properly so called. It is a variety of hornblende, or pyroxene, while that of Canada is nothing more than serpentine, which occasionally, but only rarely, assumes a fibrous character. When it so occurs, its mineralogical name is chrysotile. In form, structure, and general appearance, the two are as strangely dissimilar as any two minerals can possibly be; yet, in chemical composition they are remarkably alike, and, in many of the uses to which they are put they may be said to be absolutely identical. Indeed, to such an extent is this the case, that by far the larger part of what is sold and used for asbestos, is in reality chrysotile, which is so used and sold with full knowledge of the fact that it is so, and without any pretence of concealment or disguise whatever. The essential difference between the two, is that Italian asbestos is anhydrous, while the Canadian chysotile, being serpentine, is invariably hydrous, its water of composition amounting to between 13 and 14 per cent.

The first Italian mine was opened in Lombardy in 1866, and the first Canadian mine, at Thetford, in Lower Canada, in that part of the country which is known as "The Eastern Townships of Quebec," about the year 1877. Some considerable time before this date, the existence of the mineral there was known to geologists, and it was also exhibited at the International Exhibition in London as early as 1862, though, at that time, it was not much regarded, except by scientists, and by them chiefly as a mineralogical curiosity. But this first mine was no sooner opened, though its success at first was by no means promising, than others quickly followed, and prospecting for fresh finds was extensively carried on in every part of the province.

Somewhere about this time, a good many new mines were started, but in no case did the produce of any one of them come up to that of Thetford, which still maintains its old snpremacy, both in regard to the quality of fibre and the quantity produced.

Among these new mines, was one which was discovered near to the pleasant village of Danville, in the township of Shipton, a good many miles from the headquarters at Thetford. This mine, from its first discovery, was worked, with a fair amount of success, by a Mr. Jeffrey; but at no part of its career, up to the time of its closure—which happened shortly before the death of the proprietor—was it looked upon as of any particular importance, though its produce was invariably good and generally considered to be second only to Thetford, and much beyond anything to be found at Black Lake.

Mr. Jeffrey, whom I well knew, gave his name to the mine, or rather it was always known—and to this day is generally spoken of as—the "Jeffrey Mine." He was a well-known character among asbestos men, somewhat obstinate and self-willed, and strictly a man of the old school—independent in his ideas, by no means highly educated, and never much inclined to move out of the old grooves; indeed, his style of work might be said to have been that of the "rule of thumb." As the years rolled on, he became hampered with contracts and other matters, which presently landed him in pecuniary difficulties to such an extent that at last he found himself under the necessity of assigning the whole of his property to trustees, for the benefit of his creditors; very shortly after which the mines were closed.

Some time subsequently, proposals were made to Mr. Boas, of St. Hyacinthe, either to take over the mines or to render financial assistance, with a view to a resuscitation of the works.

Mr. Boas was a man of an entirely different calibre to that of the late owner. He was not an asbestos man, nor did he make any pretence to a knowledge of mineralogy, but all throughout the province he was highly esteemed for his uprightness, shrewdness, and sound common sense. On going over to inspect the Jeffrey mine he was soon satisfied of the character of the fibre, which, with proper management, he was assured could be made to yield valuable returns. But what struck him most of all was the apparently unusual character of the rock which carried the fibre, the texture of which was such as

he had never remarked before. It was certainly quite different from the ordinary run of asbestos-bearing serpentine which he had met with anywhere else, and it then occurred to him that it might be possible to convert such a rock into many important uses, instead of allowing it to be carted away and thrown on the dumps as waste. After reflecting on the matter, he set about making a series of experimental trials, the result of which showed him that he was entirely correct in his conjectures. He therefore decided to take over the property, and, as soon as the necessary arrangements were completed, set about erecting such buildings and fitting up such improved machinery — nearly all of which was automatic in operation—as were an astonishment to the country, and then began to work the mine as it was never worked before. His efforts in this direction soon began to be crowned with the success they deserved. His untiring energy and activity brought him many visitors to see the operations carried on at the mine, while his friends and neighbours were not slow to perceive that, at the very time when his predecessor was most in want of funds, a veritable gold mine lay unheeded beneath his feet. Some began to blame Mr. Jeffrey for being unaware of this, but if he were to blame, to how much greater an extent were all those numerous scientific men, geologists, mineralogists, mining engineers, and others who, in course of that time, had called purposely to inspect the mine, report upon, and write about it? Every one of these may be presumed to have had better, that is, more highly educated eyes than he could have had. The rock was of precisely the same texture as it had always been, but no one before this time had ever remarked anything peculiar about it. The time had evidently not yet come. The extreme importance of the matter remained unknown, until it suddenly encountered the (unpractised) eye of keen intelligence, when at once the whole thing became so manifestly self-evident that, as was the case with the famous egg problem solution, the spectators could only wonder where their eyes had previously been.

Before the time of the publication of my book on asbestos and its uses, I had more than once visited and inspected every mine in the eastern townships of Quebec, and was well acquainted with their different peculiarities and capabilities, with the single exception of this particular one at Danville. Why I neglected this I cannot tell; but so it was. Mr. Jeffrey several times invited me to go over there, but never once, in my many visits to that part of the country, did I ever avail myself of the opportunity of doing so. It was a long way from the other mines, and no doubt I was under the impression that this was mainly like all the rest, and scarcely worth the time and trouble of a special journey. At the same time, I would emphatically disclaim all idea that, had I done so, I should have discovered anything special about it, any more than Mr. Jeffrey himself had done, or any one of the numerous scientific or professional men who had already inspected and written about the mine. As an asbestos man, it is quite conceivable that my attention would at once have been attracted to the important consideration of the number, extent, and quality of the veins and seams of asbestos, to the neglect of any special peculiarity, altogether undreamed of before, in the texture of the surrounding rock. On the other hand, Mr. Boas was, as I have said, not a mineralogist or an asbestos expert, and was, therefore, untroubled with any preconceived notions. He simply looked on the matter with the keen eye of unprejudiced common sense. When I was told first of the discovery, I remembered that something like it had often occurred to my mind, but my thoughts were always directed to the question of the possibility of so crushing the rock, as to see a way to the extraction of the numerous small veins and stringers, which are commonly seen in asbestos mines, but which I afterwards found are by no means prevalent in that of Danville. This seemed to be scarcely worth the expense which would have had to be incurred, as it could have been only accomplished by the aid of special machinery; and when the description of what Mr. Boas had done was first reported to me, I could only regard the story as the effect of a too vivid or sanguine imagination. But when at length I reached Danville I was strangely undeceived. On going down into the pit to examine the result of a blast, before any of the *débris* was touched, I was literally astounded. Instead of, as I had expected, finding the result to be as 1 in 50, or even 1 in 100, I could plainly see that, regarding the mass of rock as a whole, it was undoubtedly and at the very least 90 per cent. of pure asbestos, or asbestos-like material, the like of which I had never seen before. And when I subsequently saw this very rock, after it had passed the crushers and sifters, falling automatically, without any handling whatever, from the

cyclones as pure asbestos fibre, white as the driven snow, I thought the sight of that well worth the journey from London to Canada.

I have here for your inspection a sample of the most useful of the Italian ores, with a specimen or two of Canadian ore from Thetford and East Broughton, so that you may see the strange mineralogical difference between the two species, also a sample of the Danville ore and fibre, with a lump of asbestic, which is the rock which carries the latter, and also a sample of the cleansed material, just as it falls from the cyclone, ready for use by the manufacturers. To these I would presently call your special attention in order that you may see in particular the wonderful nature of the rock itself, which is found at Danville. No lens is required, its very peculiar character being sufficiently obvious to the unaided eye.

In the Italian deposits, one often finds minute crystals of green coloured garnet, which the miners call the asbestos seeds (*semenze dell' amianto*). None of these are ever seen in the Canadian mines, but at Danville I have frequently found remarkable specimens of clear light-coloured translucent serpentine. I will show you a specimen of this, being part of a vein of pure silky fibre covered or protected by a rich delicate skin of a charming tint of light green as lovely as that of a newly expanded willow leaf in spring, yet this is in itself as clearly and compactly fibrous as that which is held compressed in the vein.

I suppose few things are better understood than this trade fact, that when any valuable or unusual commodity remains for a long time at an almost prohibitive price, on account of the difficulty of its production, so that manufacturers have been continually driven to the use of substitutes in place of the real thing; when this material happens to be, by any fresh discovery, suddenly brought down to a price within the reach of all the world, one invariable result follows. Such an impetus is given to the use of that commodity, and such an effective spur is applied to the inventive faculty, that an incredible number of uses for it are at once found, and the trade in it quickly advances by "leaps and bounds," just as is already the case with this.

One remarkable fact in connection with the discovery of asbestic is that the firm which stands at the head of the trade—that is, which is the largest dealer in, and manufacturer of, asbestos and asbestos goods in the whole world—I mean the consolidated firm of the H. W. Johns Manufacturing Company of New York, after a full investigation of all the facts connected with this matter, proceeded to make contracts of such an extent that the immediate duplication of the whole of the Danville machinery was necessitated, although it was then already by far the most extensive and effective in Canada.

With regard to this machinery, I will only say that it is unique, and well worth the inspection of any one to whom the opportunity of seeing it is afforded. The building in which it is housed is a substantial five-storey structure, so arranged by the hillside that the laden wagons can drive straight through the doorways and along the passages, to deliver and take up their loads at the required points, on four out of the five stories of the building, which is admirably ventilated and lighted in every part by electricity. The roof is covered with asbestos, and considerably more attention has been given to external appearance than I have ever seen before in mining buildings. Another building stands close alongside as an annexe, the lower part of which is utilised by the engine and boiler house.

At the front entrance to the fourth floor are seen the huge lips and jaws of the mighty crusher, which lies recumbent beneath. These lips and jaws are ever moving and at work, as one might almost imagine them to be those of a cow peacefully and slowly chewing the cud. As the masses of rock are hauled from the bottom of the pit, they are placed on cars and moved onward over the rails to the front of the crusher, where they are dumped on to the iron platform, near to the working jaws, towards which they slide and into which they gradually enter and disappear, a lump of a ton weight being drawn in with apparent ease and quietly masticated by the huge monster, which weighs 48 tons. The mastication consists of so carefully crushing the rock as in no way to injure the fibre.

There are four other crushers, two of which are duplex, making seven in all, the least powerful of which weighs seven tons. These are situate in various parts of the machine's anatomy; the machine itself being apparently so far a sentient animal, that it requires no assistance whatever in the digestion of its food, but hour after hour and day after day its process of digestion goes continuously on, working gradually, smoothly and automatically, until after the rock has left the crushers and passed through several sets of Cornish rolls, over a gigantic picking table, and has

undergone the ordeal of no less than twelve cyclone pulverisers with a whole series of fans, exhaust blowers, revolving, shaking and jigging screens, with the rest of the complicated apparatus, the spectator, as he proceeds onward, presently finds himself standing at the foot of a long gently sloping table. To this there is imparted a constant jigging motion, so that everything which touches it is irresistibly impelled to join in the dance, and slides slowly along jigging, jolting and jumping, onwards and downwards, until it reaches the lower end of the table; by which time the fluffy fibre is entirely separated from all gritty particles, when, as these last approach the edge they are gradually jerked over to be dealt with further on; while the fibre is acted upon by a strong upward current, by which it is drawn, or sucked, into a pendent receiver, after the fashion of pieces of paper carried by a draught up the chimney, where it disappears from view. Now, if we leave the concluding process and proceed to the lower floor, we shall see the result exuding from the orifice of a pipe, and falling in flakes of immaculate whiteness into bags placed there to receive it, in which it is firmly compressed and fastened up. The bags, which hold 100 lbs. each, are then loaded into waggons waiting in readiness to receive them, for conveyance by the Grand Trunk Railway on the road to their ultimate destination.

Thus, from the time that the rock is drawn from the pit, until the fibre reaches the manufacturer, no handling or interference of any kind is needed, but everything is carried on systematically and automatically, the sole exception being the employment of a single lad, whose duty is to watch the cyclones and see that they do not become clogged by reason of the fluffiness of the fibre.

Another very important and remarkable matter for consideration is that a majority of the more clear-sighted owners of the other mines, seeing at once the impossibility of any competition with Danville at anything like present or recent prices, determined for the present at any rate, without burning their ships, to close their works and await the progress of events. Their wisdom in following this course is at once apparent, when we see at what a heavy cost we arrive at the value of the crude asbestos, and its expensive character, both in labour and the extent of land required for dumping ground. The removal and disposal of the *débris* of the mines, which is incessantly increasing, is far and away the most expensive and troublesome part of the whole system of asbestos mining. In this regard, it may be worth mentioning what a well-known mining engineer says on the subject. Mr. Klein, the manager of the American Company's mine (formerly Wertheim's), who is an experienced and thoroughly reliable man, recently delivered a lecture at the Asbestos Club at Black Lake, the members of which are no inexperienced novices, but all mine owners, managers or engineers—men who would quickly have contradicted his statements, had contradiction been possible. In this lecture, while dealing with this very important part of the subject, which had necessarily to be referred to, the lecturer stated that in almost every case he had found the amount of waste in the mine to be understated in the returns and reports; that in the very best mines it could not be put at less than fifty tons of waste for every single ton of asbestos produced. And here I can well imagine a smile rippling over the faces of the audience, for the lecturer immediately began to qualify this statement by saying that, in his own belief, a hundred tons would often be much nearer the mark, and that even a hundred and fifty was by no means unknown. But even this is not all; the enormously-increasing mounds of waste, piled up around the various mines, have generally become intolerable to such an extent that in two cases extraordinary measures have had to be taken to get rid of them at any cost.

In the case of the United Asbestos Company, the form of their land at Black Lake is of so inconvenient a character that, in the course of time, it was found they could dump no more without trespassing on their neighbour's land; so, in order to prevent a stoppage of their work, the company was under the necessity of building an inclined tramway, 3,800 yards in length, by means of which cars could be drawn up the mountain side as far as the shores of Cariboo Lake, where, for the present, they could find room for dumping.

In another case, the extent of the company's holding was seriously curtailed by the decisions of the local and superior courts in the actions brought against them by their neighbours for encroachment. This was of more far-reaching importance to them than the very heavy pecuniary compensation they were compelled to pay for the quantity of asbestos they were alleged to have taken from their neighbour's land. At any rate, these

decisions of the courts left them but one way out of the difficulty, and that was to purchase land on the far side of the track of the Central Quebec Railway, across which they had to build a line of their own, and over which their dumping cars are now drawn by means of an overhead bridge. By the adoption of this costly expedient alone have they at last been enabled to get rid of their waste rock, the constant accumulation of which was shutting them out in every other direction.

This is one of the ordinary expenses incident to asbestos mining which so greatly tends to keep it at such a high price. It can therefore readily be seen that if once this enormous expense was swept away, how effectually the prime cost of the mineral could be reduced, more especially if that waste were waste no longer, but actually a substance convertible into money. This is precisely the effect of the discovery at Danville.

Now, after what has been said, two main questions will occur to the mind of every one. First, why cannot the waste of the other mines be utilised in the same way as that of Danville? And secondly, if there be any special reason why it cannot, then for how long a time is it likely that this particular mine will remain unexhausted? To the last question I reply, without any hesitation, that unless some entirely new discovery be made, the Danville mine cannot possibly be exhausted by any imaginable process of working for very considerably beyond the period of one hundred years. In fact, the mine to all intents and purposes, is practically inexhaustible. And as to the other point, none of the mines elsewhere produce asbestic, the nature of the rock being entirely different from that of Danville. I have already shown why the various mines differ in the quality of their fibre, and have no doubt that in one or two of them something approaching to this may be produced, but to what extent is as yet unknown, and whether or no it will return a profit also remains to be seen. At one mine the process was tried with somewhat similar machinery, though only on a small scale. In the first place about two-thirds of the rock was found to be so manifestly inapplicable that it was at once rejected. The remainder of the dumping ground was then picked over, and a good part of the rock passed through the crushers, sifters and cyclone, with the result that from this portion of selected rock some bags of "float" were obtained which was not much like that o Danville. No sale could be found for it, and the mine is now closed.

Well, what after all is asbestic? A dictionary will tell us that the word is an adjective, meaning something "of or belonging to asbestos;" but, as used here, it is a substantive, applying to that part of the rock which remains after the richer veins of asbestos have been extracted from it. This remainder is purely a fibrous material, which clearly shows its serpentinous origin. And here a very remarkable fact may be mentioned. The knoll-like mound in which the Danville mine is situate, is one only of a series of similar mounds which run a long distance through the country—all through the townships of Melbourne, Cleveland and Tingwick, and, after all these knolls had been carefully inspected, no single one of them was found to carry any fibrous material but this Danville one alone, in which all the fibre found in this part of the country would seem to be concentrated.

On the question of its production, as we have already stated, asbestos is nothing more than serpentine, that is serpentine in its peculiar fibrous form, which it assumes much less frequently than is generally supposed; and, when it does occur, has many peculiarities. Most minerals, as we well know, are sensitively affected by the nature of their surroundings, and especially by their more intimate associates. Even gold is no exception to this rule, as witness the effect of its association with bismuth; but I know of no mineral which is so readily affected by its associates as serpentine. This is sensitive to such an extreme degree that it might almost be called a sentient rock. From this point of view, nothing like sufficient attention has been paid to it by asbestos men, though everyone can see its alterations in every asbestos mine in the country. As a matter of fact, so many, so various, and so supreme are the changes brought about by its variable associates, that, although in some form or other asbestos can be found in nearly every part of the world, there are, as already remarked, in no two countries any two mines to be found which produce exactly the same class of fibre; and this is true, not only of any two countries, but of any two parts of the same country, and even of any two parts of the same district. In reality, it is never and nowhere the same. The difference may be slight, and may be either in colour, form, or texture. Doubtless, either the colour of the rockor the fibre itself

is so regulated that the one affects, or is affected by, the other; but to show the fact of the existence of this peculiarity, one has only to compare the fibre and its containing rock—such, for instance, as it is at Thetford—with that which is produced at Black Lake, and either of these with the produce of Broughton, Lake Nicolet, Brompton Lake, the Ottawa Valley, or, over and above all, with the special material which occurs at Danville, and which, at present, stands alone.

Before this time—provided the veins were long enough or wide enough, and the fibre in them sufficiently silky—no one paid any regard to minutiæ. Asbestos was simply asbestos, just as serpentine is serpentine. But in future much more attention must be given to this vital matter, for upon it will depend the existence and utility of many mines. In fact, the day is rapidly approaching when far more attention must be given to the study of mineralogy generally by mine owners and their superior *employés*, as well as to the special qualificatians of the local serpentine. It is to the neglect of these important matters that the new discovery has fallen in their midst with the suddenness of a thunder clap.

Now, a few words on the particular uses of asbestic as apart from asbestos. The first idea which occurred to the discoverer was to pulverise it, and to convert it in its pulverised state into a cement or plaster. A few bags were sent to the manufacturing firm of H. W. Johns and Company for trial, when they found it to be so admirably adapted for this special purpose, and so unique from many points of view, that it was at once named "the king of wall plasters." In its manufacture it requires the use of neither hair nor sand, its own fibres furnishing a perfect substitute for the former, and the pulverised rock supplying all that may be required of the latter. During the short time since its introduction, although the number of men employed in procuring it is unusually large, and the machinery employed in its preparation entirely automatic, the supply is found to be unable to meet the demand. This plaster, being composed exclusively of asbestos, is both fireproof and a non-conductor of heat, so that a room plastered with it is not only protected from fire, but at the same time is kept warmer and more comfortable than if dressed with any other known plaster. It also effects a saving of something like 25 per cent. in the fuel employed; and being also a non-conductor of sound, bedrooms may be relied upon, if the spaces beneath the floors and over the ceilings be filled with rough asbestic, to be free from overhead or internal noises. Its use also is invaluable, for the same reason, in hospitals and sick rooms, as well as in music and concert rooms. It is moreover odourless and vermin proof, and being a natural filter, if a pail be upset in the room above so that the underneath ceiling be wetted, it dries again as before and leaves no mark or stain. It is also as elastic as fibrous, so that there is no fear of any crumbling, chipping, fracture or displacement. Even if a nail be driven into it, it will enter as readily as into a deal board. Neither the heat from any stoves or furnaces, nor even the "settling" of a building, will have any effect upon the asbestic. It will adhere to metal or glass, and I have seen it applied as a covering to a tin pipe, its adhesive nature preventing any crack or split when bent round the pipe; and when walls are papered or painted with it, all danger from fire from that source is entirely avoided. When walls are plastered with it, no sooner does it become dry than all danger of having to do it again after the settlement of the building is entirely done away with.

I called at many of the huge buildings now rising about New York and Montreal, following the example of Chicago, and saw its practical use while building was going on. A coating of rough asbestic was first applied with a trowel, just as it would be with any other plaster, it might be on brick, laths, or plain boards; and, when this is dry, it forms a coating very much like the asbestos felt-board now so much in use in America and Canada. This rough coating is then surfaced over with a superior quality of asbestic called the "Finish," which dries with a fine appearance not unlike marble, and with a good polish. Its cost is about the same as that of good sand and lime plaster, which its covering capacity greatly exceeds, while its mixing is so simple, and its application so easy, that it is found to be practically cheaper.

There is a peculiar danger to be feared in all these lofty buildings, which are now so much the fashion over yonder, which specially arises from their framework. Both iron and steel are so much affected by heat that, if a conflagration should occur near to one of these Babel-like buildings, the girders would become so affected that they would be likely to bend downwards, in doing which they would assuredly draw the uprights towards

them, and cause a general collapse of the whole structure. I saw the action of this immediately after the destruction of the Tuileries and other large buildings in Paris in the time of the Commune. The plan adopted was to pile the furniture, and such other combustible matter as was at hand, in the centre of the principal room, pour petroleum over it, and then set fire to the heap. The great heat soon caused the girders to sag downwards, drawing the sustaining walls inward, so as to cause speedy and irretrievable ruin. In the case of the monster buildings alluded to, if the metal skeleton were protected by brick, and the brick plastered with asbestic, all danger from the source indicated would be avoided. This is the plan adopted at the Waldorf Hotel in the Fifth Avenue, and many of the modern buildings in New York.

Asbestic is also applied, by the manufacturers already mentioned, to the making of a special roofing material of a perfectly light and cool character, which is so effectually proof against burning sparks and cinders that, in every case of exposure to fire it has proved to be a complete protection. It is specially applied to the steep or flat roofs of factories, foundries, warehouses, railway buildings, cars, &c. It is suitable for all climates, has been used in every part of the States, and in parts of South America and Europe, for a sufficient length of time to show its superiority over corrugated iron wherever used.

In 1861, the roofs of Kingsford's Oswego starch factory were covered with the original asbestos roof coating, which is still in good condition. This is now vastly improved in strength and durability by the use of asbestic, and specially improved asbestic roofing has now become so important, and in such rapidly increasing demand, that it is manufactured at the enormous rate of *over two miles per day*.

For paper making, asbestic is so admirably adapted that it has now taken the lead in the United States of any other commodity used for the purpose, whether of wood, straw, or any kind of pulp. Wherever it has been tried, it is found to carry everything before it, and there can be little doubt that as it becomes more generally known its use will become universal. The demand for it is already so great that in the course of last year the H. W. Johns Manufacturing Company had to put up an immense new building adjoining their other manufacturing premises at Brooklyn, for the special purpose of producing asbestic paper, more especially for building purposes. Here I saw in operation a new machine capable of producing it of a very superior quality at the rate of from 30 to 50 tons per day, and of a width of 130 inches. This new building was specially erected in consequence of the vast discovery of asbestic fibre at Danville, which enables the manufacturers to enter into competition with any kind of wood or straw pulp paper now used in the trade.

There can be no doubt that, properly prepared by careful working, the shortest Danville fibre will before long become an important factor into the paper trade generally, it being of a pure white colour and of remarkable fineness, while the trade can buy it at a price much below that of any other material now in use by them. During the last year the increased consumption of asbestos by this firm was, notwithstanding the depression in prices and trade generally, nearly four times that of any former period, and this was entirely attributable to the Danville discovery.

When any of these revolutionary changes occur in any particular line of business, as is now taking place in the asbestos industry, matters are always disorganised, and many people seem to be involved in ruin, but things very soon right themselves. The new discovery has given such an impetus to the trade that no day passes without new applications of asbestos being brought to the notice of manufacturers, and very shortly more asbestos will be required and used than ever before; and when things have quieted themselves a little, and old practices have become discarded, means will be found for utilising the now standing properties and (as I believe) making them more flourishing than ever.

Perhaps no one who seriously regards the subject-matter of the paper read before them this evening will fail to see the great importance of it, and how extensive a field is now laid open to the discoveries of scientific men. The present discovery was not due to science at all, but to the unaided intelligence of keen common sense. Its extraordinary value is shown by the fact of the promptness with which the entire capital of the company recently formed was secured by the manufacturers and the few capitalists who had looked into the matter, rather than by the general investing public, to the great majority of whom asbestos—and all that relates to it—is, in a great measure even now, practically a sealed book.