CONSERVATION OF WATERLOGGED LINOLEUM

A Thesis

by

BOBBYEJO EVON COKE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

December 2004

Major Subject: Anthropology

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Approved as to style and content by:

C. Wayne Smith (Chair of Committee)	Marvin W. Rowe (Member)
Donny L. Hamilton (Member)	David L. Carlson (Head of Department)

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ABSTRACT

Conservation of Waterlogged Linoleum. (December 2004)

BobbyeJo Evon Coke, B.S., Texas A&M University

Chair of Advisory Committee: Dr. C. Wayne Smith

Linoleum has been around for over a hundred years. With its invention by Frederick Walton in the 1860's a new means of durable floor covering was introduced to the world. This new invention was promoted as durable, hygienic, and easy to maintain. In agreement with the Lake Champlain Maritime Museum, a study was commissioned to seek the best means to conserve linoleum from a canal boat excavated in the summer of 2002 in Lake Champlain. The Sloop Island Canal Boat is part of an excavation project that is studying the ways of life on the lake. Conserving waterlogged linoleum is a new area of study in conservation, and there is very little information dealing with the topic. This study will provide a baseline for the conservation of linoleum.

ACKNOWLEDGEMENTS

I wish to thank the members of my committee, Dr. C. Wayne Smith, Dr. Donny L. Hamilton, and Dr. Marvin W. Rowe, for their support and guidance to my project. I would also like to thank Chris Sabick and Adam Kane from the Lake Champlain Maritime Museum for all of their help and allowing me the opportunity to work with them.

I would like to thank my parents, Rocky and Kathy Coke, for their love and support. To them I am grateful for their guidance and for not giving up on me. I would like to thank my brother, Dr. Rob Coke for all his inspiration and encouragement. And finally to Paige, you rock!

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CHAPTER I

INTRODUCTION

Linoleum, the ubiquitous flooring of the 20th-century, has been around for over a hundred years. With its invention by Frederick Walton in the 1860's a new means of durable floor covering was introduced to the world. This new invention was promoted as durable, hygienic, and easy to maintain.

In agreement with the Lake Champlain Maritime Museum (LCMM), a study was commissioned to seek the best means to conserve linoleum from a canal boat found in Lake Champlain that was excavated in the summer of 2002. The Sloop Island Canal Boat (VT-CH-843) (also referred to as Wreck Z) is part of an excavation project that is studying the lifeways on the Lake. Wreck Z was chosen for excavation because it was easily accessible and the preservation quality of the boat was in good condition. The canal boat is located off of Charlotte, Vermont (in Figure 1), with its cargo of coal and all of the crew's belongings in situ.

This thesis follows the style of *Historical Archaeology*.

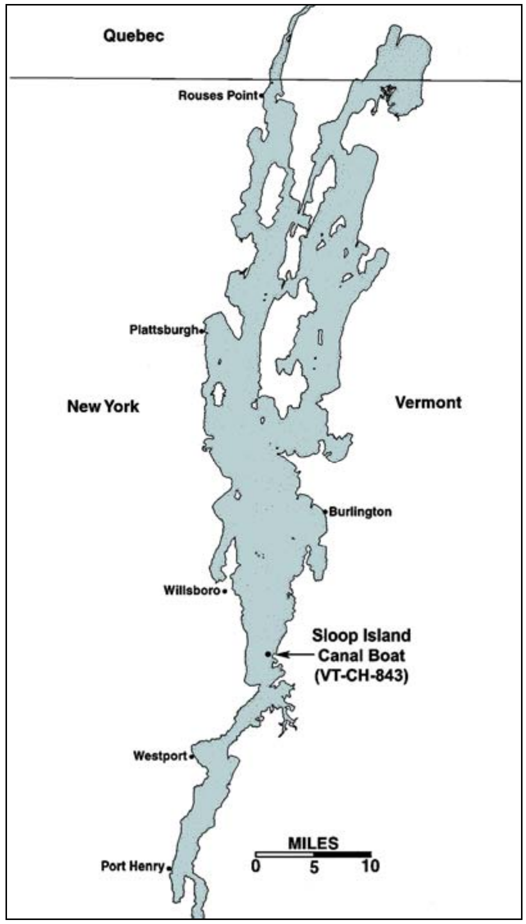

Figure 1. Lake Champlain Showing Location of Wreck (courtesy of LCMM Collection)

Because everything on the boat is still intact, researchers believe that the boat sank unintentionally. Because its demise was accidental, researchers believe the vessel holds a tremendous amount of information.

This thesis will focus on three areas of research: (1) How can linoleum be conserved? Two measures I will take in trying to answer this question will be to review all other conservation work done on linoleum and to limit my choices of conservation treatments to procedures that may be available at the Lake Champlain Maritime Museum

Conservation Laboratory; (2) What is the history of linoleum use on boats; was it a common practice; and (3) Where was linoleum manufactured in the Northeast United States and do the different manufacturers have distinctive designs?

CHAPTER II

PROJECT BACKGROUND

LAKE CHAMPLAIN MARITIME MUSEUM

The Lake Champlain Maritime Museum was established in 1986 as a non-profit organization to educate the public about the lifeways on Lake Champlain. Its mission is to:

1. *To identify and preserve for future generations a central body of knowledge, sites, and artifacts pertinent to the maritime history of the Lake Champlain region.*
2. *To pursue educational activities to furthering a better understanding of the maritime history of the Lake Champlain region.*
3. *To sponsor, coordinate, or otherwise support research projects necessary to protect or better understand the maritime history, cultural resources, prehistory, and history of the Lake Champlain region.*
4. *To foster better communication among residents of Vermont, New York, Canada, and elsewhere concerning the appropriate public policy and management issues for preservation of maritime sites.*
5. *To create and maintain a public facility for the interpretation, conservation, and exhibition of related data and artifacts.*
6. *To provide programs and publications about the activities of the Museum.*
7. *To promote use of conservation laboratories to appropriately support maritime research in the Lake Champlain region.* (LCMM 2004).

The museum established the Maritime Research Institute (MRI) in 2000 to control the underwater cultural resource management projects in Lake Champlain. The MRI's four central goals are to conduct underwater projects on the lake, conserve any artifacts found from underwater projects, help maintain shipwrecks in the lake, and offer archaeological services to organizations in need of them. One of the MRI's projects is an extensive lake survey. The lake survey was started in 1981, originally by the Champlain Maritime Society and then taken over by the museum after it was established. Many incredible discoveries have been made during the lake survey. The one of importance for this study is the Sloop Island Canal Boat found in 1998. The Lake Champlain Maritime Museum Conservation Laboratory is an integral part of the museum and was permanently established in the summer of 1997. The conservation laboratory follows the code of ethics used by the International Institute for Conservation (IIC) and the American Institute of Conservation (AIC). The code of conservation ethics that the lab follows can be viewed in Appendix A. I had the pleasure of working in the Conservation Laboratory for two summers in 2001 and 2002. The last summer I worked in the laboratory was the first field season for the Sloop Island Canal Boat Project.

SLOOP ISLAND CANAL BOAT (VT-CH-843)

The Sloop Island Canal Boat (also known as Wreck Z because it was alphabetically the 26th shipwreck the museum located) is located off of Sloop Island near Charlotte, Vermont, at a depth of about 90 feet of water. From the preliminary study of the boat, the LCMM crew was able to determine that the boat was at 97 feet long, 17 feet 10 inches wide, and 10 feet high (Kane et al. 2004:115). A perspective drawing of Wreck Z showing it at the bottom of the lake is depicted in Figure 2.

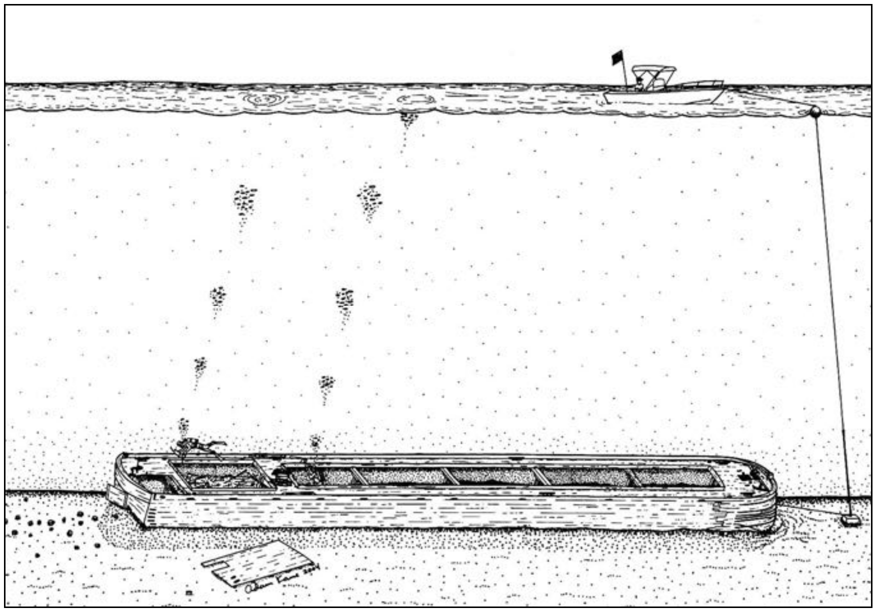

Figure 2. Perspective Drawing of Wreck Z (courtesy of LCMM Collection)

These measurements allowed the archaeologists to deduce that it was a late 19th- to early 20th-century boat. Canal boats of these dimensions were built from 1873 to 1915 and operated on the lake until the 1930's (Kane et al. 2004:10). Early assessments of Wreck Z's dimensions have led the archaeologists to conclude that the boat sank in the 1920's.

Starting in the 1820's with the opening of the Champlain Canal, canal boats became a huge part of the lake's history and an important way of life for many, causing a substantial economic boom in the Champlain Valley (McLaughlin and Kane 2003:44). Figure 3 is a photograph of a canal boat family.

Figure 3. Canal Boat with Family (courtesy of LCMM Collection)

Figure 4 shows how the canal boats were tied together in tow. This is how the canal boats commonly moved along the lake.

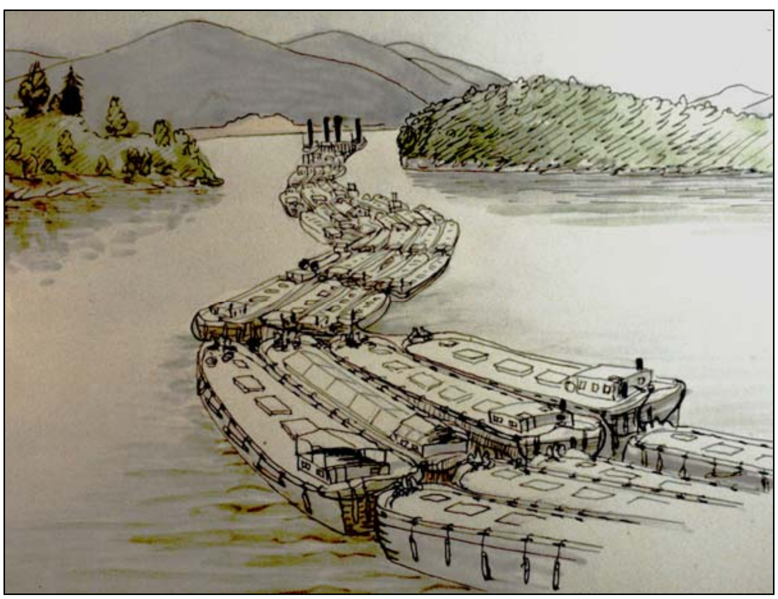

Figure 4. Towing on Lake Champlain (courtesy of LCMM Collection)

There is a relationship between widening of the canal locks and bigger canal boats. As one became larger so did the other. Therefore, as the economy increased, canal locks were made larger giving rise to larger canal boats. This relationship allowed archaeologists to judge approximately when Wreck Z was built and in use from its measurements. The Canal industry hit its peak in the late 19^{th}-century, but by the early 20^{th}-century improved railways and cheaper natural resources found in the western region led to decreasing activity on the lake. By the early 1900's trading on the lake mostly consisted of "pulpwood for the region's paper mills and coal to ports along Lake Champlain and to Canada" (McLaughlin and Kane 2003:44). Soon, wooden canal boats were in competition with steel barges and then fully replaced by the 1940's, ending wooden canal boats dominance on the lake.

Wreck Z was an unexpected answer to a perplexing problem faced by the National Historic Preservation group in Vermont. In 1983 the Pine Street Barge Canal in Burlington, Vermont, was put on the National Priorities List for environmental cleanup and became a Superfund Site. Five canal boats were located in the area but studying them was not a simple option due to hazardous waste. Because of the coal gasification plant that was established in the late 1800's on the canal, the surrounding water was contaminated with waste products from the plant. "Waste products from this process included coal tar, fuel oil, tar-saturated wood chips, cinders, cyanide, and metals" (McLaughlin and Kane 2003:42). Cleaning up the waste would require capping the area off, which would make the canal boats inaccessible to future research. This was a determent to project momentum. In 1998 during the Lake Champlain Maritime Museum survey project of the lake, Wreck Z was located; little did they know this vessel would be the answer. Figure 5 shows the location of Wreck Z to the Pine Street Barge Canal on Lake Champlain.

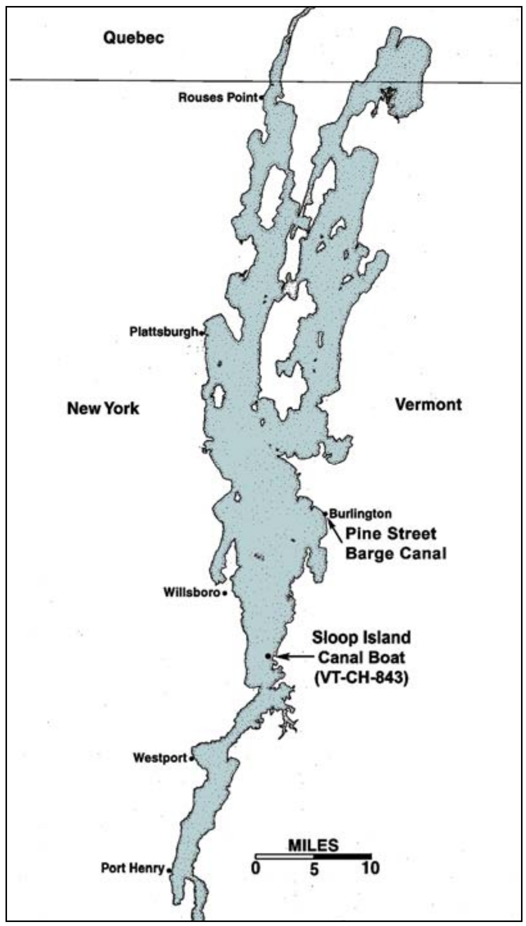

Figure 5. Locations of Wreck Z and the Pine Street Barge Canal (courtesy of LCMM Collection)

Upon further investigation of this boat, the museum discovered it was a canal boat quite similar to those found in the Pine Street Barge Canal and that it possessed most of the belongings of the former occupants in the cabin (unlike the boats of the Pine Street Barge Canal). Realizing the importance of this discovery, a proposal was made to study Wreck Z instead of the other canal boats in the Superfund Site because it was easier to access, more cost effective, and possessed a collection of artifacts. The decision was made, and Wreck Z was chosen. Lake Champlain Maritime Museum conducted excavation of Wreck Z with two main goals: (1) to document the vessels' structure and (2) to recover artifacts from the stern cabin. After two field seasons in 2002 and 2003, "LCMM researchers believe that this is one of the most in-depth archaeological investigations of a canal boat ever untaken" (McLaughlin and Kane 2003:42).

The Maritime Research Institute (MRI) spent 10 weeks studying Wreck Z. Recovered artifacts from the stern cabin and booby (a hatch located on the stern side of the vessel used to load cargo) were brought back to the museum's conservation laboratory to be evaluated and conserved. Associated artifacts were found in situ in the interior of the boat (Figures 6, 7, and 8).

Figure 6. Artifacts in Cabin (courtesy of LCMM Collection)

Figure 7. Wool Coat (courtesy of LCMM Collection)

Figure 8. Broken Dresser (courtesy of LCMM Collection)

Because so many artifacts were found in the cabin and booby, MRI archaeologists believe this boat sank suddenly and quickly. This was an unfortunate fate for the nuclear family that probably lived aboard this boat, but fortunate for the archaeologists studying canal boaters' ways of life. Approximately 300 artifacts were excavated. Most artifacts were what a family would need to support themselves, household items such as clothes, dishware, and lanterns. Also recovered were several segments of linoleum (Figure 9).

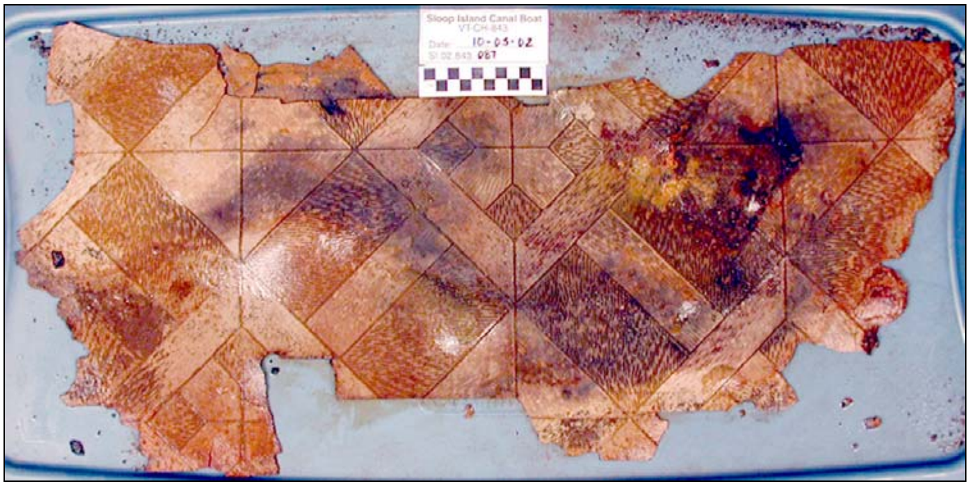

Figure 9. A Segment of Linoleum Found from the Wreck (photo by B. E. Coke)

The main segments of linoleum were found under the cook stove (Figure 10) and tool box. Unfortunately, the linoleum cannot be seen in this photograph.

Figure 10. Cook Stove (courtesy of LCMM Collection)

Not knowing how to conserve waterlogged linoleum, the museum proposed that research be conducted to determine the most effective means to preserve these artifacts. With the assistance of the Archaeological Preservation Research Laboratory (APRL) located at Texas A&M University, I accepted the task of researching viable conservation methods.

Figure 11 shows the segment of linoleum sent to APRL for conservation. This segment was utilized to find the best means for treatment. After evaluation of all available experimental conservation methods, one method was recommended to conserve the rest of the waterlogged linoleum located at the Lake Champlain Maritime Museum.

Figure 11. Linoleum Sent to APRL for Conservation (photo by B. E. Coke)

CHAPTER III

HISTORICAL BACKGROUND OF LINOLEUM

LINOLEUM'S PREDECESSORS

Before the invention of linoleum, flooring was often covered with oilcloth. The origins of floor oilcloth are a bit vague, but its use has been noted in the late fifteenth century (Simpson 1999a:75). Floor oilcloth was known by several names: oilcloth, waxcloth, and more commonly, floorcloth. Floorcloth was typically made of cotton, hemp, or linen with multiple layers of paint applied, making it waterproof. Designs often resembling carpet, marble or tile were often applied to the floorcloth (Simpson 1999a:77). Several layers of the designs were painted on the surface of the cloth. Industrialization allowed floorcloth to be affordable in most homes. Floorcloth's main use was to protect floors. But the product was also used to cover tables, mantels and shelves, as well as around sinks because it was waterproof. Despite its many uses and the fact that it was relatively inexpensive, floorcloth did have its drawbacks. "It didn't wear very well, it was cold to the feet, and had an unpleasant smell when new" (Simpson 1999a:78).

Another predecessor to linoleum was Kamptulican invented, by Elijah Galloway in the 1840's. Kamptulican consisted of India rubber, a tree sap derivative called gutta percha, and cork (Simpson 1999a:79). "This material, about one-eighth of an inch thick, could be printed with oil paints using the same methods as for floorcloth, but was to be stuck directly to the floor, giving a heavy-duty floor covering material" (Edwards 1996:154). Kamptulican became popular because of its ability to reduce noise when walked on, its waterproof characteristic, and its better resistance to wear. Despite its initial popularity, "the fierce competition of the oilcloth producers and the enormous increase in the price of the raw material India rubber led to the product's disappearance" (Ziegler 2000:36). Kamptulican's falling out of favor led to the search of a similar product without the expensive rubber ingredient. In 1871 Corticine, also known as cork carpet, was patented. This flooring material consisted of cork dust polymerized in oil (Simpson 1999a:79). Several oilcloth companies produced Corticine promoting its softness and resiliency. But by the early 1900's it fell out of favor, most likely to the rise of the more economical linoleum. These earlier floor coverings paved the way for the invention and improvement of linoleum.

HISTORICAL BACKGROUND OF LINOLEUM'S INVENTION

Pamela Simpson, an Art History professor at Washington and Lee University, quotes linoleum's inventor, Frederick Walton (Figure 12), as claiming, "the invention of linoleum might not rank with James Watt's steam engine," but nevertheless, Walton claimed '"to have done a useful work. Every householder can vouch for the utility and sanitary value of linoleum, and many house wives will, I hope, bless my memory in the future, although my name may be forgotten'" (Simpson 1999a:75).

Figure 12. Frederick Walton (after Walton 1925:4)

Frederick Walton patented linoleum in the 1860's and during linoleum's heyday it was "probably the most widely used floor covering in the world" (Simpson 1999b:17). Linoleum is roughly made up of "oxidized linseed oil mixed with ground cork dust, rosin, gum, and pigments that are pressed between heavy rollers onto a canvas" (Simpson 1999b:19). The name "linoleum" comes from the Latin words for flax, *linum* (from which linseed oil is made) and the word for oil, *oleum*. So "linoleum" translates into "linseed oil", a very fitting name that was used worldwide. Walton began to experiment with oxidized linseed oil after noticing an open paint can that had a rubbery layer (oxidized linseed oil) on its surface. Being the son of a rubber manufacturer he wanted to know how he could utilize this. Walton's father encouraged Frederick's curiosity by giving him a laboratory in his factory and helping fund his work. Frederick's experiments eventually led him to "patent processes in 1860 for exposing linseed oil to the air, enabling [the material] to absorb oxygen – that is, to oxidize and become solid," a byproduct he called, "linoxyn" (Edwards 1996:155). With this new found rubber-like substance, Walton focused his attention on how he could use it in flooring, particularly using it as a replacement of India rubber in Kamptulican.

Setting out on his own in his workshop, Walton achieved success in 1863. After receiving a patent for his new process, he established a factory in Staines, England, with William J. Taylor as a partner. The Company was known as the Linoleum Manufacturing Company, Limited. Walton promoted his invention as "an improvement on the original floorcloth stating three reasons: first, it used different materials, secondly, it used machinery to produce the design, and thirdly, its designs went right through the thickness of the material," instead of nearly surface applied (Edwards 1996:155). The factory was a profitable venture which allowed him to enlarge his plant facilities and expand to include overseas operations. An interesting fact is that Walton did not control the company. In order to expediently set up shop and gain his production quotas, he gave control to six other partners. In return, he received a salary with his name on all the patents and advertisements, but he was just the inventor and not the "captain of industry" (Simpson 1999a:80). Basically, Walton had no control over the company's operations. "Some might argue that his creation of the name 'linoleum' was almost as important as the product itself" (Simpson 1999a:80).

MANUFACTURING LINOLEUM

As basic as the definition of linoleum may seem, the process of manufacturing is much more involved. The "Walton System" of manufacture was used by all the linoleum companies with some having their own variations, but for the most part "the basic process remained much as Walton had created it" (Simpson 1999a:82).

The first step in linoleum manufacturing was to oxidize linseed oil. A light cotton scrim was coated with linseed oil and allowed to solidify by oxidizing in air. Even though the workers in Figure 13 are working on floorcloth, this same method of hanging the scrim was used for linoleum. Hanging the scrim in an upright position made applying the coats of linseed oil easier.

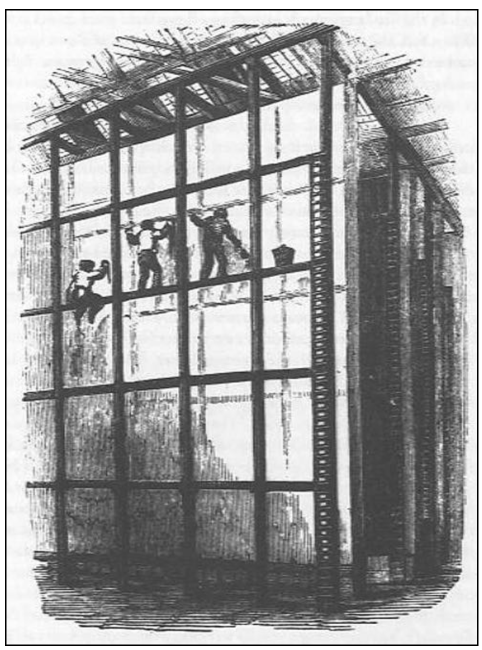

Figure 13. Floorcloth Workers on Scaffold (after Simpson 1999a:77)

“Fresh oil was applied daily over the scrim base for a period of months, until a thickness of 13-25 mm was achieved” (Drummond 1984:32). This coated scrim was then covered with a “skin” (the skin being the 13-25 mm of oil that was applied to the hanging scrim). As the linseed oil was being oxidized, cork or wood chips were ground to a fine dust and stored to be used in the next step.

The second step involves making linoleum cement. To do this, some manufacturers would cut the “skin” from the fabric, others would use the whole scrim. In either case, the skin was cut down and ground up. Then the “ground skin, [was combined] with resin and Kauri gum until the whole mass was homogenous,” forming what is known as linoleum cement (Drummond 1984:33). Figure 14 is a photograph of workers pouring linoleum cement.

The third step involved the thorough mixing of this cement mixture with cork dust. Other fillers such as wood flour (sawdust) were added. If the linoleum was to be one color or it was to act as a base, colored pigment would be added as the last part of this stage.

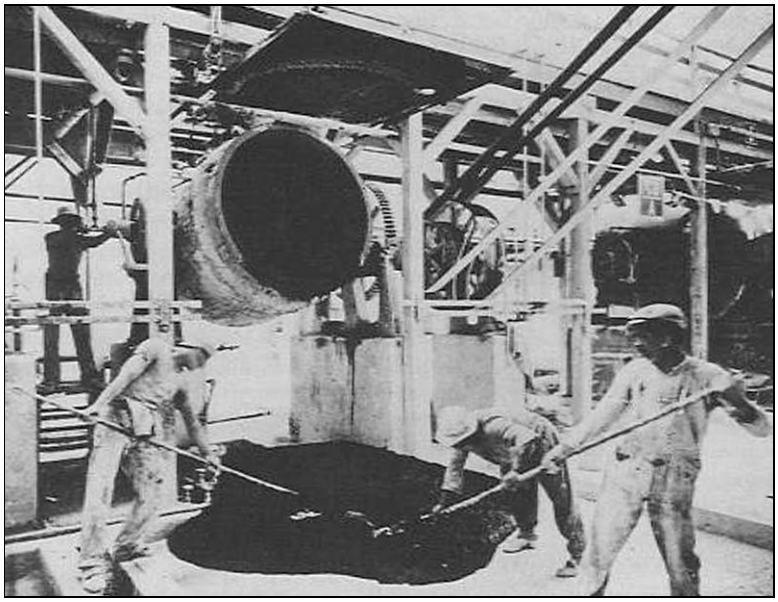

Figure 14. Armstrong Cork Co. - Pouring Linoleum "Cement" (after Simpson 1999a:82)

The fourth step was to press the granulated mixture between heated calenders (Figure 15) onto a canvas or burlap backing. To create varying thicknesses of flooring, several layers of the mixture would be rolled out onto the original to build it up, each time passing through the rollers to ensure an even coating.

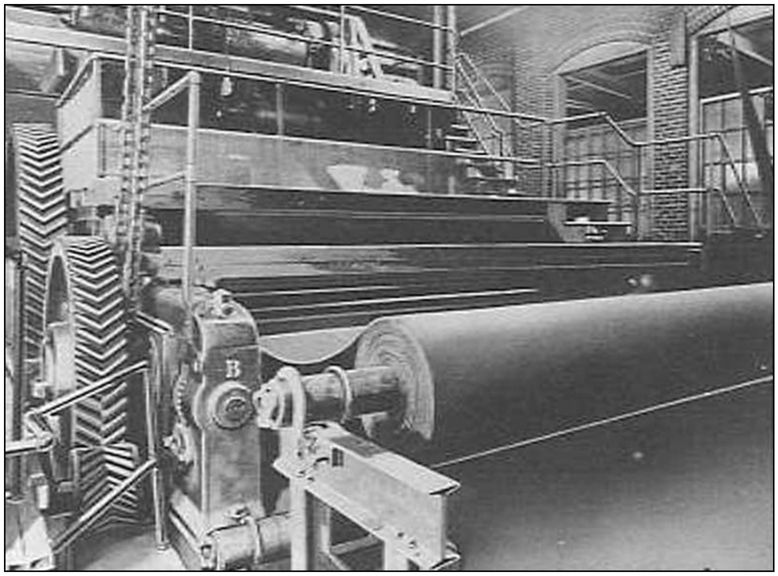

Figure 15. Linoleum Calenders - Armstrong Cork Co. (after Simpson 1999a:83)

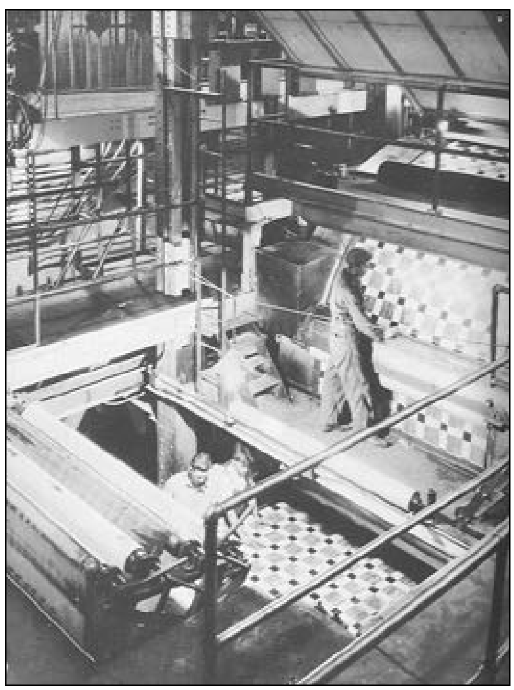

Figure 16. Rotary Machine for Producing Straight Line Linoleum - Armstrong Cork Co. (after Mehler 1987:150)

The previously described method describes the basic one color process for making linoleum. Print, straight line, and inlaid linoleum manufacturing processes were more involved (Figure 16). They were the two main basic printed pattern types of linoleum. To create printed patterns “the fabric [was] passed over a flat table, [and] under rising and falling blocks, with an arrangement of troughs and rollers spreading the coloured ink required on to the blocks. The surface descended to make its impression, then rose to allow the cloth to be moved on” (Drummond 1984:33). The fabric was re-inked until all the colors had been applied and then the linoleum was taken to a drying room to cure. When the linoleum was fully dry, a hard varnish was usually applied and then it was cut and rolled and ready for sale.

Inlaid linoleum was a more involved process and consisted of a manufacturing procedure that ensured that the pattern extended all the way through the linoleum to the backing. Inlaid linoleum “was created by cutting the required shapes, by means of dies, from sheets of coloured linoleum pulp. These pieces (Figure 17) were then arranged side by side on the backing in the desired configuration”. Once the desired configuration was achieved a pressurized heated plate was applied to the linoleum causing all the parts to weld together (Drummond 1984:33). Figure 18 shows workers making embossed inlaid linoleum.

Figure 17. Workers Hand Piecing Inlaid Linoleum Design (after Simpson 1999a:86)

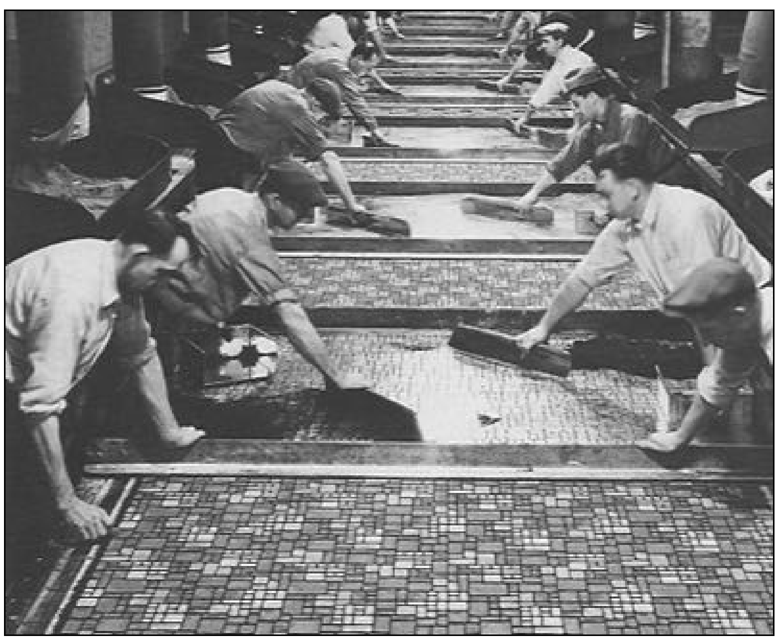

Figure 18. Workers with Embossed Inlaid Linoleum (after Mehler 1987:153)

Soon the process was made simpler by using colored granulated pulp and sprinkling it through “a series of stencils (one for each of the required colours) on to the backing” (Drummond 1984:36). Then the material was passed under a heated plate and pressure to become one whole sheet. Consumers preferred inlaid linoleum because the pattern did not wear off as easily as the surface printed linoleum. Inlaid linoleum was more expensive due to hand labor and a more involved manufacturing.

MANUFACTURERS OF LINOLEUM

There were several manufacturers of linoleum. Figures 19 through 21 show three different advertisements for linoleum featured in women’s journals. Figure 19 is a Blabon Art Linoleums advertisement. Figure 20 is an advertisement for Nairn Linoleum. Figure 21 is an advertisement for the Armstrong Cork Company Linoleum.

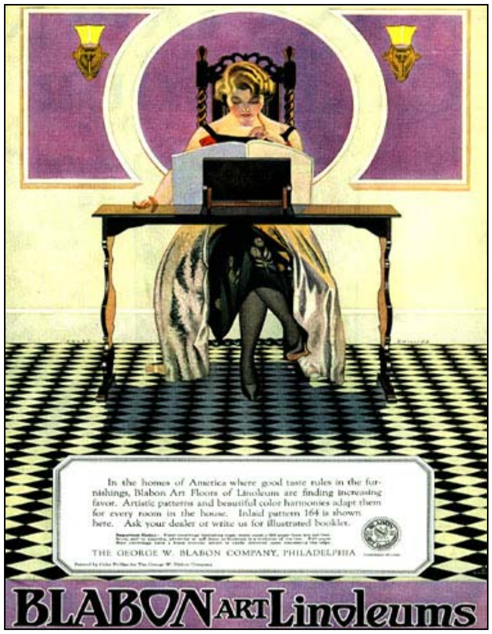

Figure 19. Blabon Art Linoleum Advertisement (personal collection of B. E. Coke 2004a)

Figure 20. Nairn Linoleum Advertisement (personal collection of B. E. Coke 2004b)

Figure 21. Armstrong Cork Co. Linoleum Advertisement (personal collection of B. E. Coke 2004c)

The main manufacturers in the United States were Joseph Wild's American Linoleum Manufacturing Company, George Washington Blabon's George W. Blabon & Son, Thomas Potter's company in Philadelphia, Michael Nairn's New Jersey company, and the Armstrong Cork and Tile Company of Lancaster. Only two of these early pioneers of linoleum manufacturing still exist: the Armstrong Cork Company and the Nairn Company (which today goes by the name Congoleum-Nairn).

Advertising opened linoleum to a huge market. The Armstrong Cork Company took a new approach by advertising to the consumer instead of the retailer. Armstrong put forth an unprecedented amount of fifty thousand dollars for a three-year consumer research experiment (Simpson 1999a:93). They placed linoleum advertisements in

Ladies Home Journal, *The Saturday Evening Post*, *McCalls*, *Delineator*, *Designer*, and *Women's Home Companion*. The other linoleum companies soon followed this example started by Armstrong, as can be seen in the linoleum advertisements in Figures 19 – 21. The promise of luxury, cleanliness, and fashion of floor coverings ensured markets and the need for continual development within the linoleum industry.

DIFFERENT THICKNESSES IN LINOLEUM

Linoleum was produced in different thicknesses allowing consumers to choose a product for optimum utilization based on placement and foot traffic in the home or business. High traffic areas and businesses generally used thicker linoleum, and floors in homes used thinner linoleum. Table 1 gives a range of the different gauges of linoleum, their description, and their typical use.

Table 1 Linoleum Thicknesses (Snyder 1995: 218-219)

Thickness	*Available Colors*	*Recommended Use*
0.250 inch battleship	Brown, Dark Gray, Green	Offices, Stores, Hospitals, Banks, Lodge Rooms, Elevators, Battleship decks
0.235 inch (6 mm) battleship (heavy)	Brown, Dark Gray, Green	Can be used in the same places as the 0.250 inch, but with lesser traffic, and is cheaper
0.187 inch battleship (medium)		
0.142 inch battleship (light)		
A Gauge	Brown, Dark Gray, Green, Light Gray, Black , Blue, Tan	Apartments and Offices where traffic was not severe
B Gauge		Residential places
C Gauge		Residential places
D Gauge		Residential places
E Gauge		Primarily for Automobile Industry

Figure 22. Linotile - 1/4 inch Thick Linoleum Tile Made for the Ford Company (after Snyder 1995:219)

With the rise in popularity and the supplement of inlaid linoleum, more colors and patterns were available for the consumers. In addition to the options in Table 1, there were special production products. Figure 22 is a photograph of a Ford Company show room. The flooring in the photograph is ¼ inch thick linoleum called Linotile. Linotile was made especially for the Ford Company and was referred to as “Ford” blue (Snyder 1995:219).

LINOLEUM USED ON BOATS

Linoleum used on boats was a thicker variety often called Battleship linoleum (Figure 23). Linoleum became popular flooring for battleships because of its durability. Battleship linoleum also provided a cushioned floor that was waterproof and reduced sound. The Navy was a huge consumer of Battleship linoleum. With linoleum being made in rug formats it is no surprise that other types of boats would soon start to use linoleum as well. Unfortunately, I found no information about linoleums use on canal boats. I assume that linoleum rugs were utilized on boats for the same reason one would utilize them in a home or business.

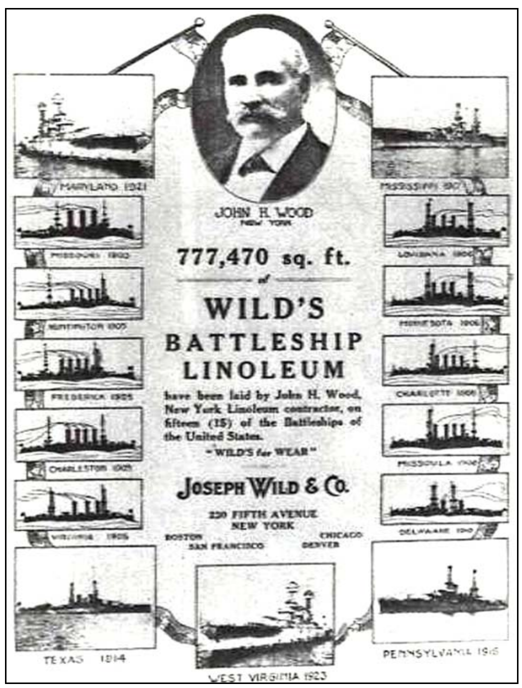

Figure 23. Joseph Wild Co. Advertisement for Battleship Linoleum (after Simpson 1999a:96)

THE DEMISE OF LINOLEUM

Three new products produced in the 1950s led to the demise of linoleum. “The first was cheap tufted carpet which exploited the needling process to produce large amounts of carpet quickly and inexpensively. Second was the development of vinyl tiles and [vinyl sheets] that could be produced to look very lifelike with the rotogravure printing process. Thirdly, and a little later (1963) was the invention of Cushionflor, a cushioned vinyl flooring with a host of distinct advantages” (Edwards 1996:158). Cushionflor was promoted for its ease in cleaning, noise reducing ability, and the fact that it was cushioned which provided more comfort to people working on it.

DISTINCTIVE PATTERNS

Each manufacturer developed patented styles that became their standards. The pattern in the linoleum specimen studied in this thesis has not been matched to any distinctive design of any particular manufacturer. The pattern in the linoleum specimen can be seen clearly, but the design might be too generic to match to a specific manufacturer and not enough of the sample is available to see the full design. A more thorough research is complicated by the fact that pattern books for all the manufacturers are not easily accessible. Armstrong and Nairn revamped their companies to fit with the modern need for vinyl flooring. Both do feature classic floor covering designs, but none of them match the specimen in this thesis.

CHAPTER IV

REVIEW OF LITERATURE

In searching for information about linoleum, conservation books were consulted first. Unfortunately, no specific treatments for waterlogged linoleum were found. The Bibliographic Database of the Conservation Information Network (BCIN) web search engine provided a good foundation for the onset of research on conserving linoleum. Their search guide is located on the web at: http://www.bcin.ca/English/home_english.html. Most sources from the BCIN search engine were retrieved through Evans Library at Texas A&M University. From these resources other useful information was found. A search of the Library of Congress web search engine located online at http://www.loc.gov resulted in other useful information, unfortunately not all relevant to this research. Utilization of the Evans Library online search engines provided no information dealing with waterlogged linoleum. Conservation/preservation information tended to be concerned with linoleum that had been in historic houses and buildings, and for maintenance of newly installed linoleum; both preservation techniques were similar.

I divided sources into five general categories: (1) Wreck Z; (2) historical background; (3) preservation/installation/maintenance; (4) manufacturers; and (5) general conservation methods.

WRECK Z

The Lake Champlain Maritime Museum's web page (http://lcmm.org) provided information about Wreck Z and the museum. That web site states the museum objectives and its role in historic preservation. A background history and excavation of the wreck and why its study is important was on their web site. The mission of the Maritime Research Institute (MRI), the nautical archaeology group that excavated part of the site, is given on the museum's web site. On the web site readers are encouraged to download the *LCMMnews* quarterly newsletter printed by the Lake Champlain Maritime Museum at Basin Harbor Inc. The newsletter provides readers with events at the museum, as well as updates on their projects. Wreck Z is mentioned in the Fall/Winter 1998 & 1999, Spring/Summer 1999, Fall/Winter 2002 & 2003, Fall/Winter 2003 & 2004, and Spring/Summer 2004 issues of *LCMMnews*. Through the museum's web site and the newsletter, a good overview of the wreck is presented. No information on the linoleum is provided.

McLaughlin and Kane (2003) provide additional information on the wreck. Their article discusses the project's background and why Wreck Z was chosen for study, and gives a general overview of what has been learned thus far. Also discussed were canal history and what life was like living and working on a canal boat. Archaeological results were discussed, giving the measurements on the boat and a little about the artifacts found in the stern cabin. They conclude by emphasizing the importance of the study of Wreck Z to the Champlain area and that researchers still have much to learn.

Other articles that give insight of canal life are Barges by Gleason (1922) published in *Scribner's Magazine*, and A Canal-Boat Voyage on the Hudson by Johnson (1898) published in *The Outlook*.

HISTORICAL BACKGROUND

Most sources I found on linoleum included a section about its history. Simpson (1997b) states the "American desire to find ways of doing things that were 'cheap, quick, and easy.'" She discusses several innovations during 1870-1930, among them linoleum and Lincrusta-Walton (linoleum for walls). In addition, she provides a brief historical overview, but the main point of the article is the advancement in industrialization that led to cheaper and timelier ways of manufacturing items. Consumers in general loved the new products and saw them as 'modern' and 'progressive.' The general public now had the advantage to have nice flooring in a variety of fashions; it was not just for the elite anymore.

Simpson (1999a) gives a further in-depth look into the historical background of linoleum. She gives a detailed description of the manufacturing process and insight into how manufacturers advertised to consumers to boost their businesses. Other articles by Simpson (1997a, 1997b, 1999b) include similar information.

Waele's (1917) article is outdated, but provides similar basic information found in other sources. The main value of this article is that it presents a more thorough examination of the manufacturing processes. Drummond (1984), Edwards (1996) and Zeigler (2000) also presented similar general background information.

PRESERVATION, INSTALLATION, AND MAINTENANCE

The sources in this category are broad. These sources were categorized under this group if they gave repetitive and little or no information about the historical background of linoleum, as well as discussed how to preserve/clean linoleum if found in an historical setting. They were placed here if they discussed anything about the maintenance of linoleum whether it was freshly installed or already in place.

Four sources refer to the "conservation" of linoleum: Pennec et al. (1996); Snyder (1995); Carlisle (1997); and Ellermann (2000). Each of these sources gives basic cleaning methods and simple repair solutions, as well as stating the importance of consulting with a trained conservator before attempting anything. Blackman and Dietsch (1982a) and (1982b), Kahn (1986), and Poore (1984) (articles found in *The Old-House Journal*); Hutchins (1988) and Von Rosenstiel (1988) (articles found in *The Interiors Handbook for Historic Buildings*); the C3 Carpet Co. Ltd. (Anonymous 1985); and the Armstrong Cork Co. all provide the same basic cleaning and simple repair methods. The cleaning and preserving methods given by the resources in this group were inadequate for the specimen in this research study. None dealt with waterlogged linoleum.

MANUFACTURERS

There were many manufacturers of linoleum by the early 1900s. I focused on the manufacturers mentioned repetitively in my sources. An initial web search for each manufacturer was performed. Very little to no information on the American Linoleum Manufacturing Company, George W. Blabon Company, and Thomas Potter's Company was found. Web information on Nairn Linoleum Company, now called Congoleum-Nairn, was found. Their web site gives a general company history and how they got started in linoleum.

The one company discussed the most is Armstrong Cork Company. They have a web site that gives a general company history and how they got started in linoleum.

Simpson (1999b), Holt (1995), and Powell and Svendsen (2003) discuss how Armstrong Cork Company was the first company to advertise to the consumer instead of the retailer. Armstrong spent fifty thousand dollars for a three year project to study the best way to advertise their product to the consumer. Mehler (1987) told the Armstrong Cork Company's story of how they got into linoleum and how the company has progressed over time.

GENERAL CONSERVATION

The primary conservation books utilized for this study are *The Elements of Archaeological Conservation* by Cronyn (1990), *Methods of Conserving Archaeological Material from Underwater Sites* by Hamilton (1999), *Archaeological Conservation Using Polymers* by Smith (2003), *The Conservation of Archaeological Artifacts from Freshwater Environments* by Singley (1988), and *The ECU Conservator's Cookbook: A Methodological Approach to the Conservation of Water Soaked Artifacts* by Rodgers (1992). These conservation books give overviews of how to conserve a variety of artifacts, but none mentioned conserving linoleum, much less waterlogged linoleum specifically.

ASSESSMENT OF THE REVIEWED LITERATURE

No treatment methods for waterlogged linoleum were found. Since wood is one of the main materials used in linoleum, it will be the basis for deciding which treatment to utilize. This research will be one of, if not the first, source on archaeological conservation of waterlogged linoleum.

CHAPTER V

METHODOLOGY

PROCEDURE

The waterlogged linoleum I received was first put in a container of water because it arrived in a plastic bag with wet paper towels and it was necessary to ensure that it remained waterlogged. Even though the linoleum was excavated from a natural, fresh water lake site, it was placed in de-ionized water (DI water). DI water flushes out soluble salts, such as chlorides, from artifacts. Chlorides left in artifacts will cause damage even after treatment is done. Pretreatment drawings and pictures were taken. Figure 11 (located in Chapter II) is an image of the linoleum before treatment.

The linoleum did not appear to be dirty. The surface was wiped by hand to remove possible surface debris. A total of 6 DI water changes were done until the chloride level was low and unchanging. Since only a small segment of linoleum was available for experimentation, it was decided to cut the linoleum into eight roughly equal segments and performing different treatments on each segment.

Before the linoleum was cut into eight segments, the soaked water was tested for chlorides. The mercuric nitrate method of chloride determination was used (Hamilton 1999 in the section for Iron Conservation Part 1). A 20 ml sample of DI water was taken from the plastic container the linoleum was in and placed into a 250 ml glass beaker. A Teflon stirring bar was dropped into the beaker and then the beaker was placed on a magnetic stirrer. Slowly the stirrer was turned on until an even stirring was achieved.

Five drops of diphenylcarbazone-bromophenol blue indicator was added. It turned the water blue. Next a few drops of sulfuric acid were added to the beaker to change the water from blue to clear and to make it acidic. Mercuric nitrate (.02N) was then titrated into the water drop by drop until a violet color appeared. This color change indicated the end point. The amount of .02N mercuric nitrate was noted. The amount of chlorides were determined by the calculation of (amount of mercuric nitrate titrated) times (normality of mercuric nitrate) times1772.5 equals the amount of chlorides in parts per million (ppm). The chloride test resulted in 18ppm chlorides, low enough to proceed.

The linoleum was cut into eight roughly equal segments. Eight treatments performed on each piece:

1. Air Dry
2. Vacuum Freeze Dry
3. Dehydration – Topical Dressing
4. Polyethylene Glycol (PEG)
5. Silicone Oil + Crosslinker
6. Acetone – Rosin
7. Crosslinker only
8. Linseed Oil

These eight treatments were chosen because they are common treatments used on wood and wood is a main component in linoleum. Figure 24 shows the first cut made to the linoleum. Figure 25 is an image showing the linoleum after it was fully cut into eight pieces. The image shows each segment's ID number.

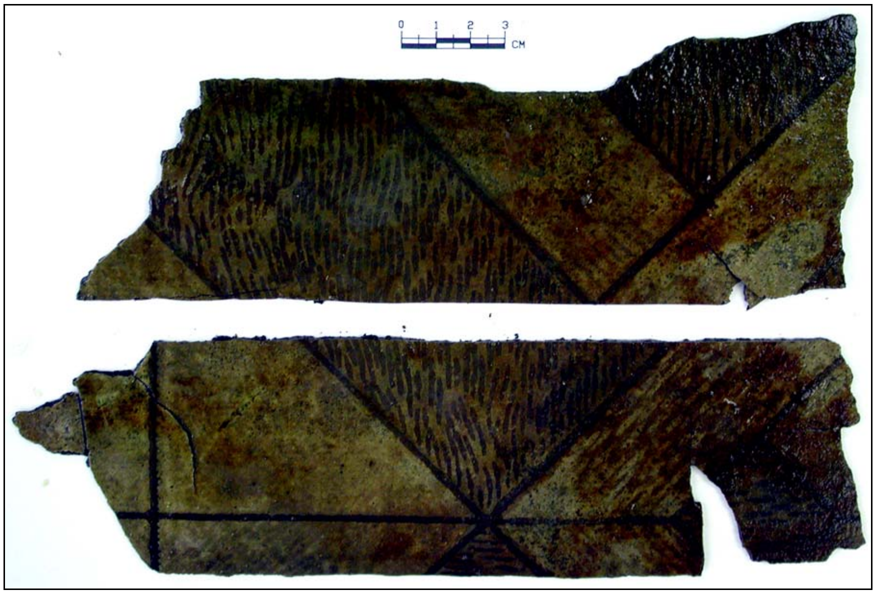

Figure 24. Cutting the Linoleum (photo by B. E. Coke)

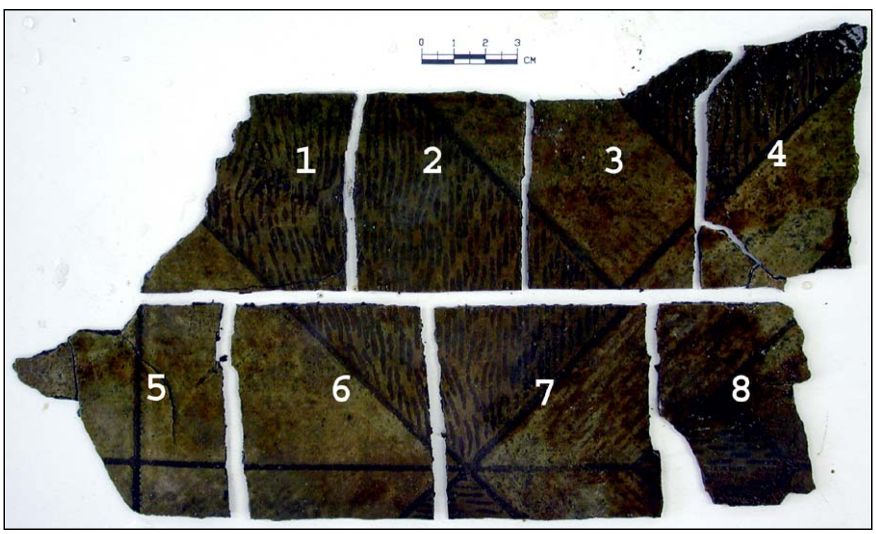

Figure 25. The Eight Segments of Linoleum (photo by B. E. Coke)

Digital images and tracings were made of each piece showing any significant markings. Measurements were taken of each segment. The lengths and widths as well as the thickness of each segment was measured and noted on the drawings. Cutting with a scalpel blade proceeded slowly and carefully because the linoleum tears easily. Each piece was placed in its own container with fresh DI water while awaiting further treatment.

LINOLEUM #1 – AIR DRIED

Figure 26 is a pretreatment image of linoleum #1.

Figure 26. Pretreatment Image of Linoleum #1 (photo by B. E. Coke)

Linoleum #1 was taken out of DI water and air dried. The water was removed from the container and the lid was left off to facilitate air drying linoleum #1. By the next day the segment appeared to be dry and had curled. This segment is used as a control to indicate condition when air dried with no treatment. Post treatment tracings and digital images were taken of the front and back. Post treatment measurements were also taken.

LINOLEUM #2 – VACUUM FREEZE DRIED

Figure 27 is a pretreatment image of linoleum #2.

Figure 27. Pretreatment Image of Linoleum #2 (photo by B. E. Coke)

Linoleum #2 was taken out of the container of DI water and placed in a mesh bag. Then it was placed into a vacuum freeze dryer. This process causes the water to freeze and then the vacuum boils the water out. Within fifteen minutes of being under the vacuum, the segment broke apart into 5 pieces. Linoleum #2 was left in the vacuum freeze dryer for four days at which point it had broken into 13 pieces. Digital images were taken of the pieces.

Paraloid B-72 (Paraloid B-72 Resin/Acetone/Cabosil) was used to glue the segments back together. Figure 28 is an image of linoleum #2 before it was glued together. Digital images were taken of the segment glued back together into one piece. Tracings of the front and back were drawn, post treatment measurements were taken.

Figure 28. Linoleum #2 Post Treatment Broken (photo by B. E. Coke)

LINOLEUM #3 – DEHYDRATION-TOPICAL DRESSING

Figure 29 is an image of linoleum #3 before treatment.

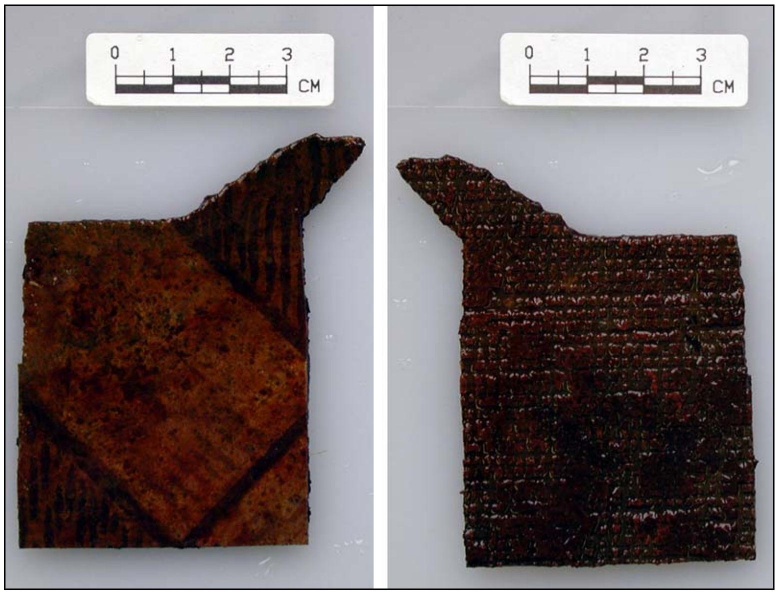

Figure 29. Pretreatment Image of Linoleum #3 (photo by B. E. Coke)

Linoleum #3 was dehydrated before topical dressing was applied. The dehydration regime used was:

1. placed in a solution of 25% Ethanol + 75% DI water for four days
2. placed in a solution of 50% Ethanol + 50% DI water for eight days
3. placed in a solution of 75% Ethanol + 25% DI water for six days
4. placed in 100% Ethanol for seven days
5. placed in 100% Acetone for sixteen days

The topical treatment chosen for this segment was a BML dressing (British Museum Leather Dressing – Hexane). The dressing is made of anhydrous lanolin, cedarwood oil, beeswax, and hexane. This dressing was chosen because of its natural ingredients. The dressing was thick but not hard. The dressing was rubbed into the front and back of linoleum #3. Figure 30 shows linoleum #3 coated in the BML Dressing.

Figure 30. Linoleum #3 Coated in the BML Dressing (photo by B. E. Coke)

Because the dressing was kept in the refrigerator to keep it viscous and paste like, linoleum #3 was placed in an oven set at about 90° F (32° C) to insure that the dressing would soak into the linoleum. The segment was left in the oven overnight. When removed from the oven, excess dressing was wiped off the linoleum. Then linoleum #3 was placed in a clean container with a piece of glass on top of it to keep it flat. Because linoleum #1 curled when it was air dried, glass was used to weigh down the linoleum segments to keep them from curling. Post treatment tracings, measurements, and digital images were taken of linoleum #3.

LINOLEUM #4 – POLYETHYLENE GLYCOL

Figure 31 is an image of linoleum #4 before treatment.

Figure 31. Pretreatment Image of Linoleum #4 (photo by B. E. Coke)

Linoleum #4 was placed in a solution of 30% Polyethylene Glycol 400 (PEG) + DI water. PEG 400 was added to the solution in 5% increments over a 3 week period to bring it to a final solution of 70% PEG 400 + DI water. Linoleum #4 was left in the 70% PEG 400 solution for 7 days and then it was transferred to a 70% PEG 3350 solution for

17 days. At this time the linoleum had broken into 3 pieces. Both solutions were kept in an oven set at 90° F (32° C) to facilitate infusion of the solution into the linoleum.

After 17 days immersion in the 70% PEG 3350, the container with the linoleum was placed into a vacuum. The solution containing linoleum #4 was under vacuum for about 3 minutes. No bubbles formed (which would indicate air escaping from the artifact) and helps the solution to enter the artifact. The air escaping the artifact's cellular structure causes a lower pressure to form which then forces the solution to enter the cells. The vacuum pulled on the chamber is measured by a manometer and the vacuum was at 83mm of mercury. The vacuum was stopped and linoleum #4 was taken out of solution and blotted dry with paper towels. Figure 32 shows the procedure used in wiping and blotting excess solution off of linoleum #4.

Figure 32. Wiping Excess Solution off Linoleum #4 (photo by E. Eilert)

Paraloid B-72 (Paraloid B-72 Resin/Acetone/Cabosil) was used to glue the segment back together. Once dry it was placed in a clean container between paper towels. A piece of glass was placed on top of the linoleum to keep it flat. Post treatment tracings, measurements, and digital images were taken of the front and back on linoleum #4.

LINOLEUM #5 – SILICONE OIL + CROSSLINKER

Figure 33 is a before treatment image of linoleum #5.

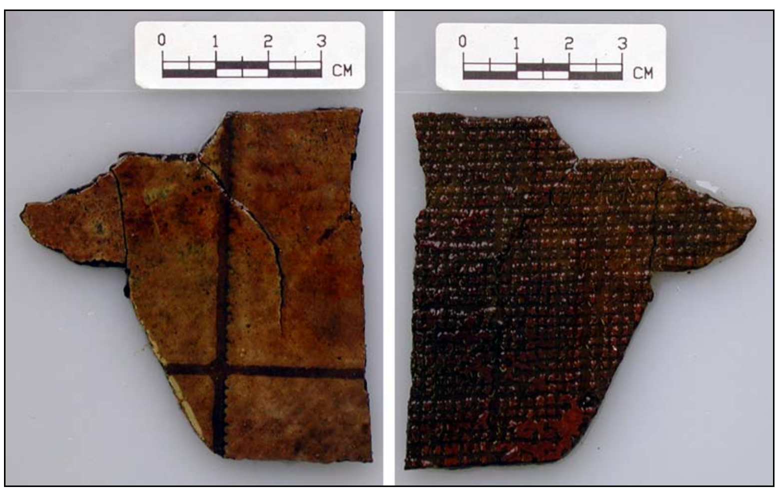

Figure 33. Pretreatment Image of Linoleum #5 (photo by B. E. Coke)

Linoleum #5 was dehydrated before it was in silicone oil solution. The dehydration regime was the same as on linoleum #3, except dehydration in 100% acetone lasted for 13 days instead of 16 days.

After thirteen days in 100% acetone linoleum #5 was placed in a solution of Silicone Oil + 3% Isobutyltrimethoxysilane (crosslinker). The silicone oil used is SFD-5, a hydroxyl ended functional silicone oil that has a functional silane crosslinker. To this was added the 3% of crosslinker which is also a functional silane. Linoleum #5 stayed in solution for three days. On the third day the container was placed in a vacuum chamber and the vacuum pulled was 83mm of mercury, as seen in Figure 34.

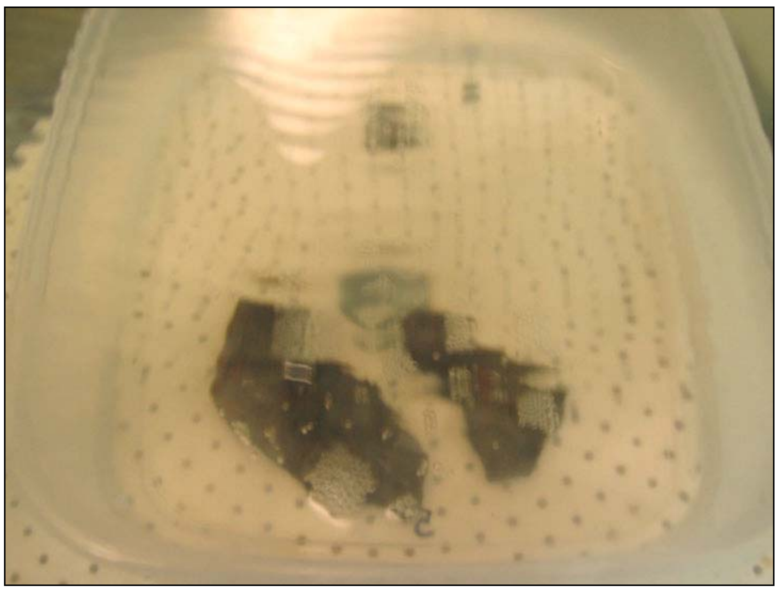

Figure 34. Linoleum #5 in the Vacuum Chamber (photo by B. E. Coke)

At first, the segment was vacuum treated for 30 seconds. The vacuum was stopped and the segment looked fine in the chamber so two more 30 second vacuum sessions were performed with a 1 minute pause between each session. The linoleum looked fine and it did not seem like it would break apart if left under the vacuum longer so it was vacuum treated for 1 hour. Extensive bubbling was noted initially, but by the end of the hour minimal bubbling was noted. After vacuum treatment, the linoleum was placed on mesh to drain excess oil. Figure 35 is an image showing linoleum #5 draining excess silicone oil off. This figure also shows linoleum #5 broken which occurred while it was in solution.

Figure 35. Linoleum #5 Draining on Mesh Screen (photo by B. E. Coke)

After a day of draining, paper towels were used to blot excess oil. The paper towels were dipped in isobutyltrimethoxysilane (crosslinker) to help remove excess oil. Linoleum #5 was blotted for about 15 minutes before the excess oil seemed to be removed. Q-tips were also used to help facilitate the removal of excess oil. Figure 36 illustrates the process of blotting linoleum #5 with paper towels to remove the excess silicone oil.

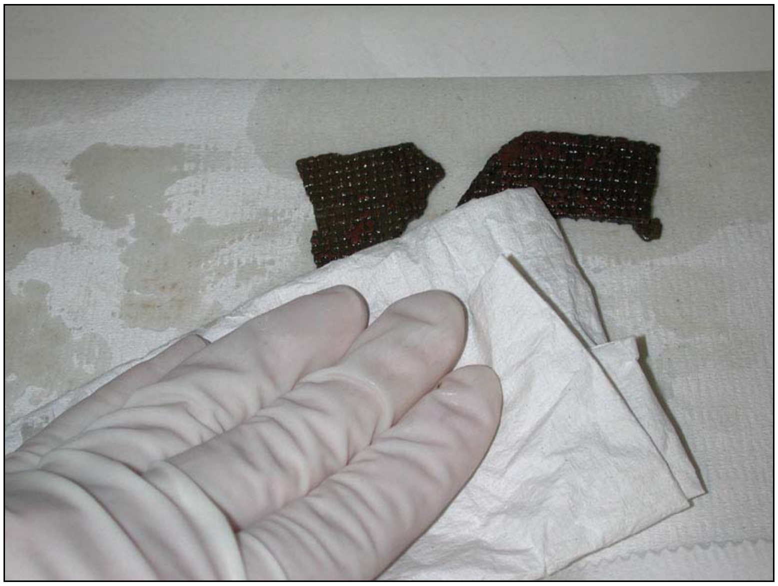

Figure 36. Blotting Excess Silicone Oil off Linoleum #5 (photo by B. E. Coke)

Once all the excess oil was removed, linoleum #5 was placed in a resealable bag with TPT Titanate (a catalyst). TPT Titanate catalysts are known for their ability to speed the polymerization of the oil and crosslinker. To ensure the effectiveness of the polymer and crosslinker, a small portion of the solution was placed in a small container and to this, the catalyst was added. The two are mixed together and the solution soon became very thick. Rapid thickening and eventual formation of a solid polymer shows that the catalyst is good and useable. The catalyst was poured into a small aluminum container and placed in the resealable bag. Figure 37 shows linoleum #5 in the fume hood going through the catalyzation process.

Figure 37. Linoleum #5 In Fume Hood Going Through Catalyzation Process (photo by B. E. Coke)

Three days later the bag was opened and more catalyst was poured into the aluminum container. The bag was resealed and left for another three days. When the catalyzation process was deemed finished, linoleum #5 was taken out and placed in a clean container with a piece of glass on top of it to keep it flat. Linoleum #5 had to be glued back together using superglue. Superglue had to be used instead of Paraloid B-72 because the Paraloid B-72 does not stick well to objects treated with silicone oil. Post treatment tracings and digital images were taken of the front and back of the linoleum as well as post treatment measurements.

LINOLEUM #6 – ACETONE-ROSIN

Figure 38 is a before treatment image of linoleum #6.

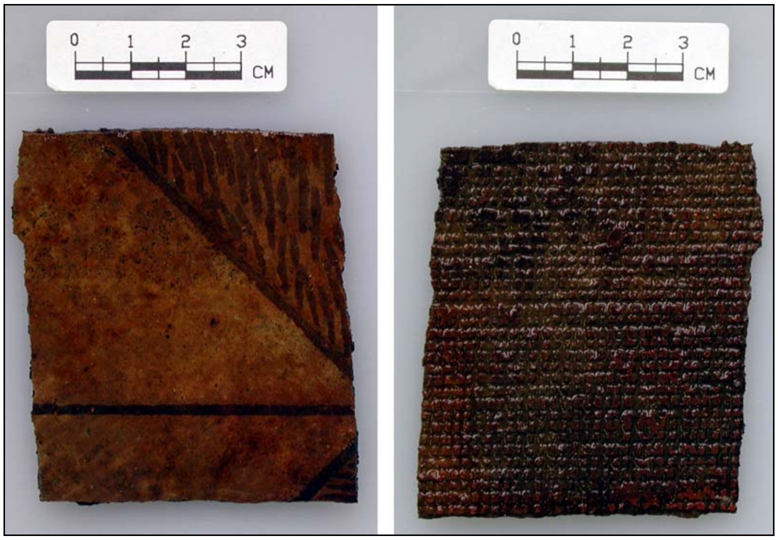

Figure 38. Pretreatment Image of Linoleum #6 (photo by B. E. Coke)

Linoleum #6 was thoroughly dehydrated before being placed in an acetone-rosin solution. The dehydration regime used was the same as that used for linoleum #5 (page 49).

After the 100% acetone soak, linoleum #6 was placed in a solution of 75% Colophony + Acetone which was also kept in the oven (90°F/32°C) for four days. Then the container was placed in the vacuum chamber and treated at reduced pressure for 30 seconds. The linoleum was placed in the vacuum to assure that the solution had entered into the cellular structure of the artifact. A short time limit for the vacuum was chosen because of the fragile state of the linoleum. The vacuum pulled on the segment was 83mm of mercury. Figure 39 shows linoleum #6 being placed into the vacuum chamber.

Figure 39. Placing Linoleum #6 in Vacuum Chamber (photo by E. Eilert)

Bubbles escaped the linoleum rapidly during the first 30 second vacuum. Two more 30 second reduced pressure treatments followed. The segment was left in the chamber after each vacuum and a 1 minute interval was between each session. The fourth reduced pressure treatment was conducted for 3 minutes at which point bubbling slowed appreciably. The linoleum was removed from the solution and surface-wiped with paper towels. The paper towels were dipped in acetone to help remove the excess rosin. Once the excess rosin was wiped away, the linoleum was placed in a clean container with glass on top of it to keep it flat, as demonstrated in Figure 40.

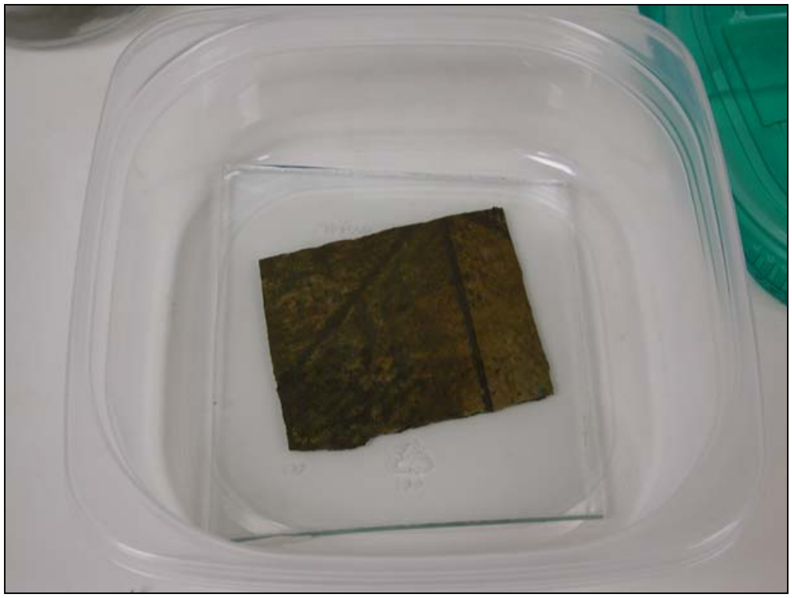

Figure 40. Linoleum #6 Post Treatment Under Glass (photo by B. E. Coke)

Post treatment tracings, measurements, and digital images were taken of the front and back of the linoleum.

LINOLEUM #7 – CROSSLINKER ONLY

Figure 41 is an image of linoleum #7 before treatment.

Figure 41. Pretreatment Image of Linoleum #7 (photo by B. E. Coke)

Linoleum #7 was dehydrated before it was immersed in a solution of 100% isobutyltrimethoxysilane (crosslinker). The dehydration regime used was the same as linoleum #5 (page 49).

After soaking in 100% acetone, linoleum #7 was placed in 100% crosslinker for four days. Then linoleum #7 was taken out of solution and blotted with paper towels to remove excess solution. Once excess crosslinker was removed, linoleum #7 was placed in a resealable bag with TPT Titanate. The catalyst was poured into a small aluminum container and placed in the resealable bag. Three days later the bag was opened and more catalyst was poured into the aluminum container. The bag was resealed and left for another three days. Figure 42 shows Linoleum #7 going through the catalyzation process.

Figure 42. Linoleum #7 In Fume Hood Going Through Catalyzation Process (photo by B. E. Coke)

When the catalyzation process was deemed finished, linoleum #7 was taken out and placed in a clean container with a piece of glass on top of it to keep it flat. Post treatment tracings, measurements, and digital images were taken of the front and back of the linoleum.

LINOLEUM #8 – LINSEED OIL

Figure 43 is an image of linoleum #8 before treatment.

Figure 43. Pretreatment Image of Linoleum #8 (photo by B. E. Coke)

Linoleum #8 had to go through dehydration before it could be placed in a solution of 100% linseed oil. The dehydration regime used was the same as that used for linoleum #5 (page 49).

After soaking in 100% acetone, linoleum #8 was placed in 100% linseed oil and then kept in the oven (90°F/32°C). The linseed oil used was purchased from the local hardware store. After four days the container was placed under a vacuum for 1 minute and no bubbles were noticed. Figure 44 shows linoleum #8 in the vacuum chamber.

Figure 44. Linoleum #8 in the Vacuum Chamber (photo by B. E. Coke)

The linoleum was taken out of the linseed oil and blotted with paper towels. Lots of blotting was needed to absorb the linseed oil. Then, the linoleum was placed in a clean container on top of a paper towel. Again, glass was placed on top of the linoleum to keep it flat. Post treatment tracings and drawings were made of the front and back as well as post treatment measurements.

STORAGE

Each segment of linoleum was placed in its own labeled resealable sandwich bag. All segments will be returned to the Lake Champlain Maritime Museum for final storage. Figure 45 is an image of all eight segments of linoleum placed back together post treatment.

Figure 45. All Eight Segments Placed Together (photo by B. E. Coke)

CHAPTER VI

RESULTS

Results have been compiled into the following two tables. Table 2 gives each linoleum's measurements taken before and after each treatment. The percent change of each measurement has been included in the table. The measurements were taken from set points on each linoleum. A1 to A2 is a horizontal measurement taken from two points. B1 to B2 is a vertical measurement taken from two points. The points of each measurement can be seen in the following illustration (Figure 46). Table 2 also gives the percent change in thickness of each linoleum. The thickness of each linoleum was taken from the A2 point, which can be seen in Figure 46.

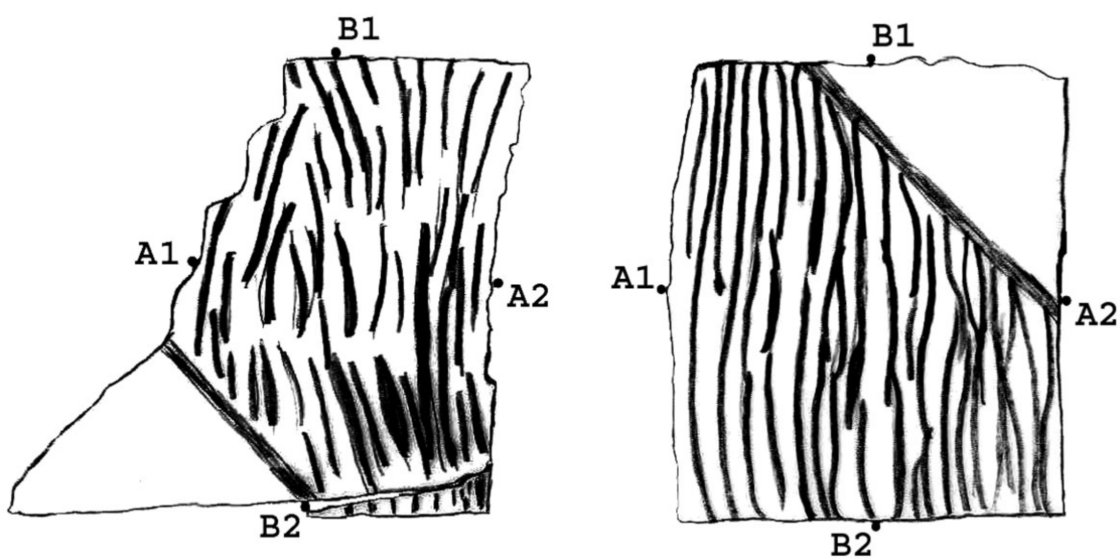

Figure 46. Pretreatment Drawing of Linoleum #1 and #2 Showing Points A1, A2, B1, and B2 (drawing by B. E. Coke)

For each segment of linoleum six questions were asked (Table 3).

1. How flexible is this segment of linoleum on a scale of 1 to 3? 1 being flexible, 2 designated as minimally flexible, and 3 being not flexible.
2. How brittle is this segment of linoleum on a scale of 1 to 3? 1 being did not break, 2 designated as breaks with force, and 3 being breaks with little force.
3. What does the texture feel like? 1 being feels smooth and dry, 2 designated as feels smooth and waxy, and 3 being feels coarse and dry.
4. Did the consolidant leave behind an odor when smelling the linoleum? 1 being no odor, 2 designated as slight odor, and 3 being moderate amount of odor.
5. Is there a noticeable color change in the segment compared to pretreatment coloration? 1 being lighter, 2 designated as similar to pretreatment color or a little darker, and 3 being noticeably darker.
6. Is the design still visible? 1 being design can still be seen well or there was no change, 2 designated as design is gone, and 3 being half or more of the design is gone.

Tables 2 and 3 present treatment results.

Table 2 Percent Dimensional Change and Percent Thickness Change

	% Dimensional Change						% Thickness Change		
	Pretreatment A1 to A2	Post Treatment A1 to A2	% Change A1 to A2	Pretreatment B1 to B2	Post Treatment B1 to B2	% Change B1 to B2	Pretreatment point A2 thickness	Post Treatment point A2 thickness	% Change at point A2
Linoleum 1	38.50 mm	35.70 mm	7.27%	58.71 mm	55.50 mm	5.47%	1.90 mm	1.50 mm	21.10%
Linoleum 2	50.80 mm	48.60 mm	4.30%	60.45 mm	58.90 mm	2.60%	1.85 mm	1.80 mm	2.70%
Linoleum 3	50.60 mm	48.50 mm	4.20%	58.05 mm	54.70 mm	5.80%	1.90 mm	2.10 mm	10.50%
Linoleum 4	46.00 mm	43.85 mm	4.70%	71.70 mm	68.20 mm	4.90%	1.70 mm	1.70 mm	0.00%
Linoleum 5	44.70 mm	41.10 mm	8.10%	65.40 mm	60.00 mm	8.30%	2.00 mm	1.50 mm	25.00%
Linoleum 6	58.30 mm	58.90 mm	1.00%	67.71 mm	68.15 mm	0.60%	1.95 mm	2.00 mm	2.60%
Linoleum 7	63.80 mm	61.20 mm	4.10%	67.51 mm	63.75 mm	5.60%	2.05 mm	1.80 mm	12.20%
Linoleum 8	42.70 mm	40.60 mm	4.90%	63.75 mm	61.80 mm	3.10%	1.90 mm	1.90 mm	0.00%

Table 3 Physical Assessment Results

	Flexibility	*Brittleness*	*Texture*	*Odor*	*Color*	*Design Appearance*
Linoleum 1	2	3	3	1	1	1
Linoleum 2	2	3	1	1	1	1
Linoleum 3	3	3	2	3	3	3
Linoleum 4	2	3	3	2	3	3
Linoleum 5	2	3	1	2	2	1
Linoleum 6	2	3	1	1	3	1
Linoleum 7	1	2	3	2	1	1
Linoleum 8	1	2	2	3	3	2

Key

Degree of Flexibility	Texture/ Feel to Touch	Color Change
1 = flexible	1 = smooth/dry	1 = lighter
2 = minutely flexible	2 = smooth/ waxy	2 = little darker/ similar
3 = not flexible	3 = coarse/dry	3 = darker
Degree of Brittleness	**Odor from Consolidant**	**Is Design Still Visible**
1 = not breakable	1 = no odor	1 = see design well/ no change
2 = breaks with force	2 = slight odor	2 = some design gone
3 = breaks with little force	3 = moderate odor	3 = half or more design gone

LINOLEUM #1 – AIR DRIED

Figure 47 is a post treatment image of linoleum #1. As can be seen in this image the segment curled when drying out.

Figure 47. Post Treatment Image of Linoleum #1 (photo by B. E. Coke)

From points A1 to A2 there was a 7.27% shrinkage and from points B1 to B2 there was a 5.47% shrinkage. Linoleum #1's thickness decreased 21.10%. Linoleum #1 was expected to shrink in size because it was allowed to dry out. Unlike adding a consolidant, which bulks up an artifact's cellular structure, drying an artifact allows it to loose its water content and causes the cellular structure to collapse on itself. This therefore results in the artifact shrinking in dimensional size. On the flexibility test linoleum #1 was a 2. When judging the brittleness of linoleum #1 it got a 3. Even though linoleum #1 was minutely flexible it does appear to be fragile and could break with little force. For texture assessment linoleum #1 got a 3. Linoleum #1 feels dry and coarse. The surface feels coarse, but it is not terribly rough. On the odor test linoleum

#1 was a 1, no detectable odor is present because nothing was added. When judging color change, linoleum #1 was a 1. Linoleum #1 is lighter than it was before drying out. For design appearance assessment linoleum #1 was a 1. The design on this segment of linoleum is still very visible and looks about the same as it did before drying.

LINOLEUM #2 – VACUUM FREEZE DRIED

Figure 48 is a post treatment image of linoleum #2.

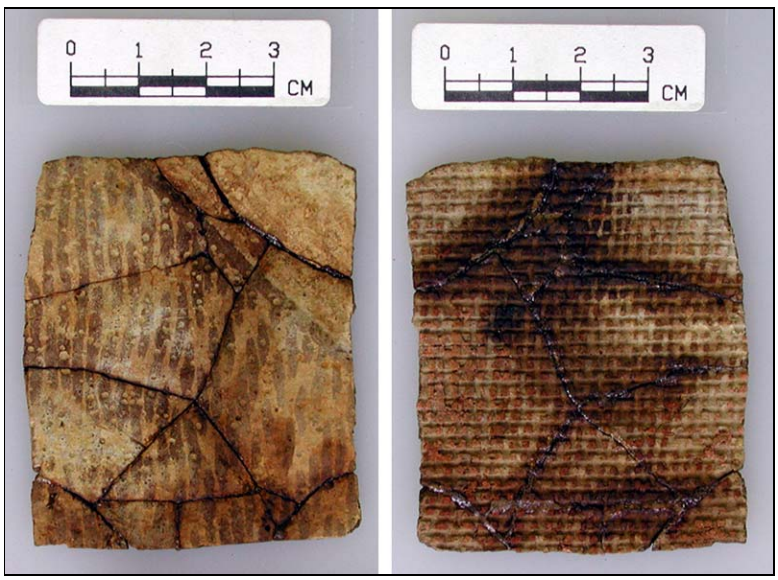

Figure 48. Post Treatment Image of Linoleum #2 with Re-glued Sections (photo by B. E. Coke)

After treatment linoleum #2 broke into a total of 13 pieces. From points A1 to A2 there was a 4.30% shrinkage and from points B1 to B2 there was a 2.60% shrinkage. Linoleum #2's thickness decreased 2.7%. Here again linoleum #2 was expected to shrink in size because no preservative was added to it. On the flexibility test linoleum

#2 was a 2. When judging the brittleness of linoleum #2 it got a 3. Even though linoleum #2 was minimally flexible it is very fragile and does break with little force. For texture assessment linoleum #2 got a 1. Linoleum #2 feels dry and smooth. The surface feels smoother than linoleum #1's surface. On the odor test, linoleum #2 was a 1, no detectable odor could be smelled from the linoleum. When judging color change, linoleum #2 was a 1. Linoleum #2 is lighter than it was before treatment. For design appearance assessment linoleum #2 was a 1. The design on this segment of linoleum is still very visible and looks about the same as it did before drying it out.

LINOLEUM #3 – DEHYDRATION-TOPICAL DRESSING

Figure 49 is a post treatment image of linoleum #3.

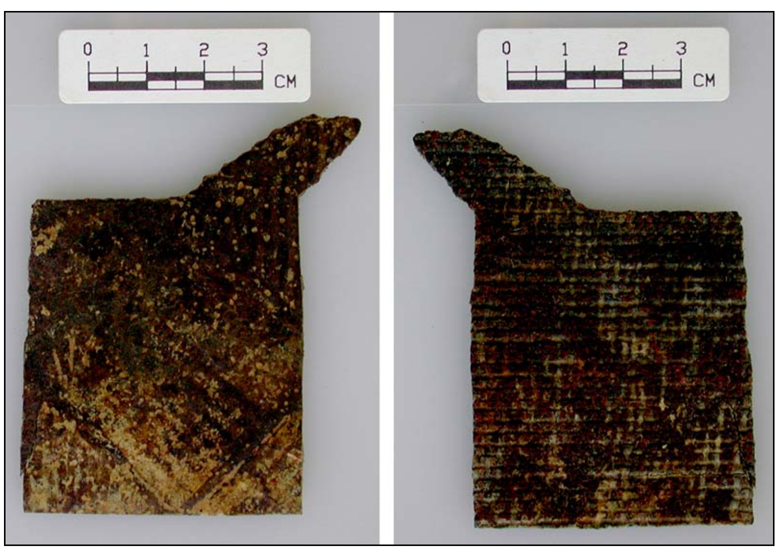

Figure 49. Post Treatment Image of Linoleum #3 (photo by B. E. Coke)

From points A1 to A2 there was a 4.2% shrinkage and from points B1 to B2 there was a 5.8% shrinkage. Linoleum #3's thickness decreased 10.50%. On the flexibility test linoleum #3 was a 3. When judging the brittleness of linoleum #3, it got a 3. Linoleum #3 is not flexible and could break with little force. For texture assessment linoleum #3 got a 2. Linoleum #3 feels waxy and smooth. The surface feels waxy due to the dressing used. On the odor test linoleum #3 was a 3, the dressing used on the segment can still be smelled on the linoleum. When judging color change, linoleum #3 was a 3, darker than it was before treatment. For design appearance assessment linoleum #3 was a 3. The design on this segment of linoleum is not very visible and part of the design is no longer visible.

LINOLEUM #4 – POLYETHYLENE GLYCOL

Figure 50 is a post treatment image of linoleum #4.

Figure 50. Post Treatment Image of Linoleum #4 with Re-glued Sections (photo by B. E. Coke)

From points A1 to A2 there was a 4.70% shrinkage and from points B1 to B2 there was a 4.90% shrinkage. Linoleum #4's thickness was unchanged. On the flexibility test linoleum #4 was a 2. When judging the brittleness of linoleum #4 it got a 3. Linoleum #4 is minimally flexible and broke with little force. For texture assessment linoleum #4 got a 3, coarse and dry. The surface feels coarse but not terribly rough. On the odor test linoleum #4 was a 2; the consolidant used on the segment can still be smelled on the linoleum. When judging color change, linoleum #4 was a 3, darker than it was before treatment. For design appearance assessment linoleum #4 was a 3. Part of the design on this segment of linoleum is no longer visible.

LINOLEUM #5 – SILICONE OIL + CROSSLINKER

Figure 51 is a post treatment image of linoleum #5.

Figure 51. Post Treatment Image of Linoleum #5 (photo by B. E. Coke)

From points A1 to A2 there was a 8.10% shrinkage and from points B1 to B2 there was a 8.30% shrinkage. Linoleum #5's thickness decreased 25%. On the flexibility test linoleum #5 was a 2. When judging the brittleness of linoleum #5 it got a 3. Linoleum #5 is minimally flexible and broke with little force. For texture assessment linoleum #5 got a 1, smooth and dry. The silicone oil did not seem to leave any residue behind on the surface that could be felt. On the odor test linoleum #5 was a 2, the silicone oil used on the segment can still be smelled on the linoleum. When judging color change, linoleum

#5 was a 2, only slightly darker than it was before treatment. For design appearance assessment linoleum #5 was a 1. The design is visible and looks the same as it did before treatment.

LINOLEUM #6 – ACETONE-ROSIN

Figure 52 is a post treatment image of linoleum #6.

Figure 52. Post Treatment Image of Linoleum #6 (photo by B. E. Coke)

From points A1 to A2 there was a 1.00% shrinkage and from points B1 to B2 there was a .60% swelling. Linoleum #6's thickness decreased 2.6%. On the flexibility test linoleum #6 was a 2. When judging the brittleness of linoleum #6 it got a 3. Linoleum #6 is minimally flexible and broke with little force. For texture assessment linoleum #6 got a 1, smooth and dry. On the odor test linoleum #6 was a 1; the colophony-rosin treatment did not leave behind any odor. When judging color change, linoleum #6 was a

3, darker than it was before treatment. For design appearance assessment linoleum #6 was a 1. The design is as visible as it was before treatment.

LINOLEUM #7 – CROSSLINKER ONLY

Figure 53 is a post treatment image of linoleum #7.

Figure 53. Post Treatment Image of Linoleum #7 (photo by B. E. Coke)

From points A1 to A2 there was a 4.10% shrinkage and from points B1 to B2 there was a 5.6% shrinkage. Linoleum #7's thickness decreased 12.20%. On the flexibility test linoleum #7 was a 1. When judging the brittleness of linoleum #7 it got a 2. Linoleum #7 is flexible and broke with some force. For texture assessment linoleum #7 got a 3, coarse and dry. On the odor test linoleum #7 was a 2; there is only a slight odor left behind from the crosslinker. When judging color change, linoleum #7 was a 1. Linoleum #7 is lighter than it was before treatment. For design appearance assessment linoleum #7 was a 1. The design is as visible as it was before treatment.

LINOLEUM #8 – LINSEED OIL

Figure 54 is a post treatment image of linoleum #8.

Figure 54. Post Treatment Image of Linoleum #8 (photo by B. E. Coke)

From points A1 to A2 there was a 4.9% shrinkage and from points B1 to B2 there was a 3.10% shrinkage. Linoleum #8's thickness decreased 0%. There was no change in the dimension of thickness. On the flexibility test linoleum #8 was a 1. When judging the brittleness of linoleum #8 it got a 2. Linoleum #8 is flexible and broke with some force. For texture assessment linoleum #8 got a 2. Linoleum #8 feels smooth and waxy. On the odor test linoleum #8 was a 3; the linseed oil left behind a strong odor. When judging color change, linoleum #8 was a 3, much darker than it was before treatment.

For design appearance assessment linoleum #8 was a 2. Some of the design is hard to see, but this could be due to the darkening of the segment from the linseed oil.

CHAPTER VII

CONCLUSIONS

This thesis focused on three areas of research: (1) How can linoleum be conserved? Two measures taken in answering this question were to review all previous conservation work done on linoleum and to limit treatment choices to those that would be available at the Lake Champlain Maritime Museum Conservation Laboratory; (2) What is the history of linoleum's use on boats and was it a common practice; and (3) Would it be possible to find the manufacturer of this linoleum?

To answer the first question, each segment of linoleum needed to be evaluated individually to see if the treatment was beneficial. When evaluating the outcome of each treatment, none of them gave a perfect result. Overall they are all fragile and easily broken.

Linoleum #1 was left to air dry naturally. Because of this the linoleum curled and is no longer flat. In retrospect a piece of glass, or anything to weigh it down, should have been placed on top of the linoleum segment to keep it flat. Overall linoleum #1 experienced one of the higher amounts of shrinkage. Despite the state of fragility linoleum #1 possesses no odor, it does not have a residual coating, and its design is very visible. This proved to not be a viable treatment choice because of the amount of shrinkage and curling.

Linoleum #2 was put into a vacuum freeze dryer. Unfortunately it could not handle the pressure and broke into a total of thirteen pieces. Linoleum #2 experienced little shrinkage compared to the others. It as well does not have an odor or a residual coating from a solution. But unfortunately it is very fragile and experienced too much trauma during the treatment.

Linoleum #3 was dehydrated and then had an application of a topical dressing. Linoleum #3 had a moderate amount of shrinkage. It is very fragile. The treatment did not have good results. The dressing left a waxy coating and strong odor. The segment of linoleum is now darker and part of the design is hard to see or no longer there. This treatment did not prove to be beneficial.

Linoleum #4 was consolidated with PEG. Linoleum #4 experienced a small amount of shrinkage. No residual solution was left behind but there is a slight odor, it's darker, and part of the design is no longer visible. Therefore this treatment did not prove to be beneficial.

Linoleum #5 (silicone oil + crosslinker) had a high amount of shrinkage compared to the others and it again is fragile. No residual silicone oil was left behind but a slight odor is present. The design is still very visible and there was very little color change. This treatment was beneficial in keeping the design but the segment is fragile, broke during treatment, and had the highest amount of shrinkage.

Linoleum #6 (acetone-rosin) experienced the least amount of shrinkage. No residual rosin or odor was left behind by the treatment. Even though the segment is darker than before treatment, the design is still very visible. This treatment proved to be beneficial.

Linoleum #7 (crosslinker) had a moderate amount of shrinkage. Unlike linoleum's #1 through #6, linoleum #7 is flexible to a degree. The surface is dry, but a slight odor remains. It is lighter than before treatment and the design is very visible. This treatment of using only a crosslinker proved to be beneficial.

Linoleum #8 (linseed oil) had a small amount of shrinkage. Like linoleum #7, it is flexible to a degree. A waxy residue was left behind by the linseed oil, as well as a strong odor. It is much darker than before treatment and part of the design is hard to see. Even though linseed oil seemed like a logical treatment, it did not perform well in this particular experiment.

To answer question number one, the treatments that proved to be the most beneficial from this particular experiment were the colophony-acetone treatment and the crosslinker only treatment. Both of these treatments can be performed at the LCMM Conservation Laboratory.

As far as linoleum's use on boats, not a lot of information could be found per se. The Navy was a big consumer of linoleum, a.k.a. Battleship Linoleum. Information for use of linoleum on small vessels such as canal boats was not found. One can make an assessment that linoleum rugs were an easy addition to canal boats to help make them more home-like and provide a nice surface to walk on.

The manufacturer of this particular specimen of linoleum could not be easily matched to a pattern to a particular manufacturer. Most likely it was one of the manufacturers from the northeast, but which one is unknown for now.

Linoleum was a large part of the late 19th- and early 20th-century culture. It provided a new means of floor covering that was durable and its legacy paved the way for modern day floor coverings.

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APPENDIX A

CONSERVATION CODE OF ETHICS

These guidelines are modeled after those adopted by the International Institute for Conservation (IIC) and the American Institute of Conservation (AIC).

1. Respect for Object Integrity: All professional actions of the conservator are governed by their respect for the aesthetic, historic, and physical integrity of the object or artifact. This truth must guide the conservator's choice of treatment, methods of documentation, and the long-term curation of an object.

2. Competence and Facilities: It is the conservator's responsibility to undertake the investigation or treatment of an historic or artistic work only within the limits of their professional competence and facilities, to do otherwise would be putting the object at risk.

3. Single Standard: With every artistic or historic work they undertake to conserve, regardless of their opinion of its value or quality, the conservator should adhere to the highest and most exacting standard of treatment. Although circumstances may limit the extent of treatment, the quality of treatment should never be governed by the quality or value of the object. While special techniques may be required during the treatment of large groups of object, such as archival and natural history material, these procedures should be consistent with the conservator's respect for the integrity of the objects.

4. Suitability of Treatment: The conservator should not perform or recommend any treatment which is not appropriate to the preservation or best interests of the historic or artistic work. The necessity and quality of the treatment should be more important to the professional than their compensation.

5. Principal of Reversibility: The conservator is guided by endeavors to apply the "principal of reversibility" in their treatment. They should avoid the use of materials which may become so intractable that their future removal could endanger the physical safety of the objects. They also should avoid the use of techniques, the results of which cannot be undone if it should become desirable. In general, all treatments should be reversible. This requirement recognizes that a conservation treatment may not last indefinitely nor remain superior to all future techniques. If the treatment is reversible, the option to re-treat is always open and the continued preservation of the material is assured. However, it should be noted here that the idea of reversibility in archaeological conservation is undergoing close scrutiny. In the case of archaeological artifacts, especially those from submerged sites, the conservator often has only one chance to save an artifact, and this may necessitate the employment of a technique that is not

completely reversible. While reversibility is a concept that should be aimed for, the preservation of the artifact must have first priority.

6. Limitations on Aesthetic Reintegration: In compensating for damage or loss a conservator may supply little or much restoration, according to a previous understanding with the owner or custodian. It is equally clear that he cannot ethically carry compensation to a point of modifying the known character of the original.

7. Continued Self-Education: It is the responsibility of every conservator to remain abreast of current knowledge in their field and to continue to develop their skills so that he may give the best treatment circumstances permit.

8. Auxiliary Personnel: The conservator has an obligation to protect and preserve the historic and artistic works under their care at all times by supervising and regulating the work of all auxiliary personnel, trainees, and volunteer under their professional direction. A conservator should not contract or engage himself to clients as a supervisor of insufficiently trained personnel unless he can arrange to be present to direct the work.

9. Documentation: The conservation professional shall document all stages of artifact processing including examination, scientific investigation, treatment, and storage by producing detailed records and reports of all activities. This is very important for the long-term preservation of objects. Without thorough documentation of procedures carried out on an artifact future curators of the collection may not be able to properly assess the condition of the item and treat it accordingly.

10. Safety First: The conservator must practice in a manner that minimizes personal risks and hazards to co-workers, the public, and the environment. He must be aware of issues concerning the safety of materials and procedures and should make this information available to others as appropriate.

These guidelines were taken from the Lake Champlain web page located at www.lcmm.org.

VITA

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EDUCATION

December 2004 Master of Arts in Historical Archaeology, Texas A&M University

May 1999 Bachelor of Science in Biomedical Science; and Minor in Anthropology, Texas A&M University

EXPERIENCE

Summer 2004 Conservator, Conservation Research Laboratory, Texas A&M University

Summer 2003 Conservator, Museum of Tropical Queensland, Townsville, Queensland, Australia

Summer 2001, 2002 Conservator, Lake Champlain Maritime Museum, Vergennes, Vermont

Summer 2000 Field worker, Field School sponsored by Illinois State University, Ballykilcline, Ireland

1999-2002 Field volunteer, Center for Ecological Archaeology, Texas A&M University