Burning Down the House! An Analysis of Carbonized Textiles from the Waterman Site in Marshfield, Massachusetts

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Burning Down the House!
An Analysis of Carbonized Textiles from the Waterman Site in Marshfield, Massachusetts

Abstract

The excavation of the seventeenth-century Robert Waterman house site in Marshfield, Massachusetts yielded thousands of carbonized textile fragments. Of these, 146 samples underwent analysis; the majority represented wool fabrics, which include a 3/1 reverse herringbone twill weave and plain weaves. No other seventeenth-century site has yielded a 3/1 reverse twill herringbone fabric. Six fragments came from a silk satin ribbon with silver wrapped-core yarns; only two other contemporary archaeological sites have had a silk and metal ribbon.

The locations of the artifacts likely reflect preservation and artifact selection, not indication of use at the time of destruction. The burned wool samples varied in their characteristics from being able to see fibers in yarns to having a shiny-smooth surface with little detail. Burning tests of wool fabrics suggest that differences among the archaeological fragments’ appearances are due to variables in the burning conditions including burning times and the objects’ proximity to the heat source.

These fragments are the earliest known European textiles recovered from seventeenth-century New England and the first documented from the Plymouth Colony. They provide a reference set for textiles excavated in the future. The silk and silver ribbon would have been imported, but the source of the wool textiles—imported or locally produced—is unknown.
Introduction

This study includes the examination of the oldest excavated European textiles in New England with a fixed date. They came from a burned house in Marshfield, Massachusetts on property once owned by Robert Waterman, who came to Plymouth as an indentured servant. As a freeman he built a house in Marshfield and rose to a respected position with good social standing. The house where he and his family lived burned around 1643 to 1645 leaving these carbonized textiles.

The analysis of textiles included determining fiber content and fabric construction, not specifically described in historical sources. The characteristics seen in archaeological samples lead to experiments to determine how wool burns. This assemblage provides a basis for future comparative studies of early seventeenth-century textiles.

Archaeology and the Site

Archaeological and Historical Services, Inc. (AHS) in Storrs, Connecticut conducted an archaeological survey preceding construction for an expansion project of the Marshfield Municipal Airport that began in September of 2013. The archaeologists discovered several archaeological sites; one revealed an early seventeenth-century earthfast house (Fig. 1). They excavated an area of 132 square meters and collected soil from features for analysis. Excavation uncovered various features such as postholes, a circular sub-floor storage pit, an unlined 8x4 foot rectangular-shaped cellar, a sunken hearth two feet below the floor, and palisade walls (Fig. 2). Recovered artifacts like carbonized house timbers, burned ceramics, melted bottle glass, concentrations of carbonized food remains, and carbonized textile fragments indicate that fire destroyed the house. Historical evidence associates the house with Robert Waterman, who
traveled to Plymouth from Norwich, England in 1636 and settled in Marshfield two years later (Ross, 2014).

**About Marshfield and Robert Waterman**

The settlement of the area known as Marshfield occurred as a result of freemen leaving the original Plymouth Colony. As the colony grew, less room was available, so younger men left to settle other lands where they would have more space to raise cattle and farm. The initial scattering of people from Plymouth caused great concern as it was viewed as weakening the colony. To combat the dispersion, the Plymouth General Court offered grants of nearby land to those made freemen in return for living there and helping the Church and Commonwealth. Lands granted in an area north of Plymouth called Greens Harbor were incorporated into a town in 1640 under the name of Rexhame, but later renamed Marshfield (Bradford, 1856).

Robert Waterman married Elizabeth Bourne in December 1638. He probably had settled in Marshfield Neck earlier that year on land he received as a grant or from his future father-in-law Thomas Bourne. Waterman was a yeoman until 1643 when he became a freeman. After that, he held several public offices including Grand Juror of Marshfield and Committee Deputy of the General Court of the Colony and served in Marshfield’s military company. In 1645, he helped to set up one of the first public schools in New England (Waterman, 1939). He made his living through a diverse set of activities (common for colonists) that included raising cattle, farming,

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1 Stratton states that "Many calculations of total population in 1643 are possible, depending on the assumptions one makes. A very rough estimation of some 2,000 people would seem plausible, based on reasoning too complicated to be given here," (E. A. Stratton, *Plymouth Colony: Its History & People 1620-1691*, pp. 70, 72 (Salt Lake City, UT: Ancestry Publishing, 1986).
fowling, and fishing. Waterman also owned a share of a shallop and engaged in trading (Ross, 2014).

Sometime between 1643 and 1645, a catastrophic fire destroyed Robert Waterman’s home according to Dr. Ross Harper. No known records document this incident, so an exact date is unknown. He and his family escaped the blaze, but the loss of the home and possessions would have been a major financial hardship. The house was not rebuilt on the site, and the remnants became buried over time. The decision not to rebuild has allowed thousands of artifacts to be preserved including many textile fragments that would have otherwise not been saved.

**Importance/Justification and Similar Work**

Textiles were extremely important commodities during this time not only for essential basic survival, but also for functioning within social constructs and to reflect ones’ status within society (Demos, 2000). The cost of textiles was high due to the amount of skilled labor required to produce them and the cost of transportation. Many colonists had experience in textile production, but local output was low, as the time for basic survival took precedence (personal communication with Ross Harper, 7/24/15). This meant most textiles had to be brought into the colony, adding importation costs and raising their value. Clothing was a form of wealth like cattle and land; anyone who could acquire it in any significant quantity did so. The worth of textiles is well illustrated in Robert Waterman’s own probate inventory; he died 7 to 9 years after the fire in December of 1652. The second most valuable asset listed was his clothes, appraised at £20s10; in comparison his house and lands were listed as worth £30 (Bowman, 1909).

At present, this is the only first-period Plymouth Colony house to be located and completely excavated (Ross, 2014). The earliest recorded excavations at the Colony sites go
back to the 1930s or 1940s and were conducted by the Harvard Excavators Club led by Henry Hornblower II (Beaudry and George, 1987). Their work included property in Marshfield that the Winslow family once owned. Numerous excavations since then have been conducted, but the Waterman House represents the first one to yield textiles in its artifact assemblage. New England’s soil and climate do not support preservation of buried textiles. Previous excavators also might have misidentified extant textiles as non-important material, i.e. blue roots and fuzzy dirt (Welters and Ordoñez, 2004).

    We know what the Plymouth colonists wore because of records and artwork. Portraits of wealthy individuals provide examples of elite dress and are found in various museums such as Pilgrim Hall Museum (2012). Artwork showing dress exists as well in the form of prints, drawings, and wood cuts with examples found in books such as Elisabeth Louise Roark’s 2003 publication, Artists of Colonial America, or Valerie Cumming’s 1987 publication, A Visual History of Costume: The Seventeenth Century. Probate inventories are helpful in the reconstruction of dress. For the nearby Massachusetts Bay Colony, Patricia Trautman used the probate inventories of 74 men and 48 women from seventeenth-century Cambridge to demonstrate how dress reflected individuals’ social standing and socio-economic class (1987).

    Even though we have a reasonable understanding of what was being worn, evidence pertaining to the fabrics’ construction is greatly lacking. Shipping records from the period list the names of fabric, but even this is vague. An example includes fabrics called “frieze,” which is a napped and fulled plain or twill weave of heavy coarse woolen yarns (Harmuth, 1915). This name does not tell us anything about fabric count or yarn construction and can represent various fabric weaves. The understanding of fabrics from this time is limited since only a few items of cloth and clothing have survived from seventeenth-century New England. These objects also
tend to be from higher status families and are not representative of the average colonist (personal communication with Dr. Linda Welters, August 2015).

Seventeenth-century European textiles have been found in southern New England Native American cemeteries. Margaret Ordoñez and Linda Welters analyzed the textiles from two of these sites: the Long Pond site in Connecticut and the RI-1000 site in Rhode Island (Ordoñez and Welters, 2004). Phyllis Dillon (1980) analyzed textiles from a third gravesite called Burr’s Hill in Warren, Rhode Island. The graves of 21 Mashantucket Pequots (c. 1670-1720) excavated at Long Pond, Connecticut, yielded 122 European textile fragments made from wool and cotton. Of these only two were twill weaves, while the rest were plain weave, (Welters and Ordoñez, 1996). The RI-1000 site, a Narragansett cemetery, consisted of 56 graves (c. 1650-1670). The site yielded 80 local and imported textile fragments with 32 types of weave structures made of wool, cotton, or native plants. Plain weaves predominated, but twill and knitted fabrics also survived (Welters and Ordoñez, 1996). The Burr’s Hill site is a Wampanoag cemetery containing 42 graves that date between the 1630s and 1640s to the end of the century. Excavators recovered seventy-four textiles fragments, one being a silk and silver-wrapped core galloon, one plain weave linen, and the rest wool. Of the wool cloths, 33 are balanced plain weaves, and 39 are types of twill (Dillion, 1980).

The textiles recovered from Native graves do not necessarily represent those used by the colonists in Plymouth. These textiles generally would have been varieties reserved for trading with the Natives, and the majority of the Native textiles date to a later time than those from the Waterman site. Even though the Burr Hill’s site contained graves dating from the 1630s and 1640s, the materials from these graves were mixed with the contents of later graves when a bulldozer disturbed the site. This makes it impossible to confirm an exact date of textiles from
these graves. One Colonial site produced textiles; this was the Cross Street Back Lot Privy site in Boston. Ordoñez and Welters analyzed fabrics from this site as well and identified 161 fragments (1998). A wide variety of textiles represented from this assemblage include woven silk fabrics, silk ribbons, silk knits, silk lace, wool twill and plain weaves, pseudomorphic cotton fabric, mixtures of wool and silk, and a variety of yarns. This privy was in use from the 1660s until 1709 so it is not contemporary to the Waterman site (Ordoñez and Welters, 2004). The Waterman house fragments provide a starting point for information on early Plymouth textiles. These fragments are the earliest European textiles found in New England, and their analysis will allow for future comparative studies.

Artifact Selection, Preparation, and Analysis

The actual number of textile fragments recovered from the Waterman house site extends into the thousands, and analyzing them all would be impractical. AHS archaeologists excavated many from a disturbed context, i.e. a plow zone; these are limited in the information they can provide. Fragments analyzed in this study have context within undisturbed features. Dr. Ross Harper chose 146 textile fragments from ten artifact inventories found in four features at the Marshfield site. Artifact size and condition factored in their selection; he focused on those with a high likelihood of identification of fabrics.

Fragments from each artifact number were placed in a petri dish for examination under a Nikon SMZ800 microscope (Fig. 3). All fragments were covered in a thin layer of sandy soil that contained sharp-edged quartz, mica, and feldspar granules. This layer of soil often obscured features such as weave structure, yarn construction, and interstices; the fragments required cleaning with a fine brush and gentle flicking motion. Before and after treatment
Photomicrographs were taken with a Nikon Digital Sight DS-Fi1 camera using NIS-Elements D Microscope Imaging Software (Fig. 4). A centimeter ruler indicated scale in photomicrographs. Samples recovered from flotation required less cleaning than those that had been hand excavated. A JEOL Model 1200EX scanning electron microscopy (SEM) with an energy dispersive spectrometer (EDS) was used to further analyze two fragments.

Results

Silk Trim:

The most unique textile fragments from the assemblage came from the cellar (Feature 23). Six pieces are a reversible silk and silver ribbon with a 5/1 satin-weave center stripe and decorative edges showing silver wrapped-core yarn wefts. The edge warps and the weft cores are the only s-spun yarns in the assemblage; the silver strips are wrapped around the wefts in the s direction. The multi-filament warps in the satin stripe had no apparent spin. The plain weave along the edges has a fabric count of 35 x 35 yarns/cm, while the satin-weave center has a warp count between 100 and 125 yarns/cm (a more accurate warp count is not possible due to the deterioration of the fragment). The ribbon is approximately one centimeter in width with the center satin stripe being 0.6 cm wide. The once-shiny silver wrapped core weft yarns made this satin ribbon subtly decorative (Figs. 5-6).

Yarn Diameter:

The warp yarns along the edges ranged from 0.15 to 0.275 mm in diameter with an average diameter of 0.217 mm. The weft core yarns ranged from 0.18 to 0.263 mm in diameter with an average diameter 0.215 mm, not including the wrapped-metal. The wrapped silver has
not stayed in place and has broken making it not possible to measure yarn diameter with the wrap. This damage is likely due to original wear, the way the silver reacted to the fire, and subsequent moving of the fragments. Yarn diameter for the 5/1 satin silk warps in the center of the trim could not be determined.

Scanning Electron Microscopy and Elemental Analysis:

The EDS identified the wrapping around the ribbon’s weft yarns as silver. The EDS also detected sulfur in the analysis due to the tarnished surface of the silver, as well as aluminum and silicon from dirt (Figs. 7-8). As expected, the analysis of one of the silk fibers showed primarily carbon (found in silk/fibroin protein) with some aluminum and silicon from dirt and a small amount of silver.

Wool Fabrics:

The remaining 140 fragments are made of wool. Fiber identification was very difficult due to the samples’ brittleness and carbonized condition. Only a few of the samples had distinct fibers visible in the yarns, and these typically broke off in groups rather than individual fibers. Under the microscope, these showed a scale pattern, indicative of wool. In addition, a test using 6% sodium hypochlorite solution (Clorox® bleach) showed that these burned fibers still had a protein component. Protein fibers exposed to sodium hypochlorite form bubbles on their surface, indicating that these fibers did not completely carbonize during the fire (Fig. 10). The fiber widths ranged from 10 to 15 microns across; burning and desiccation undoubtedly reduced the fibers’ original diameters. Protein fibers (silk and wool) burn slowly and are self-extinguishing; this could have contributed to their survival.
From the wool fragments, 38 fabric surfaces are identified as plain weaves and 49 as twills; on 78 surfaces the weave could not be specifically identified, but they showed evidence of a fabric structure. Of the 140 samples, 67 were recovered from flotation. The yarns from these samples, where the spin could be seen, were all z-spun. No remarkable difference between the flotation samples and the ones excavated by hand could be detected except the amount of soil on the surface.

Plain Weaves:

The most numerous type of textile in the assemblage was 20 x 20 yarns/cm balanced plain-weave fabrics (24 structures) from four artifact numbers all from the cellar (Feature 23). A third of the fragments with multiple layers included this balanced plain-weave fabric, often in conjunction with a different fabric type. One of these other fabrics is a 24 x 24 yarns/cm plain weave with interstices smaller than two 20 x 20 yarns/cm plain-weave layers that are over it (Fig. 11). This was the only 24 x 24 balanced plain-weave fabric sample found in the assemblage. One other plain-weave wool textile with a fabric count of 20 x 16 yarns/cm survived in three features: the cellar, the southwest posthole, and the palisade wall on the south side of the house (Features 23, 40, and 41). Seven fabrics could only be identified as plain-weave fabrics; most were from the cellar, but one was from a posthole from the east side of the house (Features 23 and 27).

Twill Weaves:

One wool fabric in this collection is a 3/1 symmetrical herringbone twill with a 30 x 30 yarns/cm fabric count (Figs. 11-12). This is the first herringbone twill fabric identified in an archaeological assemblage from a New England Colonial site. Twenty-three examples of this
reverse-twill weave were analyzed and represent the second most numerous type of fabric in the assemblage. Fourteen examples are of a 3/1 twill weave with no reversal, but of the same fabric count. Six others also shared similarities to the aforementioned twill fabrics. Likely, all the samples are of the same fabric, but how the fragments broke and their degradation obscures twill reversals and accurate fabric counts. Evidences of a finish such as napping would not have survived a fire, but the high fabric count of this twill suggests that it was fulled, a process that creates a tightly woven fabric. Six other twill fabrics could not be identified further due to their poor condition.

These wool fabrics with the 30 x 30 yarns/cm fabric count came from six artifact numbers. Most of these samples were in Feature 23, the unlined cellar; a few of these fragments came from floatation samples out of Feature 27, the area around a post hole on the house’s east side.

Yarn Twist:

Of the wool fabrics, yarn twist could be observed in 68 of them often in both yarn systems. This is only about half of the wool fabrics; all were single z-spun yarns. Of these, only a few were preserved well enough to measure yarn twist angle from multiple yarns and multiple positions on yarns. Nine different fabrics were selected for measurement based on visibility of fibers in yarns; they represent artifact number groups 1175, 3547, and 4640. Four were 3/1 twills, three 20 x 16 yarns/cm plain-weaves, and two were 20 x 20 yarns/cm plain weaves. Obtaining yarn twist measurements began under the microscope with the yarns from the chosen fabrics displayed on a monitor. Next, outlines of yarn peripheries and well-defined fibers were traced onto Mylar sheets laid over the monitor. These lines were transferred to a sheet of paper and extended. Measuring the extrapolated lines with a protractor acquired the angle of twist in
multiple locations on a single yarn (Fig. 13). The angle of twist could be measured in both yarn systems for three of these samples (Table 1).

**Table 1: Angle of Twist in Wool Samples**

<table>
<thead>
<tr>
<th>Fabric and yarn system</th>
<th>Min °</th>
<th>Max °</th>
<th>Max Diff.</th>
<th>Mean</th>
<th>Mode (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; 20x20 S1 Plain</td>
<td>35°</td>
<td>38°</td>
<td>3°</td>
<td>36.7°</td>
<td>N/A</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; 20x20 S2 Plain</td>
<td>30°</td>
<td>32°</td>
<td>2°</td>
<td>31.3°</td>
<td>32°</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; 20x20 Plain</td>
<td>17°</td>
<td>25°</td>
<td>8°</td>
<td>20°</td>
<td>20°</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; 20x16 Plain</td>
<td>16°</td>
<td>35.5°</td>
<td>19.5°</td>
<td>22.7°</td>
<td>N/A</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; 20x16 S1 Plain</td>
<td>26°</td>
<td>32°</td>
<td>6°</td>
<td>29°</td>
<td>N/A</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; 20x16 S2 Plain</td>
<td>38.5°</td>
<td>45°</td>
<td>6.5°</td>
<td>42.7°</td>
<td>43°</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; 20x16 S1 Plain</td>
<td>31°</td>
<td>40°</td>
<td>9°</td>
<td>34.4°</td>
<td>34°</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; 20x16 S2 Plain</td>
<td>32°</td>
<td>36.5°</td>
<td>4.5°</td>
<td>33.9°</td>
<td>N/A</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; 3/1 Twill</td>
<td>29°</td>
<td>43°</td>
<td>4°</td>
<td>35.2°</td>
<td>29°, 30°</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; 3/1 Twill</td>
<td>31°</td>
<td>34°</td>
<td>3°</td>
<td>32.8°</td>
<td>33°</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; 3/1 Twill</td>
<td>36°</td>
<td>46°</td>
<td>10°</td>
<td>38.9°</td>
<td>36°</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; 3/1 Twill</td>
<td>21°</td>
<td>36°</td>
<td>15°</td>
<td>28.7°</td>
<td>27°</td>
</tr>
</tbody>
</table>

Initial review shows variations in the angle of twist in samples with different and similar constructions. Differences existed in angle twist within most yarns, in one case as much as 15.5°. Even though some yarns appeared to have a consistent angle of twist, they could only be observed for a short distance due to damage on the fabric surface and fragments’ small size. Some yarns visible over a longer area showed a gradual change in angle twist, while another had variations in close proximity as high as 12.5°. These variations are almost certainly the result of the yarns being hand spun, but use or wear also could have played a role in dislocating the fibers.
from their original positions. The fabric with the least variation in twist angle was the 20 x 20 yarns/cm plain weave.

Yarn Diameter:

Yarn diameters of seven wool fabrics from artifact number groups 1175, 3547, and 4640 were selected to be measured. These included two 20 x 20 yarns/cm plain-weaves, two 20 x 16 yarns/cm plain-weaves, and three 30 x 30 yarns/cm 3/1 twills; both yarn systems for the plain weaves were measured. The wool fabrics had similar yarn diameters in like and different fabric types. The means of the yarn diameters recorded in Table 2 ranged from 0.33 to 0.382 mm, a maximum difference of 0.052 mm; this is less than 10% of the 11 standard deviations of yarn size within the measured yarn systems. This small difference indicates that the diameters are quite uniform despite their being in three different fabric structures.

Table 2: Wool Yarn Diameters

<table>
<thead>
<tr>
<th>Sample</th>
<th>Min.</th>
<th>Max.</th>
<th>SD</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st 20x20 S1</td>
<td>0.281 mm</td>
<td>0.479 mm</td>
<td>0.068 mm</td>
<td>0.350 mm</td>
</tr>
<tr>
<td>1st 20x20 S2</td>
<td>0.218 mm</td>
<td>0.437 mm</td>
<td>0.066 mm</td>
<td>0.351 mm</td>
</tr>
<tr>
<td>2nd 20x20 S1</td>
<td>0.270 mm</td>
<td>0.470 mm</td>
<td>0.064 mm</td>
<td>0.369 mm</td>
</tr>
<tr>
<td>2nd 20x20 S2</td>
<td>0.208 mm</td>
<td>0.468 mm</td>
<td>0.073 mm</td>
<td>0.339 mm</td>
</tr>
<tr>
<td>1st 20x16 S1</td>
<td>0.229 mm</td>
<td>0.530 mm</td>
<td>0.076 mm</td>
<td>0.369 mm</td>
</tr>
<tr>
<td>1st 20x16 S2</td>
<td>0.291 mm</td>
<td>0.499 mm</td>
<td>0.058 mm</td>
<td>0.382 mm</td>
</tr>
<tr>
<td>2nd 20x16 S1</td>
<td>0.292 mm</td>
<td>0.447 mm</td>
<td>0.053 mm</td>
<td>0.360 mm</td>
</tr>
<tr>
<td>2nd 20x16 S2</td>
<td>0.302 mm</td>
<td>0.458 mm</td>
<td>0.047 mm</td>
<td>0.374 mm</td>
</tr>
<tr>
<td>1st 3/1 Twill</td>
<td>0.229 mm</td>
<td>0.458 mm</td>
<td>0.063 mm</td>
<td>0.335 mm</td>
</tr>
<tr>
<td>2nd 3/1 Twill</td>
<td>0.260 mm</td>
<td>0.458 mm</td>
<td>0.054 mm</td>
<td>0.361 mm</td>
</tr>
<tr>
<td>3rd 3/1 Twill</td>
<td>0.292 mm</td>
<td>0.417 mm</td>
<td>0.039 mm</td>
<td>0.330 mm</td>
</tr>
</tbody>
</table>
Scanning Electron Microscopy and Elemental Analysis:

The EDS analysis of one wool fragment that showed a visible weave structure, but not individual fibers, and showed that carbon was the main element in the sample. The presence of sulfur indicated that disulfide linkages in the wool proteins remained as shown by the hypochlorite tests discussed earlier. Both analyses indicate that the fragments were not totally carbonized. Aluminum, silicon, iron, copper, potassium, and calcium in the analysis are likely from compounds in the soil on the sample (Figs 14-15).

Surface Characteristics:

Many of the burned wool fabrics have some physical properties that are uncharacteristic of laboratory fiber analyses. Wool fibers and yarns form a crushable bead of black ash during burn tests (Appleyard, 1978); the brownish-black to black carbonized Marshfield samples are hard, not crushable. The fragments can have three distinct surfaces: (1) yarn and weave structures of a woven fabric (Fig. 11); (2) shiny, smooth, undulating surface (Fig. 17); and (3) rough, porous-looking surface created by air pockets (Fig. 18). Most of these air pockets tended to be too small to measure accurately using the optical microscope, but some were as large as 5 mm in diameter. Each of these could transition from one to the other on the same face of a fragment. They differ from the typical ash of laboratory test samples.

The characteristics of carbonized wool fabric are not discussed in the readily available resources, only that it forms a crushable ash and occasionally bubbles as it burns (Florian and Kronkright, 1990). Only Laudermilk (1933) describes the physical characteristics of burned cloth, for forensic purposes. He states that “wool and silk, unless the latter has been heavily weighted, swell in burning, to a black, vesicular mass of slag-like appearance.” Laudermilk is
describing cloth made from protein fiber that has completely carbonized; these characteristics are present in many of the artifacts in the Marshfield assemblage. He affirms that these characteristics are, in fact, typical, and discusses the factors that affect the rate at which wool carbonizes. Laundermilk’s description inspired further investigation of how wool burns.

Burning Experiments:

Four 6 x 9 inch wool fabrics were folded into 1¾ x 3 inch rectangles with 10 layers to simulate folded garments. The wool fabric had a 2/1 twill weave with 10 x 10 yarn/cm fabric count and a napped finish; microscopy showed it to be 100% wool. The experiments were conducted outdoors in a steel container with ventilation holes. The first sample was placed in a thin-walled cardboard box (6 x 8 x 3 in) surrounded by paper to mimic an intense quickly burning fire. The second was laid directly on top of hot wood coals to simulate what would happen to a wool textile next to an intense prolonged heat source. The third was placed on a metal grill 4 inches directly above hot wood coals to demonstrate what happens when wool cloth is exposed to, but not touching an intense heat source over time. The fourth was exposed to a match in several locations for several seconds each time to mimic a standard burn test. The samples were exposed to each heat source until the source stopped burning on its own. The first sample had a burn time of approximately 5 min (the time it took the surrounding material to stop smoldering); the second and third samples burned 42 min approximately, and the fourth sample burned only several seconds before self-extinguishing.

The first three samples all had burn characteristics seen in the Marshfield samples. Photomicrographs of the first sample in the intense, quick-burning fire show the characteristics clearly (Figs. 19-20). The vesicular mass of air pockets, smooth surface, and charred twill fabric
with weave and fibers visible are all present on the experimental fabric remains. In addition, the inner layers melded to the outer layers forming a hollow inside the sample. The second sample on top of the coals was nearly entirely consumed; the top-most layers remained largely intact, and a few of the other layers around the edges formed into the air pockets like the first sample (Fig. 21). The weave structure of the top layer was clearly visible, and individual fibers could be seen in some of the yarns.

The third sample on the grill above the coals showed some formation of the air pockets and a smoothing out of the bottom-most layer (closest to the heat source) with some areas that still can be identified as twill-weave (Fig. 22). Only the layers closest to the heat source carbonized in the sample, the rest remained largely undamaged, showing no signs of burning. The burned layers adhered to one another as had several of the archeological samples (Fig. 11), and the weave structure was discernable for each layer. Furthermore, individual fibers could still be seen in the yarns of the upper-most layers that had been carbonized, as with the archeological samples. The fourth sample self extinguished quickly once the match was removed. The wool nap burned on contact with the heat source. Only the surface of the yarns charred with this sample, and the backside remained undamaged. None of the samples were hard like the archeological samples, and all could be crushed with relative ease.

Testing for the presence of protein remaining in the experimental samples was conducted using a 6% solution of sodium hypochlorite, which forms bubbles on the fibers’ surface as it disassociates the protein. Four small pieces were taken from each sample, crushed, and put on microscopic slides; each sample represented a different area in the burned test pieces. The first sample came from an area with air pockets where no fabric structure could be seen; the second from an area where a fabric structure could be discerned; the third where the twill structure was
clearly visible, and fibers had fused together; the fourth from an area where fibers could be distinguished individually. The first and second tested negative for the presence of protein, indicating complete or nearly complete carbonization, while the third and fourth tested positive for protein, indicating only partial carbonization.

Comparison of yarn diameters of the unburned experimental wool fabric and burned test samples showed that burning conditions affected final yarn diameters. The yarns in the unburned fabric had diameters that ranged between 0.96 to 0.77 mm, with a mean diameter of 0.86 mm. Yarns from test sample 1 in the quick burning fire ranged in diameter from 0.92 mm to 0.73 mm with an average of 0.82 mm. Yarns from test sample 2 on the coals ranged in diameter from 0.81 to 0.54 mm with an average of 0.66 mm. The yarn diameters from test sample 3 above the coals had a range of 0.92 to 0.77 mm and an average of 0.85 mm. The diameters of the unburned yarns and those from sample 1 and sample 3 are similar, but the diameters from sample 2 are smaller. The differences are likely the result of both proximity to the fire (intense fast burning vs. on the coals vs. above the coals) and time of exposure (5 min vs. 42 min—samples 1 and 3). This demonstrates that wool yarn diameters are not always reduced when fabric is burned.

These tests suggest that the physical characteristics in the majority of the Marshfield textiles resulted naturally from exposure to high temperatures during a long burning fire. Several factors seem to play a role in the condition of burned fabric in different layers. This includes the intensity of the heat source, proximity to the heat source, protection from the heat source (including other layers of fabric), and duration of exposure.
Location of Artifacts

Of the 146 artifacts selected for analysis, 94 came from Feature 23 (the unlined cellar), 26 from Feature 27 (the east-side posthole), 25 from Feature 41 (the south-side palisade wall), and one from Feature 40 (the south-west posthole) (Fig. 1). Initially a pattern appears to be present with data on artifacts’ distribution, but one must resist the appeal to immediately draw conclusions. The reason for this has to do with both artifact selection and basic preservation of materials. The number of artifacts suspected to be textiles recovered number in the thousands; many of those resided within the plow-zone level and undoubtedly have been disturbed from their original context. The artifacts selected represent those that were in a protected feature and less likely to have been disturbed. The artifacts from the cellar feature also were recovered from a greater depth, which provided better conditions for preservation than other areas in the site. Possibly, some textiles were only partially carbonized or were shielded from the heat by carbonized layers and degraded during the subsequent interment. The burn experiment showed wool’s inherent abilities to self extinguish and the ability for carbonized/partially carbonized layers to provide insulation for the inner layers when only several inches from an intense heat source. Fungi and bacteria in the soil could have broken down material that was not protected by carbonization; wool is susceptible to microbial attack (Hearle, et al., pg 390-94, 1989). Keeping the ideas above in mind, several possible scenarios could explain how these particular artifacts came to rest in their locals and the differences in their physical condition.

The textiles recovered from the cellar could have either fallen into that space or were already stored there; either way the cellar may have helped protect the fabrics as the house was burning. Being an unlined cellar, it might have had little wood to burn around the fabrics. Of the 94 fragments, 34 to 36% were burned to such an extent that only slight evidence of a fabric
structure was present. In comparison, 50% of those recovered from the east-side posthole were in this condition, as well as 96% (all but one fragment) of those recovered from the south-side palisade wall. The difference between the east-side posthole and palisade fragments could be the result of more combustible material being present in that area.

The construction of the house may give clues as to why textiles were located in postholes and the palisade feature. Some of the first permanent kinds of homes built in Plymouth were constructed with a post frame, referred to as earthfast houses (Fig. 2), and were typically one-story-and-a-half high. Walls would be constructed via clapboarding using cut planks of wood that were planed and secured to the frame with pegs or nails (Johnson, 2002). According to Dr. Ross Harper (head site archaeologist), these types of houses were not as steadfast as modern buildings (personal communication, 7/24/15). Wind could cause the frame to sway causing gaps to form where posts enter the ground, allowing items to work their way into spaces. The walls also did not contain any inner structure or insulation, and strong winds could blow through spaces in the clapboarding; because of this, a southern palisade wall was constructed right up against the house wall to cut down on the prevailing southern winds of the area. The close proximity of the palisade to the house, coupled with the lack of an inner wall, could easily permit any textiles located against the southern wall to become buried in the palisade feature during the house’s destruction.

Important to keep in mind is that sites are not stagnant. The possibility exists that after the fire the archaeological materials were moved from their initial area of deposition to the place where they were excavated. Movement of materials is common knowledge among archaeologists. Natural processes like animal activity, such as burrowing rodents, and plant roots push materials to different locations. This also may explain the presence of textiles in the
palisade area. These textile remnants also may have been moved to their locations if the
Waterman’s had sifted through the ashes in an attempt to reclaim any possessions that could be
salvaged after the house burned.

**Imported or Produced Locally**

The fragments of the silk and silver ribbon were undoubtedly not of local production. Even though sericulture began in the Virginia Colony as early as 1608, the silk filaments were exported back to England; this kind of ribbon would not have been woven in the colonies this early (Staples and Shaw, 2013). The ribbon could have either been transported by someone of the Waterman household on their way to the colonies or imported later. If the trim were an import, it could have come from either England, France, or Spain since Navigation Acts barring the trading of foreign merchants had yet to be passed at the time of the house’s destruction (Bailyn, 1955). Determining whether the wool textile fragments recovered were locally produced or imported is not possible at this time. This has to do with the lack of comparative materials with evidence-backed origins for comparison. A determination of the wool fabrics’ origins based on historical evidence can be made to consider either position.

Waterman’s house burned between 1643 and 1645, which was a time when the local laws encouraged home production of textiles. Small-scale wool and linen fabric production existed early in the colony. Sheep accompanied the first settlers, and more were imported later (Bailyn, 1955). Also tools for textile production can be found in probate inventories, such as the spinning wheel listed in William Serjeant’s records (1628). Up until the 1640s, the majority of textiles owned by colonists were imported. Most wealth was in resources and materials, such as livestock, which could be traded to newcomers, but a drastic drop in immigration to the colony at
the end of the 1630s caused an economic disruption (Staples, 2013). This development left little money and credit for colonists to purchase imported goods. Thus laws were passed to support local production of cloth, and many colonists already possessed the skills required to spin, weave, and finish cloth. The encouragement for home-spun textiles even lead to the first cloth processing and fulling mill in 1643, built on Rowley River in Rowley, Massachusetts by John Pearson; fulling would have been done prior to this by hand (Bailyn, 1955). Local textile production had a major increase 2 to 4 years before the Waterman House burned. Arguments can also be made in favor of the artifacts being imported fabrics.

Many fabrics worn by Plymouth colonists were heavy and durable, providing many years of use before wearing out (Demos, 2000). Some of the textile fragments recovered could have been from items Waterman originally brought to the colony. He was also a merchant, and these could have been imports acquired shortly before the economic change that occurred when the rate of new immigrants dropped. Evidence suggests that Waterman’s father-in-law Thomas Bourne traded in textiles as he refers to himself as, “Thomas Bourne … Draper” in his will (Waterman and Jacobus, 1939). Draper was the name of those in the profession of selling yardages of cloth, particularly those for clothing. Additionally, Thomas Bourne lived on Marshfield Neck near Waterman, facilitating his access to these goods (personal communication with Ross Harper, 7/27/15).

**Discussion and Conclusion**

The Waterman house textiles are a truly unique assemblage as they represent early European or locally made textiles in New England and are the first recovered from the Plymouth Colony area in nearly 75 years of documented digging. The carbonization process changed many
fragments’ original characteristics beyond recognition, but is responsible for the Marshfield samples’ survival over the last 370 years. To date, they are the oldest European textiles found in New England with an approximate burial date of 1643-1645. Other seventeenth-century sites yielding European textiles are mostly Native American burials with textiles dating after the 1640s. This limits their usefulness in comparison to the Marshfield textiles. Despite inventory lists, shipping records, portraits, and other art work not much is known about fabric construction at this time; names do not always identify construction and often nothing about fiber content. This work provides data on fiber content and fabric construction in clothing as well as a basis for comparative analyses of similar textiles from future excavations.

During the seventeenth century, both men and women commonly decorated their apparel and accessories with ribbons (Staples, 2013). The Marshfield s-spun silk and silver trim (1 cm wide) has similarities to the Wompanoag Burr’s Hill galloon also constructed from s-spun silk and silver wrapped-core yarns. Ordoñez and Welters (1998) analyzed a silk and metal ribbon and satin ribbons from the seventeenth-century privy on Cross Street in Boston. Their narrow widths could have been influenced by sumptuary laws in the Massachusetts Bay Colony, which restricted what people could wear based on their social and economic status (Johnson, 2002). The laws included limitations on width of decorative trims and wearing silver, gold, or silk laces, girdles, and hatbands (Dow, 1988). However, Plymouth Colony did not have these types of laws in place; none are listed in the William Brigham’s 1836 compilation of Plymouth legal documents, which included laws. Despite an absence of laws, societal pressure encouraged people to dress within their means (Demos, 2000).

The Waterman ribbon fragments showed no evidence of being sewn to any other fabric; this suggests that they had either yet to be attached to garments or were worn as accessories
although the ribbon could have been attached to a cellulosic fabric that did not survive the fire. The silver wrapped-core wefts are visible on both sides along the edges of the ribbon and are covered in the center by the warp floats in the satin weave. This would have been referred to as a double ribbon, an English term to describe reversible ribbons (Harmuth, 1915). EDS showed that the metallic wrap is silver, which corresponds to ship inventories from as far back as 1652 that show similar textiles like silver lace being imported to the colonies (Dow, 1988). This ribbon could have been for a woman’s bodice, skirt, or under skirt as well as a man’s shirt, doublet, cape, or breeches as seen in Figure 23. The wool textiles in the artifact assemblage could have been for these same garments.

In general, the Waterman wool textiles had a much higher fabric count than those from the three Native cemeteries: Long Pond, Burr’s Hill, and RI-1000. The balanced plain-weave wool fabrics from Long Pond and RI-1000 had a fabric count around 8 x 8 yarns/cm, but one from Long Pond had 34 x 28 yarns/cm (Welters and Ordoñez, 1996). Plain weaves from Burr’s Hill ranged from 6 x 6 to 10 x 10 yarns/cm (Dillion, 1980). The plain weaves from the Boston Privy site had fabric counts between 10 x 9 yarns/cm to 24 x 16 yarns/cm. The majority of these plain weaves are less than those found in Marshfield.

The twill weaves from Burr’s Hill had fabric counts between 2 x 2 to 6 x 6 yarns/cm for bulky fabrics and 16 x 16 yarns/cm for medium-quality woven fabrics. A twill from Long Pond had 13 x 10 yarns/cm, and the twill fragments from RI-1000 were 20 x 20 yarns/cm (Welters, 1985: Ordoñez and Welters, 1991). Fabric counts for the wool twill weaves recovered from the Boston Privy ranged from 20 x 20 yarns/cm to 28 x 20 yarns/cm, finer than those commonly used for trade with Native Americans (Ordoñez and Welters, 1995 and 1998).
The variation in yarn twist angles seen in the Marshfield wool textiles indicates they were hand spun. The yarns from these textiles are all z-spun, while the wool fabrics from the Boston Privy and Long Pond had both s- and z-spun yarns. Comparison of fiber diameters to those from Native sites is not possible as only a small number of the Marshfield samples could have fiber diameter measured. The fibers also were reduced in diameter because of the fire, further compounding any comparison to textiles from the other sites. The fire would have destroyed evidence of napping, which was present on some Native samples. The high yarn count of the twill fragments could be the result of fulling like fabrics from the Boston privy. The 3/1 twill construction, let alone herringbone twill, is not seen in any later seventeenth-century assemblages; these twill weaves are either 2/1 or 2/2.

The burn experiments showed that yarn diameters could remain unchanged after being burned. Furthermore, the experiments showed that different burning conditions could yield unchanged diameters. The low range of variation among the Marshfield archaeological samples’ mean diameters supports that they suffered little or no loss and may reflect the fabrics’ original yarn diameters.

Both the sodium hypochlorite test and the EDS analysis suggest the presence of keratin in the archaeological fragments. However, the test for protein using sodium hypochlorite on the fabrics from the burn experiment only yielded positive results from samples that either had clearly defined individual fibers or a visible weave structure.

Despite the similarities between the Marshfield samples and those from the burn experiment, the one thing that could not be explained was the hardness of the archaeological samples. One area to explore is a link between the samples’ hardness and mineralization. This may explain why the Marshfield samples were heavier than the burn experiment samples.
Further research also needs to be done to understand how wool burns. An in-depth review of forensic science literature could reveal studies done on burned wool beyond Laundermilk’s work. This might clarify how variables of a fire affect the burning of wool and why protein was left in the samples after they were burned. Research also needs to determine if carbonization helps protect wool from microbial attack and how proteins remain in the archaeological samples. More experimentation will be necessary if these answers cannot be found in a literature review. One additional characteristic to examine is twists per inch in the yarns. This measurement is difficult with such small samples, but could be helpful in evaluating quality of fabric.
Figure 1. Seventeenth-century earthfast house reconstruction in Londontown, Edgewater, MD. Photo courtesy of Anne Arundel’s Lost Towns Project
Figure 2. Site map draft, curtsey of Dr. Ross Harper
Figure 3. Nikon SMZ800 microscope
Figure 4. Uncleaned fragment from sample set 3547

Figure 5. Silver wrapped-core wefts along the ribbon’s edge
Figure 6. Decorative silver edges on either side of satin stripe

Figure 7. Silver wrapped-core wefts exposed by missing satin weave warps in center stripe
Figure 8. Silk filaments and broken silver wrap from ribbon edge

Figure 9. EDS elemental analysis of silver wrap
Figure 10. Bubbles forming around wool fibers upon introduction of hypochlorite solution
Figure 11. Two 20 x 20 yarns/cm plain weave fabrics on top of a 24 x24 yarns/cm plain weave, sample set 3547
Figure 12. 30 x 30 yarns/cm herringbone twill from sample set 3547
Figure 13. Herringbone twill from sample set 4439
Figure 14. Diagram showing angle of twist
Figure 15. Burned plain-weave wool sample

Figure 16. EDS elemental analysis of carbonized wool sample
Figure 17. Fragment with a shiny, smooth, undulating surface with no identifiable weave structures from sample set 1464

Figure 18. Matrix of air-pockets with smooth shiny interiors
Figure 19. Sample 1, wool fabric that burned in a quick burning fire

Figure 20. Sample 1, wool fabric from quick burning fire; note the smooth and porous looking surfaces
Figure 21. Sample 2, wool fabric in contact with hot coals

Figure 22. Sample 3, wool fabric above coals, closest layer; note transition from the shiny smooth surface to one where weave structure is clearly visible; grey material is ash from coals
Figure 23. Family portrait by Frans Hal, ca. 1648, showing male and female dress of the period; note ribbon trim on garments
Sources Cited:


Probate Inventory for William Serjeant, 1628.
http://www.histarch.illinois.edu/plymouth/P419.htm


