Blackbeard Sails Again? Conservation of Textiles from the Queen Anne's Revenge Shipwreck (31CR314)

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Abstract

In 1996, a shipwreck believed to be the pirate Blackbeard's sunken flagship, the *Queen Anne's Revenge* (QAR), was discovered off the coast of North Carolina. Of the thousands of artifacts that have since been recovered, a small number of textile fragments have survived. Textile fragments recovered from the QAR wreck site are preserved in unique, localized environments and therefore require individual analysis and treatment. During necessary conservation processes, textiles may undergo stressful physical and chemical changes that may permanently damage these artifacts. The primary goal of this research was to determine the most effective conservation methods for cleaning and drying textile fragments recovered from the QAR so that they may be available for future research and public exhibit. To achieve this goal, the efficiency of conservation methods previously used on fiber perishable artifacts from the QAR was evaluated and retested both on modern textiles and on historic artifacts. The results of this testing will help to establish a protocol for the future conservation of textiles and other fiber perishables recovered from the QAR site. Textile technical attributes essential for historical comparison and interpretation of function were also recorded for each QAR textile artifact. Distinctions in technical attributes were then used to develop a typology of textiles in the QAR assemblage. Key attributes diagnostic of early eighteenth century sailcloth manufacture were identified in several QAR samples; other QAR textiles that have been identified as the same textile type can now be functionally classified as sailcloth.

INTRODUCTION

From 1710 to 1717, Frenchmen aboard the ship *La Concorde* captured numerous foreign ships and traversed the Atlantic several times as slave traders, carrying around 500 slaves on each voyage. In 1717, English pirates under the direction of the notorious Blackbeard captured *La Concorde* and renamed the ship the *Queen Anne's Revenge*. Blackbeard and his crew of several hundred men went on to plunder more than 40 vessels in the following year, and with the aid of three smaller sloops they blockaded the port of Charleston for over a week before running the QAR aground in Beaufort Inlet, NC in 1718 (Lawrence and Wilde-Ramsing 2001).

In 1996, the remains of a shipwreck (31CR314) believed to be the *Queen Anne's Revenge* were discovered just over a mile off the coast of Beaufort Inlet, NC, under 22-28 feet of water. Under the direction of the Underwater Archaeology Branch of the North Carolina Department of Cultural Resources, underwater archaeologists have excavated approximately 30% of the site area and recovered tens of thousands of artifacts. These artifacts are usually concreted in iron corrosion, sand, shell, and other mineral products and require intensive long-term conservation. Therefore, before QAR artifacts can be made available for public viewing and further study, they must first be sent to the QAR Conservation Laboratory in Greenville, NC for conservation treatment.

Chen (2006) conducted a preliminary analysis of plant fiber artifacts from the QAR site, producing an introductory report on rope, cannon wadding, and textiles in the assemblage. However, due to time and funding constraints, an assessment of necessary conservation treatments and a comprehensive comparison of textile fragments within the QAR artifact assemblage had not yet been conducted as of January, 2008. To begin to address these issues, a 5-month independent study was conducted by Adria L. Focht, Graduate Student of Anthropology at East Carolina University and directed by both Dr. Runying Chen, Associate Professor in the Department of Interior Design and Merchandising at East Carolina University and Sarah Watkins-Kenney, head conservator of the Queen Anne's Revenge (QAR) Shipwreck Project Conservation Laboratory. This report presents the results of that study, which can now be applied to further treatment and analysis of QAR textile artifacts.

Preservation States of Textiles Recovered from an Underwater Environment

Archaeological textiles may be preserved in an underwater environment in a variety of ways, including: in concretions, as impressions, or as pseudomorphs. Each of these states of preservation must be analyzed individually using specialized conservation methods. Extant textile fragments may be preserved within concretion materials. Figure 1 shows textile fragment QAR345.014 as it was being removed from the surface of lead shot in concretion. Textile fragments may be extracted from concretions using a variety of chemical and mechanical methods. QAR345.014 was removed from concretion with a combination of submersion in hydrochloric acid and air scribing.

Figure 1: Textiles Preserved in Concretion

While a textile artifact may have completely deteriorated in the marine environment, a negative, mirror-imaged impression of a textile sometimes remains preserved on the surface of concretions and other artifacts. Positive casts can be created from these impressions to attain the textile technical attributes necessary for comparison with other samples. Figure 2 shows negative textile impressions preserved in iron corrosion materials on a lead shot concretion.

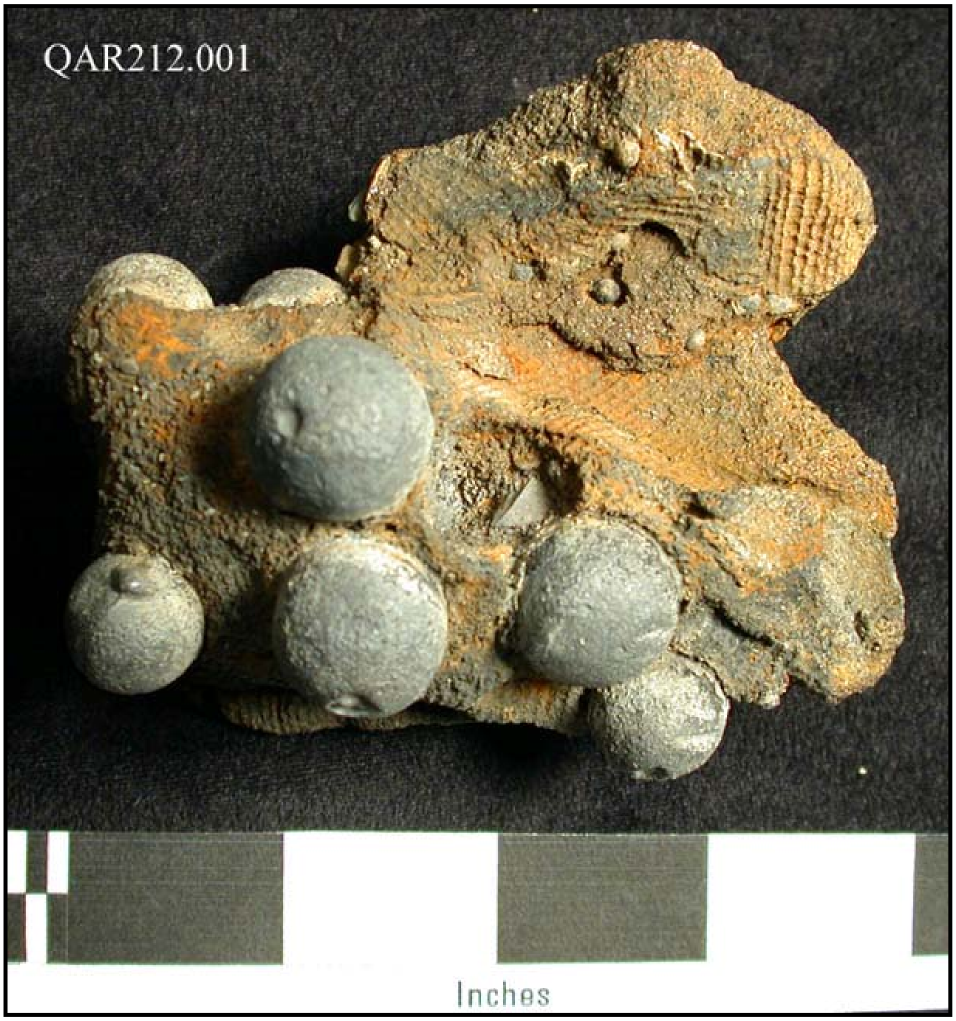


Figure 2: Textiles Preserved as Impressions

Pseudomorphs can be difficult to conserve because salts may not have completely replaced textile fibers, and the conservation techniques for these two different materials are frequently mutually exclusive. For example, the conservation of iron chlorides that may preserve a textile as a pseudomorph would normally require treatments with tannic acid and/or Acryloid B-72; however, these treatments have the potential to cause damage to fibers and may also be inappropriate for achieving other conservation standards for textiles.

In addition, textile conservation usually requires the removal of iron chlorides in order to protect fibers from potentially active iron corrosion and further damage upon dehydration. QAR347.004 (Figure 3) is a lump of iron corrosion that has become inextricably integrated with a textile artifact. This sample illustrates the multiple states in which textiles may be preserved in an underwater environment: pseudomorphs (top left), organic textile fibers (center), and textile impressions (bottom right) are all present on an artifact less than 15 millimeters in length.

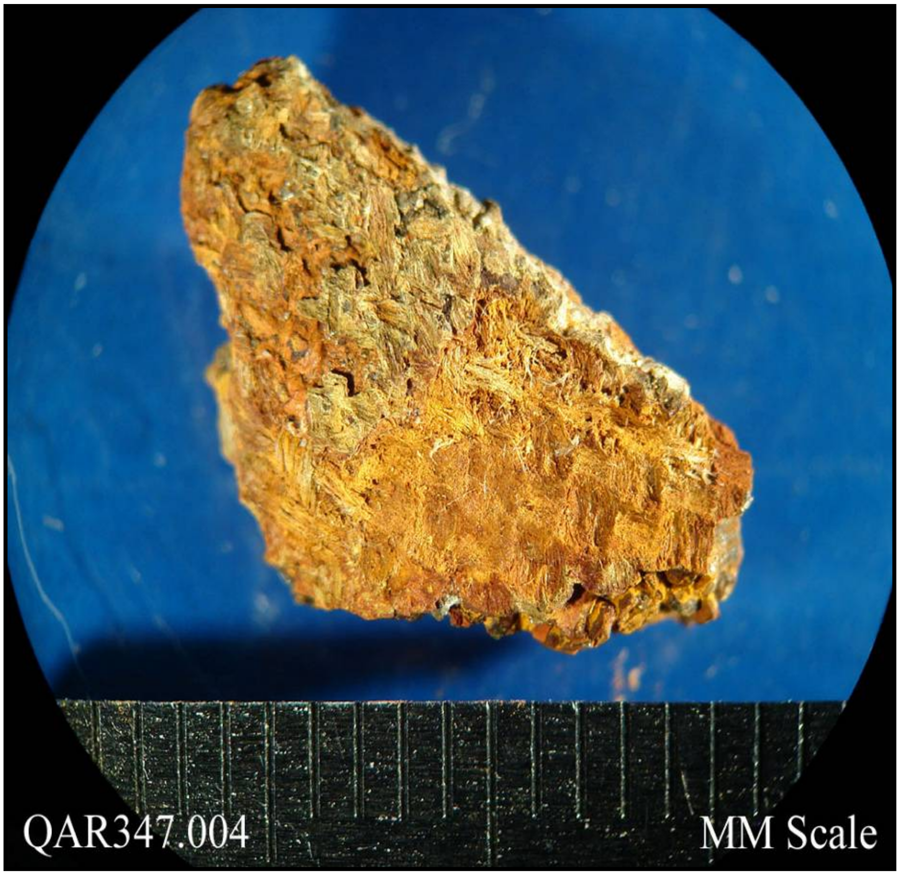


Figure 3: Textiles Preserved as Pseudomorphs

The most well-preserved QAR textile artifacts and those most useful for historical research are the textile fragments with extant organic fibers recovered from within concretions; these are most likely to remain structurally intact, preserving technical attributes useful for comparison with other samples. Fifty-four such textile fragments have so far been extracted from nine different concretions recovered from the QAR wreck site; these artifacts are the primary subject of this research.

METHODS AND RESULTS

Effectiveness Assessment of Previous Conservation Treatment Methods

QAR textile artifacts are in various stages of conservation treatment: some are dehydrated, some are not, and most require further treatment and analysis before they can be sent to the North Carolina Maritime Museum in Beaufort, NC for permanent storage and display. To determine which conservation methods would be successful for future treatments, the effectiveness of previously-used conservation methods was evaluated. Problems with storage, cleaning, and dehydration were identified; immediate concerns were addressed and recommendations were made for future conservation treatments (Table 2). Textile fragments in wet and dry storage were evaluated based on the following conservation standards for fiber perishable artifacts recovered from an underwater environment (adapted from Jenssen 1987):

Conservation Standards for Fiber Perishables:

- The wet dimensions of textile fragments should be preserved as much as possible. While some shrinkage is to be expected when dehydrating textiles from an underwater environment, minimal shrinkage is most desirable. Any changes in dimensions should be fully documented.

- The wet appearance, and to some extent, the appearance of original artifact, should be preserved as much as possible. For example, certain consolidants (such as Acryloid B-72) may leave glossy finishes or cause textiles to become stiff and inflexible. Ideally, conservation treatments should not alter the appearance of an artifact from the way the object was intended to appear. Any changes in appearance should be fully documented.

- Treatment should be as non-intrusive as possible and the over-treatment of artifacts should be avoided.

- Treatments should be archival and reversible or re-treatable.

- The treated artifact should be physically stable: the physical strength and integrity of the artifact should be at an acceptable level: the textile fragment should not be too fragile, friable, flaking, brittle, dry, or wet.

- The treated artifact should be chemically stable: it should be free of staining and other potentially harmful and unstable intrusive materials such as iron corrosion and salts.

- The treated artifact should be able to be studied on both sides with minimal handling.

- The treated artifact should be able to support its own weight, and proper support should be provided.

- Proper storage and/or display mounting should be provided. The artifact should not be loose in a box, but secured by packaging or mounting. There should be sufficient air circulation around the textile. There should be no off-gassing or static-causing materials present in the storage space. Light, especially ultraviolet light, should be kept at a minimum. Temperature and humidity should be controlled (temperature should remain below 70 degrees with a relative humidity of 50 degrees year-round.

Evaluation of Dry Storage Conditions

Dehydrated organic artifacts had previously been stored either in sealed plastic bags or in polystyrene Petri dishes. Sealed plastics trap moisture, allowing bacteria, mold, mildew, and fungi to grow; these growths can have devastating effects on fiber perishable artifacts such as textiles (Chen and Jakes 2001). Unfortunately, static charge can build up in polystyrene Petri dishes which can attract fibers, encouraging shedding of fibers and subsequent structural loss in textiles (Jenssen 1987:148). As a temporary solution until more suitable storage can be attained, plastic bags were punctured to improve air circulation and reduce the risk of damage to artifacts.

Peacock (2001:613) recently chose polystyrene boxes as suitable containers for the long-term dry storage of Trondheim’s medieval collection of 2400 archaeological textiles. She lined these boxes with fabric-covered mobile support trays that reduced the threat of potential fiber damage due to static charge between the polystyrene boxes and the textile artifacts. Treated textile artifacts from the QAR could be permanently stored in polystyrene Petri dishes; however, fabric-covered trays are inappropriate for the extremely small textile fragments in the QAR assemblage. Therefore, to reduce the risk of physical damage due to static, a single layer of acid-free paper should be cut to fit the bottom of the container as a liner.

These polystyrene Petri dishes are transparent, which aids viewing in storage. To view the reverse face of a textile fragment, a thick layer of Mylar sheeting cut to fit inside the Petri dishes should be laid over the textile and supported with one hand as the dish is turned upside down. In addition, polystyrene Petri dishes currently used at the QAR Conservation Laboratory are not air-tight; these containers should allow for sufficient air circulation and should therefore not be further sealed in plastic bags or placed within larger sealed storage containers.

There is also an unresolved issue with tagging these artifacts: Dymo labels have unstable, non-archival adhesive backings and the Sharpie markers used to write on Tyvek tags can bleed and stain artifacts. It may be appropriate to use a Sharpie marker to write QAR numbers on the exterior of the polystyrene Petri dishes in order to avoid problems with these issues in the future.

Evaluation of Wet-Storage Conditions

Two groups of QAR textile fragments (QAR345.014 and QAR347.006) had been removed from concretions using chemical methods (hydrochloric acid) and mechanical methods (air scribing) in 2005; these fragments were then placed in RO water in a small Tupperware container and were kept in refrigeration for 3 years. A comparison of the current appearance of these artifacts to a photograph taken in 2005 indicates that the small amounts of iron corrosion materials that remained on the edges of textile fragments QAR345.014 continued to actively corrode in wet storage, adding further staining to the textile fibers.

This behavior was also noted in other organic artifacts in wet storage, including rope and hair; when these objects are integrated with heavy iron corrosion materials and are stored in minimal water in plastic bags, iron frequently actively corroded and re-deposited on the surface of the artifacts. This suggests that textiles conserved in long-term wet storage should be first thoroughly cleaned of intrusive materials, especially those that are unstable and may create active corrosion environments potentially destructive to textiles.

When cleaning can not be done immediately following removal from concretion, and textile fragments and other fiber perishable artifacts (especially rope) containing heavy iron corrosion materials must be kept in long-term wet storage, the artifacts should be stored not in plastic bags with minimal water but in individual Tupperware containers with plenty of water. Ample water will allow for iron to precipitate out of the organic materials without re-depositing on the surface of the artifact and will reduce the risk of unintentional dehydration in storage. Water levels should also be systematically checked (monthly or bi-monthly) to prevent premature drying in refrigeration.

Numerous textile fragments recovered from the same concretion had been stored in a single storage container; this allowed fragments to move freely and resulted in several problems. First, the textiles were frequently moving over one another, causing friction which physically degrades fibers. Second, several textile fragments overlapped one another as they settled, causing the textiles to be distorted instead of laying flat. Third, fragments that had overlapped in wet storage required considerable physically handling to separate for analysis.

After nearly 300 years in the ocean and recent removal from the concretion preservation environment, these textile fragments are extremely fragile and susceptible to damage from physical activity. Before further analysis and treatment could begin, a new storage system had to be developed to support and protect textiles fragments while handling. Mylar sheeting and Trilene fishing line were used to create supports that fit inside Petri dishes in wet storage (Figure 4). These supports allow conservators to process textile fragments in wet storage without directly handling them.

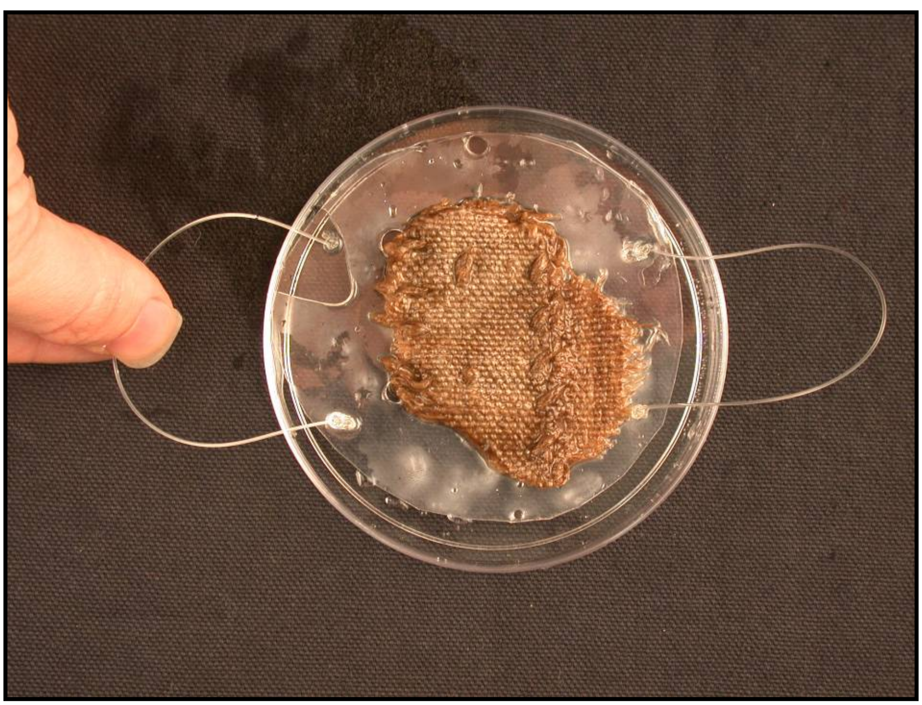


Figure 4: New Wet-Storage Supports

Assessment of Fiber Structure

Fiber content and the level of fiber degradation must be identified before further treatment of textiles can begin because conservation methods may vary dependent on these factors. Several methods were utilized to identify fiber content, including: standard light microscopy, polarized light microscopy, and fiber twist tests. Similar methods were used by Chen and Lusardi (2001) to identify fiber types and assess the level of fiber degradation in cordage wadding recovered from within cannons from the QAR site. Observations of fiber structures under standard light microscopy indicated that textile fragments QAR347.006 and QAR345.014 are composed of bast fibers. While bast fibers such as hemp and linen are taken from the phloem or inner bark of the stem of a plant and have a distinctive bamboo-like structure, cotton is the seed hair of the plant and exhibits a characteristic twisted-ribbon structure; these distinctions are usually made clear with microscopic analysis (Jakes and Mitchell 1987; Florian, Kronkright, and Norton 1990).

Since the most common fiber materials that composed eighteenth century French sailcloth were hemp, linen, and blends of hemp or linen with cotton (according to Marquardt 1992), and since microscopic analysis did not indicate the presence of cotton, fiber twist tests were conducted to differentiate between hemp and linen fibers. While cotton fibers will spin both counter-clockwise and clockwise as they dry; linen (flax) is a right-hand fiber, so it will usually spin clockwise when it dries, and hemp is a left-hand fiber, so it will usually spin counter-clockwise when it dries (Jakes and Mitchell 1995; Chen 2006). To conduct fiber twist tests, fibers extracted from QAR textile artifacts were separated from fiber bundles into individual fibers with a fine-tipped tweezers under a microscope. Individual fibers were held in the tweezers and spin direction upon dehydration was observed (this spin behavior happened very quickly after wet fibers were exposed to air).

Fibers isolated for twist testing from textile fragments QAR347.006 behaved like hemp fibers, consistently spinning counterclockwise (Figure 5). However, while fibers from QAR345.014 predominately spun clockwise, a few displayed a clockwise spin. Since the microscopic structure of the QAR345.014 fibers appears to be bast and is therefore unlikely to be cotton, it is possible that this sample is a hemp and linen blend. Louie Bartos (personal communication 2008) and Goodway (1987:27) have reported that twist tests can be defunct on degraded underwater samples; randomness of twist can occur due to degraded fiber structure, producing contradictory results. To clarify the hand and spin direction of the fiber, an attempt was made to replicate Herzog's polarized light microscopy test using a red gypsum plate (Goodway 1987). Unfortunately, results were inconclusive and hemp and linen fibers were indistinguishable even when comparing known modern samples.

More sophisticated techniques such as scanning electron microscopy or mass spectrometry should be conducted in the future to precisely determine the fiber content of QAR textile samples. In addition to hemp and linen, other bast fibers not common in the literature such as stinging nettle, ramie, jute, and kenaf should also be considered when identifying samples. It may also be advantageous in the future to take fiber samples directly from a warp and a weft element separately, because even though these elements were woven at the same location, fibers or spun thread may have been obtained from separate proveniences and may not be the same type of fiber. The identification of fiber content will aid in the assessment of further conservation treatments for QAR textiles and will facilitate historical comparison. More specifically identifying the fiber content of QAR textiles will also assist in interpretations of the country of origin of these artifacts.

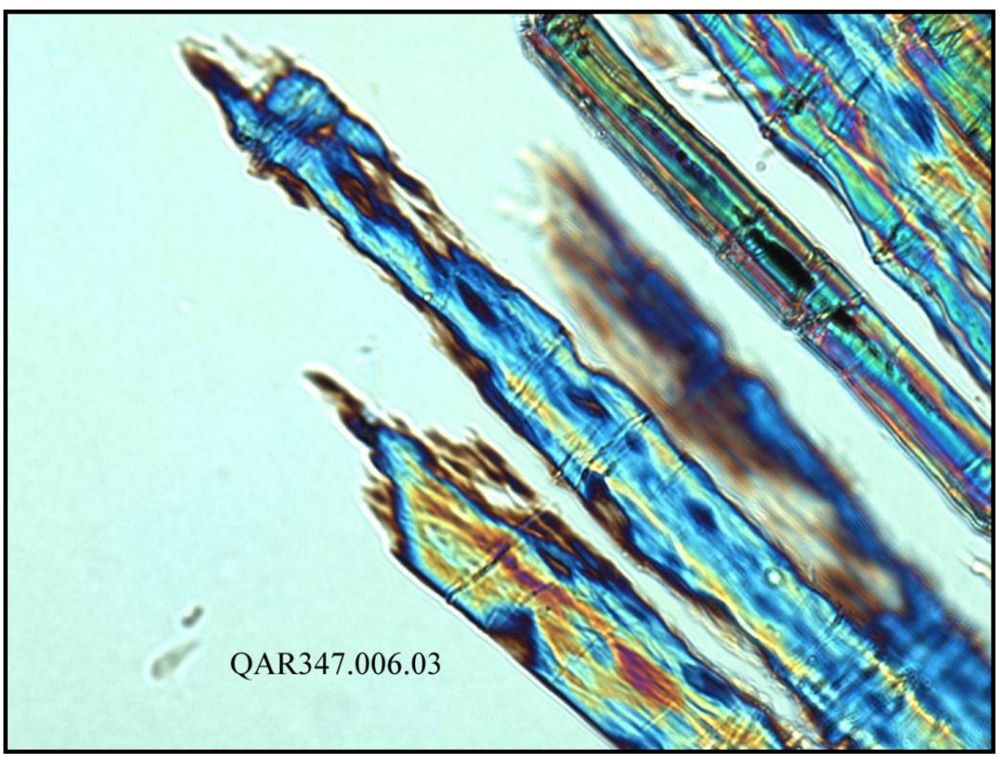


Figure 5: Bast Fibers with Advanced Bio-deterioration under a Polarized Light Microscope

In addition to determining fiber type, it may be necessary to determine the level of fiber degradation of textile artifacts prior to dehydration to ascertain whether or not bulking agents or consolidants would be appropriate pre-treatments. Figure 5 illustrates the appearance of bast fibers sampled from QAR347.006(4) under a polarized light microscope. Fibers such as these that exhibit advanced biodeterioration are more likely to require treatment with bulking agents prior to dehydration to prevent structural collapse (Florian 1987; Peacock 1996a, 1996b, 2004:506; Jakes and Mitchell 1992:348).

Identification of Intrusive Materials

A variety of intrusive organic and inorganic materials become integrated with archaeological textiles recovered from an underwater environment. Metal corrosion products, other salts, and sand are the most common intrusive materials in QAR textiles. Figure 6 is a microscopic photo showing fine salts that precipitated out of textile fragment QAR366.086 upon drying. Samples such as these strongly suggest that textile fragments require formal cleaning and desalination prior to dehydration.

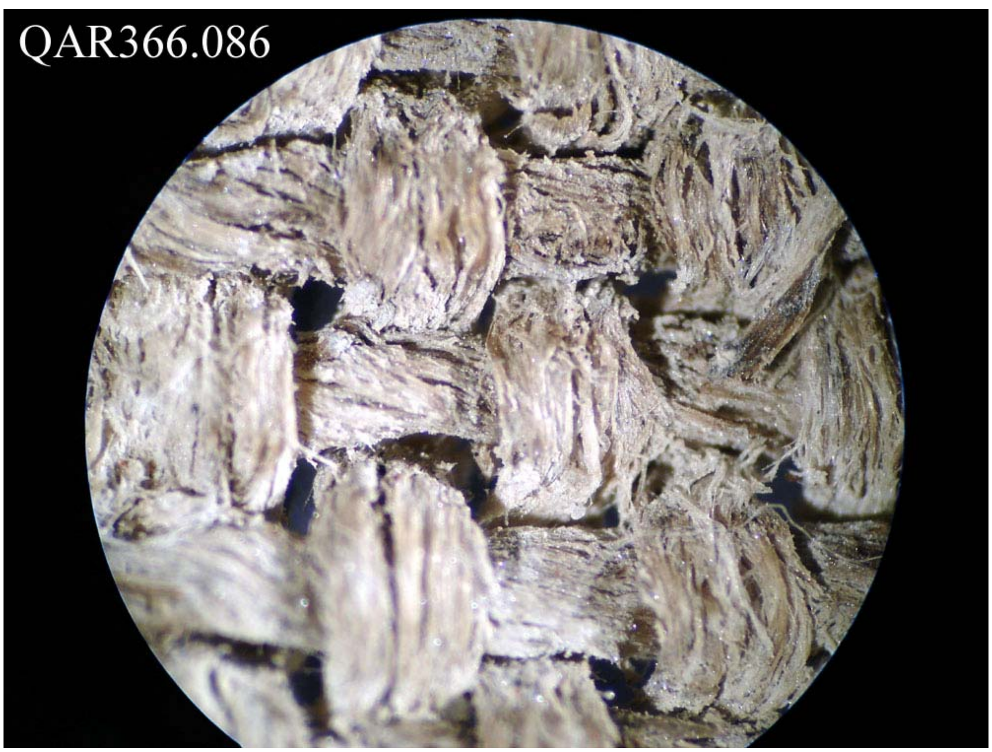


Figure 6: Microscopic Photo of Salts on Textile Fibers

In addition to being unsightly and obscuring the appearance of the textile, intrusive materials can be damaging to textile fibers, especially if not removed prior to dehydration. The identification of these intrusive materials is sometimes necessary to determine appropriate cleaning methods. Intrusive materials that cannot be identified with microscopy and chemical spot-testing and are not removed with conventional methods may be identified using mass spectrometry to determine appropriate cleaning methods.

If the presence of dye, tar, paint, pitch, wax, tallow, or oil that may be original to the textile artifact is ever suspected in the future, various methods including mass spectrometry or gas liquid chromatography may be necessary to identify the material and determine whether or not it should be removed. If materials such as these are suspected, textile fragments should not be treated with solvents or solvent-based solutions which may remove materials original to the artifact that should be preserved and researched.

Testing Iron Removal Methods

Many QAR textile fragments exhibit intrusive iron corrosion products. Iron must be removed because it too is potentially harmful to textiles upon dehydration. To assess which iron removal methods would be most appropriate for use on QAR artifacts, methods were first tested on the modern textiles composed of the three most common eighteenth century sailcloth materials: hemp, linen, and hemp or linen blended with cotton. These samples were submerged for several weeks in sea water, active iron corrosion, and other concretion materials recovered from the wreck site. This process simulated the underwater concretion environment and impregnated modern textile fibers with intrusive materials similar to those found in QAR textile samples (Figure 7).

Tarleton and Ordonez (1995:84) conducted a similar experiment by creating a simulated wet terrestrial archaeological environment in which they immersed modern wool textiles to “degrade and weaken new textile samples to a point where they attain physical characteristics similar to archaeological textile samples”. A comparison of stabilization methods subsequently used on these modern test samples was then applied to archaeological textile artifacts.

Figure 7: Modern Textiles in Simulated Concretion Environment

Following immersion in the simulated concretion environment, soiled samples were submerged for 24 hours in a variety of chemical baths previously used for the removal of iron corrosion materials from organics on the QAR and other shipwreck conservation projects. Chemicals tested included: 2.5% oxalic acid, 5% oxalic acid, 2% dibasic ammonium citrate, 10% dibasic ammonium citrate, and 5% citric acid. All solutions were prepared as percentage weight per volume in reverse osmosis (RO) water.

Figure (8) illustrates the results of this testing. Control samples that were not subjected to the simulated underwater concretion environment are present in the columns to the far left and right to exhibit the original state. Both concentrations of oxalic acid (2.5% and 5%) produced the desired result; however, because the low pH of oxalic acid is potentially damaging to fibers, the lower concentration (2.5%) was recommended for use on QAR textiles.

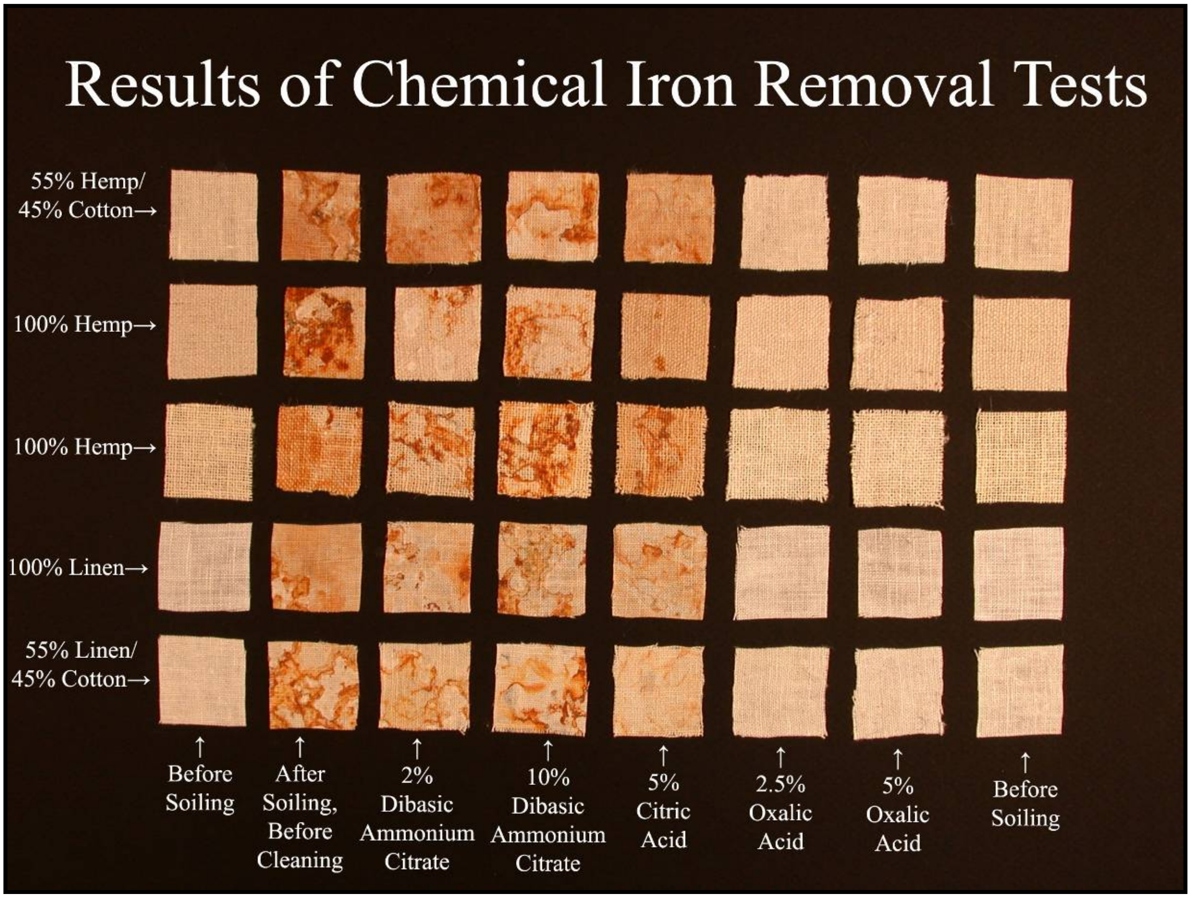


Figure 8: Results of Chemical Iron Removal Tests

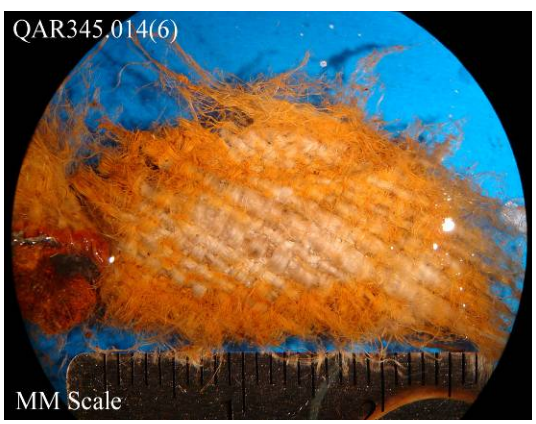
Iron removal was observed after as few as two hours, so acid immersion baths should be visually monitored and textiles removed as soon as desired results are achieved. The use of oxalic acid is recommended with one caution: oxalic acid appears to have had a very slight bleaching effect on several of the modern textile fragments tested. Therefore, the use of oxalic acid may only be appropriate on textiles that were originally white in color (which can usually be determined with a microscopic evaluation). Fortunately, no damage to fibers due to this bleaching action was observed.

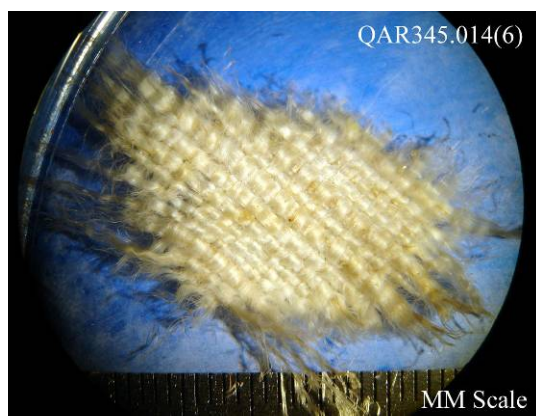
It should be noted that while dibasic ammonium citrate was proven ineffective for iron removal from hemp textiles, conservators have found that dibasic ammonium citrate in concentrations as low as 2% is very effective for iron removal from wood (white oak, pine, and fir specifically). In addition, dibasic ammonium citrate has been ineffective on iron removal from hemp-based rope samples, indicating that dibasic ammonium citrate may be suitable for iron removal from artifacts composed of wood, but not those composed of hemp.

It should also be noted that while the use of oxalic acid has been proven effective for iron removal from hemp, linen, and cotton fibers, other plant fibers and especially animal fibers may require different treatment methods. In addition, other intrusive materials may be present in archaeological textiles which oxalic acid will not remove. These materials must be identified on a case-by-case basis before additional treatment methods may be assessed. It may be acceptable to allow certain stable or inert intrusive materials (e.g. sand) to remain in or on textile fragments if the removal of these materials would require excessive physical or chemical damage to the artifacts.

Following this testing, QAR345.014(6) was immersed in 2.5% oxalic acid for a little under two hours, when iron staining was visibly removed. This textile fragment was then rinsed in RO water several times; the pH of the rinse water was checked for the presence of acid. To test the pH, rinse water was placed in a separate container so that the pH paper did not come into direct contact with the textile artifact because pH paper dyes have been known to bleed onto artifacts.

Figures 9 and 10 display the results of the 2.5% oxalic acid immersion bath for iron removal on QAR textile fragment QAR345.014(6).





Figures 9 and 10: Textile Fragment QAR345.014(6) Before and After Iron Removal with 2.5% Oxalic Acid

While 2.5% oxalic acid is appropriate for the removal iron staining and minimal iron concretions on textiles; the use of 5% hydrochloric acid may be a more appropriate method for cleaning textiles that are completely concreted in iron. Conservators have disagreed about the use of hydrochloric acid, some making strong recommendations against it and some reporting successful results. Ten percent weight per volume hydrochloric acid has been successfully used to extract several QAR textile fragments from within concretions (including QAR326.015, QAR344.017, QAR345.014, QAR347.006, QAR387.17, QAR387.017.01, and QAR387.018). In addition, fibers have been successfully extracted from very small fragments of iron corrosion dissolved in hydrochloric acid.

As a test, modern textile samples that had been subjected to a simulated concretion environment were left to sit in hydrochloric acid for 3 weeks (which is much longer than the time recommended for use of hydrochloric acid on textile artifacts). These fragments were then tested for reduction in tensile strength and analyzed microscopically for fiber damage; neither were observed. The use of both 5% oxalic acid and 5-10% hydrochloric acid for iron removal has also been used with successful results on textiles recovered from numerous other shipwrecks (Jenssen 1987; Tilbrooke and Pearson 1976). Godfrey, Kasi, and Richards (2001:440) caution that while the use of hydrochloric and oxalic acid is efficient for iron removal from organic artifacts, these reagents may lead to significant shrinkage upon dehydration if not pre-treated with consolidants or bulking agents.

Testing Dehydration Methods

To establish the most appropriate methods of dehydration for QAR textile fragments, tests were conducted on the concreted-then-cleaned modern textile samples. Methods tested were adapted from Peacock's (2004) account of dehydration methods used on textiles recovered from the *Hunley*, from Jakes and Mitchell's (1992) report of drying experiments on textiles recovered from the *Central America*, and from Jenssen's (1987) assessment of drying techniques used on organic artifacts from several different shipwreck sites. Methods tested include: humidity-controlled air-drying from the solvent ethanol, freeze-drying with and without a quick rinse of 5% PEG 400, freeze-drying with and without 5% PEG 400 in a block, and freeze-drying after 1-week immersion in 5% PEG 400. Several of these methods produced undesirable results: freeze-drying in a block of 5% PEG 400 resulted in excess PEG in the storage container and on the textiles, air drying from a solvent and freeze- and air-drying without PEG resulted in stiff and warped textiles.

Of the methods tested, freeze-drying after a 1-week immersion in 5% PEG 400 produced results that meet conservation standards considered most appropriate for use on QAR textile fragments. The successful use of 5% PEG 400 has also been reported for the conservation of textiles and other organic artifacts recovered from the *Elizabeth and Mary*, the *Hunley*, and the *Defence* (Bergeron 2004; Peacock 2004; Morris and Seifert 1978).

Thread count was recorded before and after dehydration to determine whether or not shrinkage had occurred. Thread count may be a better measure of shrinkage than weight and dimensions because these measurements are often subjective. Weight is skewed because it is difficult to account for the amount of water weight present textiles, and even with diagrams of the artifact illustrating where length, width and thickness dimension measurements were taken, it may be difficult to recreate exact dimensions, especially with pliable and irregularly shaped artifacts such as textile fragments. Thread counts indicated that minimal shrinkage occurred.

Textiles in wet storage are more difficult to analyze than dry samples, and they are more vulnerable to damage due to the physical stress of water weight. If textile fragments have not been thoroughly cleaned before they are stored long-term in RO water, they may be further subjected to active metal corrosion and subsequently experience significant fiber damage. In addition, textiles are susceptible to a whole host of organic growths while in wet storage. This study has indicated that once textiles have been removed from the localized concretion environment that was responsible for preserving them, they should be desalinated, cleaned, and dehydrated as soon as possible.

TECHNICAL ATTRIBUTES AND RESULTING TYPOLOGY

To facilitate historical comparison and interpretation of function, a standardized series of diagnostic technical attributes were recorded for each textile fragment in the QAR assemblage. Attributes recorded include: weave structure, thread count, warp and weft spin direction, element gauge, and fiber color. Artifact dimensions and weight were also recorded for conservation purposes, and a photographic record was created for each artifact. Stitching and other distinctive characteristics were also documented. All measurements were taken with inch-scale sliding calipers. A photographic record was also created for each artifact.

Distinctions in technical attributes were then used to develop a typology of textiles in the QAR assemblage. Table 1 presents the results of these comparisons. Technical attributes were recorded from a total of 54 textile fragments from nine different concretions. A minimum of three textile types was identified within the QAR assemblage. This typology will aid in the classification and analysis of textile samples recovered from the site in the future.

Textile Types Identified

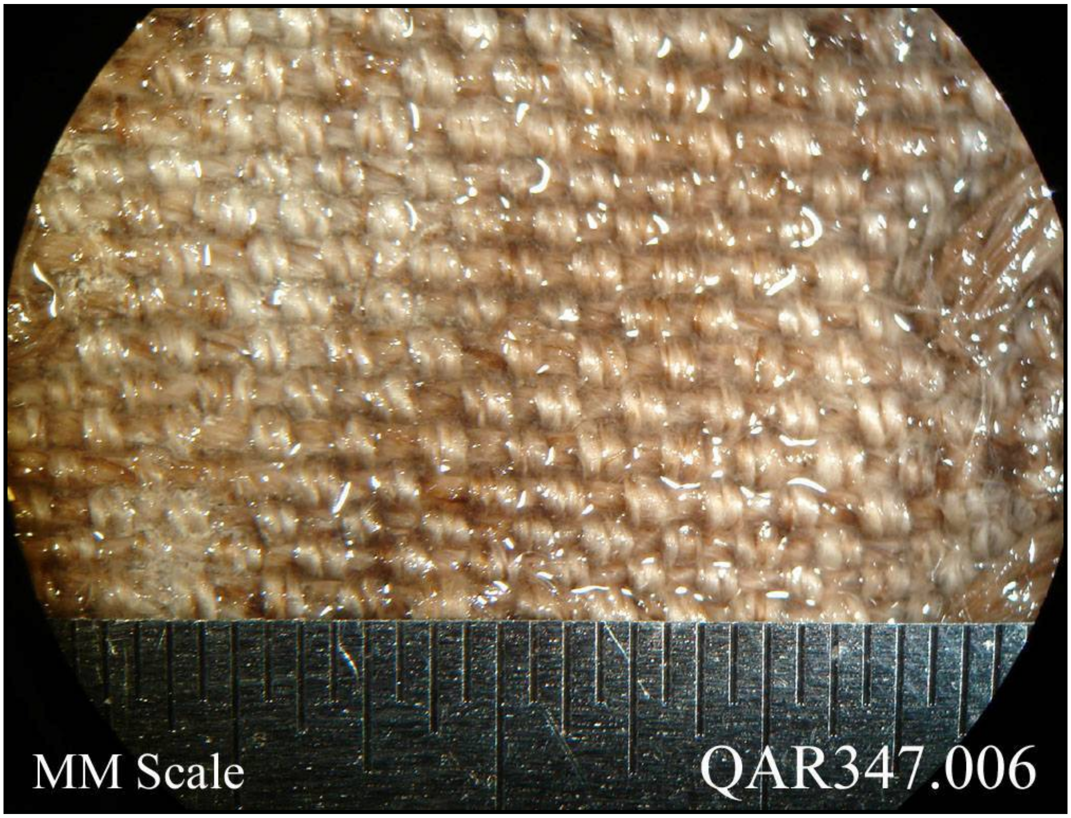


Figure 11: Textile Type 1

Figure 11 illustrates QAR Textile Type 1. This type is a ½ basket weave (two warps to one weft). It displays two distinctly colored fibers (brown and buff) spun into warp and weft elements. The thread count of this textile type averages 44 warps by 20 wefts per inch and it has plain selvage edges. Warp gauges average around 0.025” and weft gauges average around 0.035”. Warp and weft gauges are fairly consistent throughout. Textile Type 1 was first identified in QAR387.006 (Fragments 1, 3, and 5-8), and further identified in textile fragments QAR326.015, QAR344.017, QAR347.004, QAR366.086, QAR387.014, QAR387.017, and QAR387.018. Textile Type 1 was also identified as an impression on concretion 1401.000 and from a casting QAR351.004 of an impression on pewter plate fragment QAR351.001.

Figure 12 illustrates QAR Textile Type 2. This type is a plain weave (one warp to one weft). It also displays two distinctly colored fibers (brown and buff) spun into warp and weft elements, although the buff color is lighter and more predominant in Textile Type 2 than it is in Type 1. The thread count of this textile type averages 40 warps by 38 wefts per inch and has also has plain selvage edges. Warp and weft gauges are highly inconsistent throughout the sample: warp gauges range from 0.010”- 0.048”; weft gauges range from 0.015”- 0.058”.

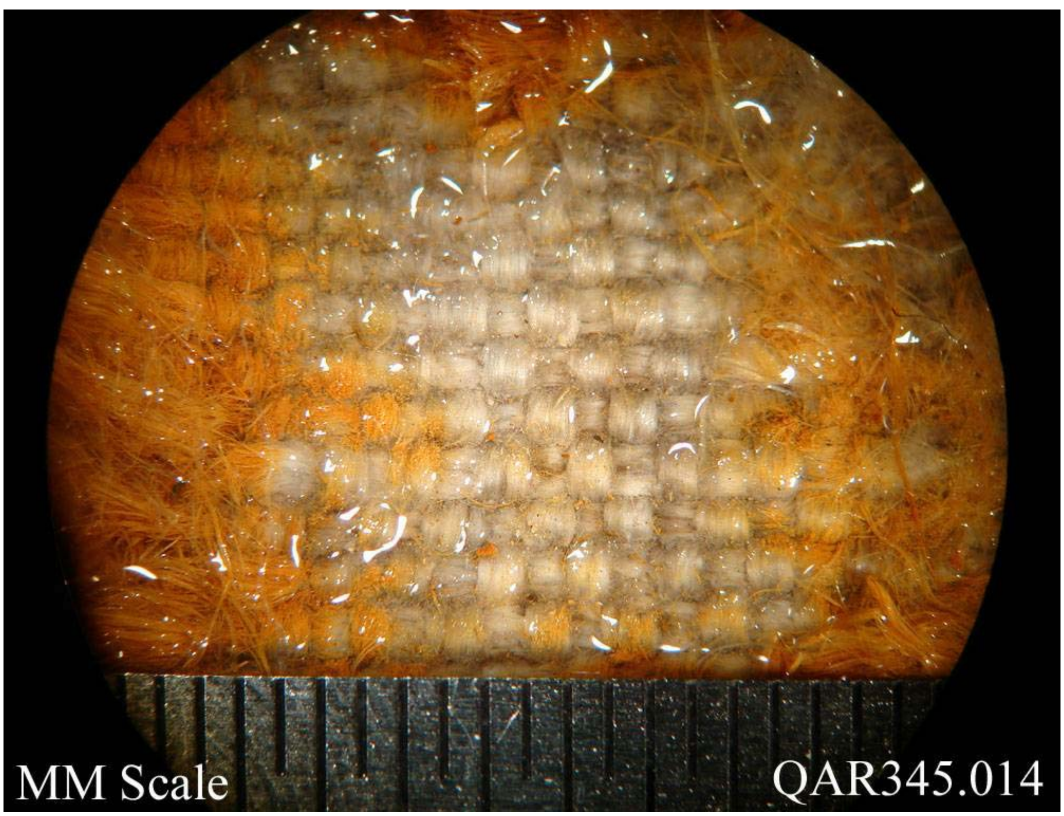


Figure 12: Textile Type 2

Textile Type 2 was first identified in QAR345.014 (Fragments 1-10). Many other plain-woven samples are present in the QAR textile assemblage including QAR 247.006, QAR343.007, QAR345.014, QAR347.004, QAR347.006 (fragments 2 and 4), and QAR387.024. These artifacts have tentatively been identified as Textile Type 2. However, due to inconsistent thread gauges and remaining iron corrosion materials, further cleaning and analysis will be needed to confirm that these textile fragments are in fact the same type as QAR345.014. It should be noted that textile fragments QAR347.006 (2 and 4) have a more pronounced warp and weft spin than is apparent in QAR345.014 fragments. Comparisons of tightness of spin may be useful for future determinations of textile types.

Figure 13 illustrates QAR Textile Type 3. This type is a plain weave (one warp to one weft). The fiber content of this textile type is more like raffia or some other kind of leaf fiber rather than a bast fiber; warps and wefts are broad and flat, giving the textile a plaited appearance; warp and weft elements also appear to be unretted (compare to the more formally retted and processed fibers spun into warp and weft elements that appear more cylindrical in Textile Types 1 and 2). This textile type is considerably more fragile and friable than Textile Types 1 and 2 as well; this appears to be a result of the fiber content and not from post-depositional preservation.

The thread count of Textile Type 3 averages 28 warps by 28 wefts per inch and it also has plain selvage edges. Warp and weft gauges average around 0.040" and they are fairly consistent throughout. Textile Type 3 was first identified in QAR387.017.01. Textile fragments QAR387.014 were later tentatively described as Type 3 because of the flattened and unretted appearance of the warp and weft elements; however, thread counts are significantly different. Again, further cleaning and analysis are needed to determine if these two groups of textiles are in fact the same type.

Figure 13: Textile Type 3

In concretions QAR347.000 and QAR387.000, distinct textile types were found in close proximity to one another. This indicates that it should not be assumed that textiles recovered from the same concretion proveniences are the same textile type, and that textile fragments should be given separate accession numbers if they are technically distinct from one another.

INTERPRETATION OF FUNCTION

Unlike some other underwater sites (e.g. *Hunley*, *Central America*, *Mary Rose*) where people perished and clothing constitutes a large portion of the textile artifacts recovered, lives were not lost on the QAR and therefore textile fragments recovered from the wreck site appear to mostly represent sailcloth and possibly arms-related materials such as lead shot or langrage bags (Peacock 2004; Jakes and Mitchell 1992:344; Jones 2003). Textiles were integral to the eighteenth century mariner's tool kit: fabrics were sewn into bags to hold foodstuffs, cargo, ammunitions, other tools, and personal affects; textiles were used to wrap cargo; fabric straps or strops were used to tie objects down during rough seas; and of course, the most critical use of textiles in eighteenth century maritime history was for sailcloth (Jones 2003).

Evidence of Sailcloth in the QAR Assemblage

Even the smallest textile fragments may exhibit diagnostic technical attributes to aid interpretations and historical comparisons. QAR347.006(8), a textile artifact just over 2 inches in length, displays several technical attributes diagnostic of use as sailcloth (Figure 14).

Figure 14: Sailcloth Fragment QAR347.006(8)

The warp orientation, double-round seam, and running or "stuck" stitching on QAR347.006(8) clearly indicate that this sample was once a vertical seam on a square sail. This artifact exhibits two fragments of Textile Type 1 seamed together along their warp ends. A characteristic seam ridge and parallel rows of whip stitches sewn from opposite faces of the fabrics indicate that this was a double-round seam. Double-round seaming (Figure 15) was the standard type of vertical seam on square sails in the first half of the eighteenth century and is distinguishable from a flat seam (Figure 16-which became the vogue during the latter half of the eighteenth century) by a distinctive seam ridge (Figure 17). The late eighteenth century *HMS Victory*'s fore topsail, for example, was vertically seamed with a flat seam (Bartos 2005:11).

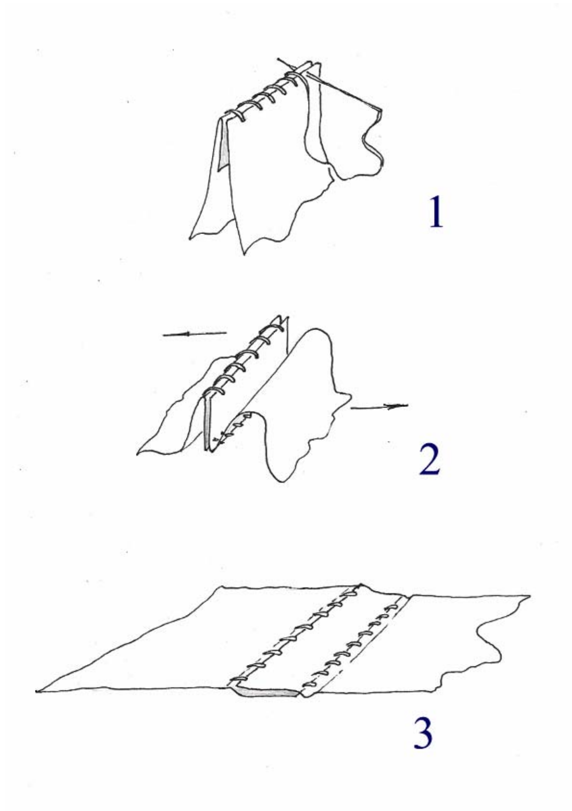


Figure 15: Double-Round Seaming, Illustration Courtesy of Louie Bartos.

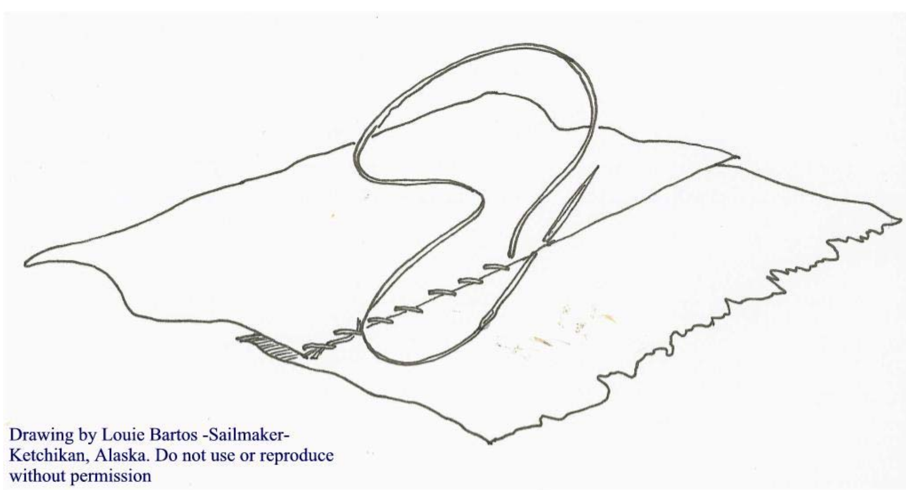


Figure 16: Flat Seaming, Illustration Courtesy of Louie Bartos.

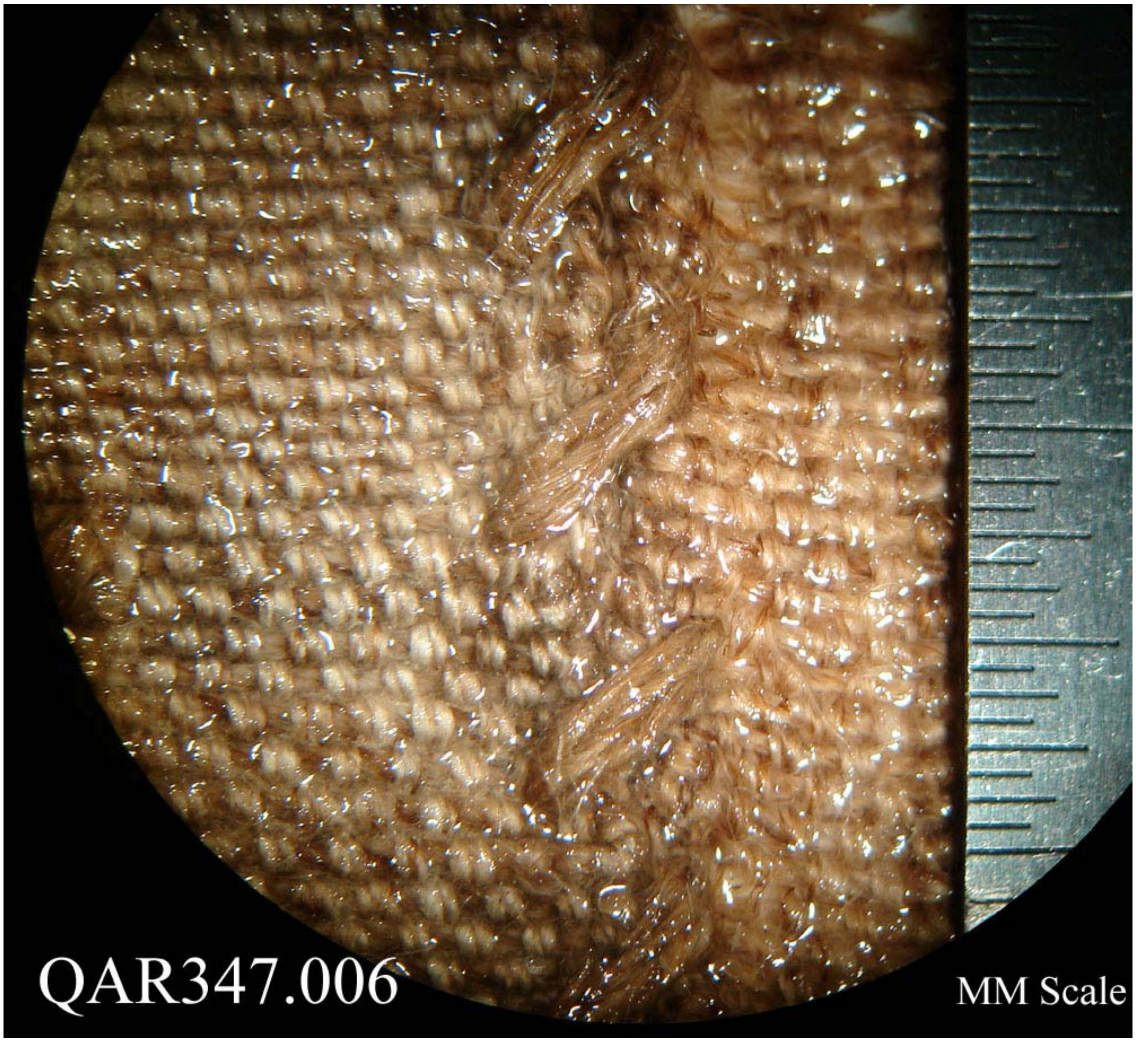


Figure 17: Seam Ridge Diagnostic of a Double-Round Seam

In addition to a double-round seam, QAR347.006(8) exhibits a running or stuck stitch between the parallel whip stitches (Figure 14). Interestingly, while stuck-stitching was commonly used for added reinforcement during the late eighteenth century, it was not the norm during the early eighteenth century. Therefore, this sample may represent one of the earliest known examples of stuck stitching used in historic sailmaking (Louie Bartos, personal communication 2008).

Almost all sails were sewn warp-oriented or "leech-cut" (with warps running vertically) on square sails during the early eighteenth century, further suggesting that the stitching patterns on QAR347.006 (8) represent a vertical seam on a square sail. Foot tablings and head tablings are the only horizontal seams that would have been present on the QAR (other than possible repairs), yet these are distinguishable by the types of seams used (e.g., boltropes would be present on tablings; flat, tabling, or herringbone stitching would be used for repairs).

Key technical attributes used in early eighteenth century sailcloth manufacture are also present in QAR387.017 (Figure 18). This 8-inch long artifact exhibits Textile Type 1 with tabling seams intact attached to served boltrope with marling hitches. Boltrope was sewn along the edges of square sails for added strength and to take stress off of the cloth when it was stretched taught. Tablings were the broad hems on the top and bottom horizontal edges of a square sail; in the early eighteenth century, these would have finished the loose warp ends because selvage edges were sewn vertically. The resulting perpendicular orientation of textile warps to the boltrope indicates that this artifact was once a portion of the foot of a square sail; the presence of served rope and the use of a marling hitch suggest this may have been near the clew (Louie Bartos, personal communication 2008).

Figure 18: Boltrope Fragment QAR387.017

Another boltrope fragment with similar technical attributes has also been recovered (QAR387.018), although this artifact is more iron-concreted and will require further analysis following cleaning. QAR347.006(8), QAR387.017, QAR387.018, the three most conclusive pieces of evidence for sailcloth, all exhibit Textile Type 1. The many other textile fragments in the QAR assemblage that have been identified as Type 1 may now be functionally classified as sailcloth (for QAR database purposes: “Ship’s Architecture: Fixtures and Fittings: Sailcloth”).

Several small Type 3 textile fragments with stitching were recently found floating in the storage water of boltrope sample 387.017; these fragments were assigned sub-number QAR387.017.01. Two of these fragments are sewn together along their selvage edges with a whip stitch (two stitches are visible in Figure 19 at the bottom near the scale). It is unclear if these fragments were structurally integrated into boltrope sample QAR387.017, or if they were just concreted together.

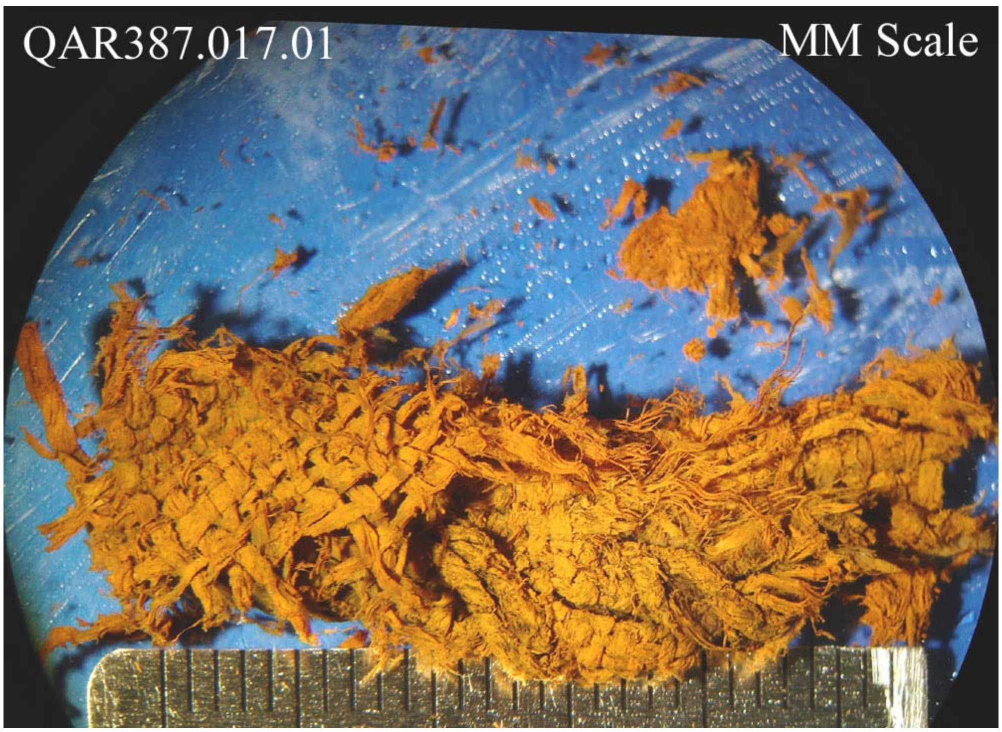


Figure 19: Textile Type 3 with Whip Stitches along Selvage Edges

Other small textile fragments QAR387.024 (Figure 20) from the same concretion exhibit small stitching holes along folded seams and portions of sewing thread similar to that used on the 387.017.01 sample. QAR387.017.01 and QAR387.024 textile fragments may represent sailcloth linings. Further cleaning of boltrope fragments QAR387.017 and QAR387.018 may clarify the relationship between these textile fragments and those more definitively used as sailcloth.

Figure 20: Textile Fragments with Stitching Holes and Sewing Thread

Additional Interpretations

It had also been suggested that textile impressions on pewter plate fragment QAR351.001 (Figure 21) may represent protective wrappings for cargo in storage, but the fact that these impressions were determined to be Textile Type 1 indicates that these textiles more likely represent sailcloth that came into contact with a pewter plate in the post-depositional environment.

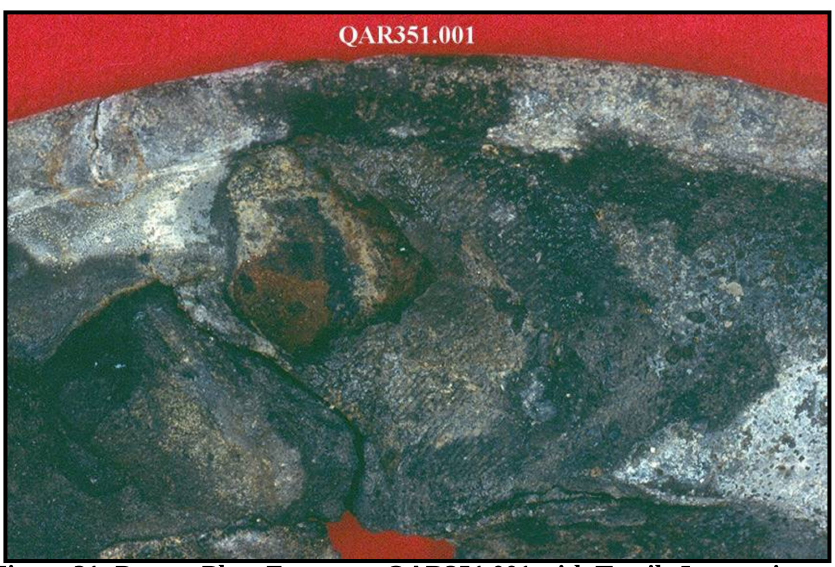


Figure 21: Pewter Plate Fragment QAR351.001 with Textile Impression

Textiles have also been recovered from concretions with lead shot, glass, ceramics, and iron fragments: this context may indicate that these textiles were used as bags of lead shot or langrage. Again, further comparisons of textile types and their association with boltrope fragments should help clarify the historic function of these textile fragments.

Conclusions and Recommendations for Future Treatment and Analysis

Recommendations for future conservation treatments and analysis of textile fragments in the QAR assemblage are outlined in Table 2. In addition to textile fragments, dozens of concretions exhibit textile impressions which must be molded and analyzed. Since it is unclear whether or not immersing concretions in sodium carbonate diminishes the integrity of textile impressions, molds should be created as soon as possible following recovery. Many textile-impressed concretions also likely preserve textiles within them; once these fragments are extracted from concretions they should also be analyzed for textile technical attributes and compared to known textile types. Conservators must also work with museum professionals in the future to establish proper display methods for QAR textile fragments. Suspension in nylon mesh (similar to the method currently used in the traveling exhibit of the Dead Sea Scrolls) may be a suitable display method for QAR textile fragments; it is one of many to consider.

The textile typology developed can also now be used to aid in conservation decision-making (e.g., if a freshly excavated textile fragment is determined to be Type 1, it may be assumed that it is composed of bast fibers and safe for use with oxalic acid) as well as interpretation of function (if the textile fragment is determined to be Type 1, it may be classified as sailcloth). Cleaning and dehydration testing results can now be applied to the assessment of conservation methods necessary for composite objects (artifacts composed of more than one type of material) such as the boltrope fragments (see Jenssen 1987 and McLeod, Mardikian, and Richards 2001 for further discussion on conservation treatments for composite objects). The textile typology should also be applied to a comparison of textiles described in historical literature (see Samuel Pepys's *The Navy White Book*; David Steel's *The Art of Sailmaking*; Marquardt 1992; and Bengtsson 1975).

The conservation of archaeological textiles recovered from an underwater environment integrates multiple disciplines including textile history and technology, materials science, archaeology, and maritime history. The discipline is in its infancy and comprehensive literature is lacking. The results of this study will aid in further analysis, classification, and conservation of textiles currently identified in the QAR assemblage as well as those recovered in the future. Care must be taken to properly conserve and analyze archaeological textiles because of their historical significance and tremendous research potential.

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