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A JOINT SESSION WITH THE OBJECTS SPECIALTY GROUP
CONCERNING COMPOSITE OBJECTS

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30th Annual Meeting
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June 2002

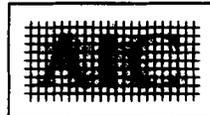
VOLUME TWELVE



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Miami, Florida
June 2002**

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**THE TEXTILE SPECIALTY GROUP
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PREFACE

The twelfth volume of POSTPRINTS contains the papers and one poster presented at the joint Textile Specialty Group (TSG) and Objects Specialty Group (OSG) session of the annual meeting of the American Institute for Conservation of Historic and Artistic Works (AIC), in Miami, Florida from June 6-11, 2002.

TSG POSTPRINTS is a non-juried publication. Submission of these papers to juried publications, such as the *Journal of the American Institute for Conservation*, is encouraged. The papers, chosen from abstracts submitted to meeting co-chairs Christine Giuntini, Textile Specialty Group Chair 2001-2002, and Patricia Griffin, Objects Specialty Group Program Chair 2001-2002, are published as submitted by the authors. Editing of papers was done according to the *Journal of American Institute of Conservation's* Guidelines for Authors. Materials and methods presented within the papers should not be considered official statements of either the Textile Specialty Group, the Objects Specialty Group, or the American Institute for Conservation.

The Editors wish to thank the contributors to this publication for their cooperation and timeliness. Without their enthusiasm and hard work this publication would not have been possible. Special thanks are extended to Carole Sinclaire, Archaeologist from the Museo Chileno de Arte Precolombino (editor in charge), and Isabel Alvarado, Textile Conservator at the Museo Histórico Nacional, both from Santiago de Chile, and Patricia Lisa, Textile Conservator from the Museo Isaac Fernández Blanco, Buenos Aires, Argentina, for translating the Abstracts into Spanish. All are members from the Comité Nacional de Conservación Textil, Chile.

Publication of this volume of the Textile Specialty Group Postprints is made possible with funding from the Harpers Ferry Regional Textile Group, organizer of conferences on textile preservation from 1978 to 1992.

INITIAL INVESTIGATION INTO A RESINOUS MAYA BURIAL SHROUD

CANDIS GRIGGS

ABSTRACT—During the excavation of a crypt burial at the Maya site of Buenavista del Cayo, Belize, archaeologists encountered a flake-like debris of unknown origin associated with a skeleton. During a fellowship in archaeological conservation at the Smithsonian Center for Materials Research and Education, Suitland, MD the author undertook a technical study of this material.

Many of the flakes exhibited undulations as if following the bunched surface of a cloth, as well as an apparently fibrous texture. Present also were adherents, including up to five textile types. Using various analytical techniques, the principal component of the flake material was determined to be a natural resin or gum resin. An additional inorganic clay-like component may have been the result of post-depositional contamination or may have been an intentional additive. Analysis of the most prevalent textile type on the samples, a 1/1 plain weave, showed it also to have a strong resinous constituent. It appeared that this textile or some other cloth was coated with the resin, then wrapped around the body prior to final interment.

TITULO—INVESTIGACIÓN PRELIMINAR DE UNA MORTAJA FUNERARIA RESINOSA MAYA. **RESUMEN**—Durante la excavación de una elaborada cripta funeraria del sitio Maya de Buenavista del Cayo, Belize, los arqueólogos encontraron los restos de una cubeta, en forma de hojuela, de origen desconocido. El material se hallaba sobre, alrededor e inmediatamente bajo un esqueleto y además envolviendo algunos huesos largos y dedos. Durante una pasantía de Conservación Arqueológica en el Centro Smithsoniano de Investigación de Materiales y

Educación, este autor realizó un estudio técnico de las hojuelas de la cubeta y determinó que ellas eran los restos de una práctica funeraria nunca antes descrita.

Las muestras eran fragmentos pálidos y muy frágiles, con la apariencia general no muy lejana a hojuelas de cereal (lo que llevó al autor a referirse a ellas -al menos íntimamente- como "K Especial" -haciendo alusión al cereal "Kellogs"). Muchas tenían ondulaciones paralelas como si siguieran las formas de una tela plegada o arrugada. En la superficie de las hojuelas estaban presentes varios tipos diferentes de adherentes, incluyendo más de cinco tipos de textiles distintos. Se usaron varias técnicas analíticas para estudiar los componentes de estas muestras, entre ellas PLM, FT-IR, SEM-EDS, XRD (Difracción de Rayos X), tests de quemas y calentamiento, test microquímicos y exposición a rayos ultravioletas. El componente principal de las hojuelas resultó ser una resina natural, posiblemente copal, el que era usado extensivamente por los antiguos mayas en sus rituales. Se detectó también un compuesto inorgánico tipo arcilla que pudo haber sido resultado de contaminación post-depositacional o bien un aditivo intencional. El análisis del tipo textil más destacado (tejido balanceado 1:1) mostró que también tenía un fuerte componente resinoso. Pareciera ser que este textil o alguna otra tela fue cubierto con esta resina, y luego envuelto alrededor del cuerpo humano antes de su entierro.

Mayores análisis de estas hojuelas y otros materiales parecidos, si es que se encuentran, permitirán comprender mejor las prácticas funerarias de la elite Maya. Se espera que este nota acerca de la

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importancia potencial que tienen estos materiales fragmentarios, prevendrá su futura pérdida u omisión del registro arqueológico.

1. INTRODUCTION

The subject of this paper is a material analyzed in 1999 and 2000 during the author's post-graduate fellowship at the Smithsonian Center for Materials Research and Education (SCMRE), Suitland, MD. Prior to this, Harriet (Rae) Beaubien of SCMRE's Objects Conservation lab had asked Maya archaeologists for samples of any clay-like coatings they might have found on or around a skeleton. This request was made to follow-up on the discovery of a clay-rich burial coating excavated from the Mayan site of Copán, Honduras (Peschken 1997; Fash et al. 2000).

In response, Drs. Joe Ball and Jennifer Taschek of San Diego State University, CA sent several fragments excavated from an elite burial at the Maya site of Buenavista del Cayo, Belize(1) and dated to the early 8th century CE (Common Era) during the Late Classic period. The burial was filled with rich grave offerings as well as a loose mix of powdery clay, mortar, and limestone fragments from partial collapse of the structure. The material sent to SCMRE was found above, around and immediately below the skeleton of a young adult male, with some fragments seeming to encircle the long bones and possibly the fingers. From this distribution, the excavators concluded that the material was the remnant of a shroud or burial wrapping (Taschek and Ball 1992; Ball and Taschek, 2000).

2. DESCRIPTION OF THE MATERIAL

The fragments (fig. 1) were distinct from the dark, thick Copán material with which they were to be compared. The pale, buff-colored fragments had an appearance similar to flake cereal, measuring about 1 mm in thickness and a few millimeters to several centimeters across. Many fragments curved and undulated as if following the pleated surface of a cloth. Though fragile-looking, they could be handled lightly without breakage or surface loss. Fine layering was visible within some of the fragments, and most had additional material adhered to their surfaces.



Figure 1. One of several boxes of flakes, during unpacking.

3. ANALYSIS OF THE MATERIALS

3.1 PALE FLAKE MATERIAL

The initial focus of this study was the pale material making up the bulk of each flake, which at first was thought to be a clay or plaster. A simple firing test, however, quickly revealed there to be a large organic component; with heating to 300°C and then 600°C the test fragment lost more than 90% of its weight, charring first to black and then leaving a pale pinkish remnant.

Examination of several fragments with raking light revealed surface textures resembling a fibrous and sometimes woven pattern (fig. 2). Meanwhile, cross-sections of many flakes revealed a shiny dark orange core, which also appeared somewhat fibrous. Other cross-sections showed continuously pale but also vaguely fibrous cores.

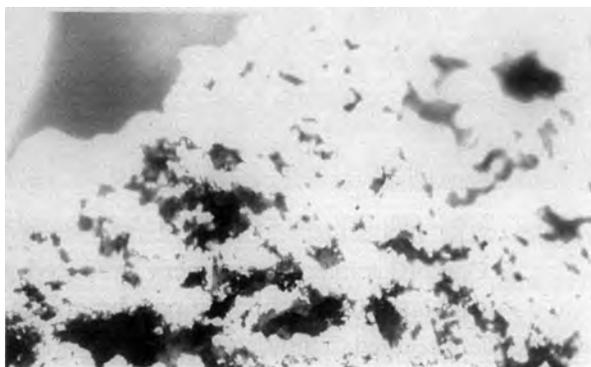


Figure 2. Textile-like surface pattern on a flake, raking light.

Scanning electron microscopy (SEM) was unsuccessful in clarifying the surfaces and interior textures. Energy dispersive X-ray spectroscopy (EDS) analysis with the SEM revealed a general trend: a prevalence of the elements Ca, Si, Al, C,

and O; and varying lesser amounts of Fe, Na, Mg, Cl, P, K, S, and Ti. Many of these elements are typical of clays, though the spectra also exhibited a sine wave-like baseline curvature believed to indicate an organic component. EDS analysis was performed using a Tracor Northern TN-5502 dispersive X-ray spectroscopy system on a JEOL JXA 840A SEM.

These EDS data were used in conjunction with Fourier transform-infrared spectroscopy (FT-IR). The instrument used was a Mattson Galaxy 4326 Upgrade/Spectra Tech IR Plan microscope. IR spectra were obtained at 8 cm⁻¹ resolution in 2½ minute scanning time.

The preliminary FT-IR spectra of the flake material had peaks typical for a polysaccharide, a series of small peaks indicative of micro-channel water (as is seen with clays), and a peak from quartz or other silicate (fig. 3, #1 of bottom). Solvent extraction with ethylene dichloride was performed to focus on the flakes' organic component(s). A large proportion of each sample was extractable, and thus organic, which concurred with the earlier firing test. The extracted samples then were analyzed with FT-IR. The first sample yielded a spectrum indicative of a natural gum resin (fig. 3, #3 of bottom). The closest computer matches were the gum resins frankincense, or olibanum (fig. 3, #2 of top), and myrrh, neither of which are native to the Americas. The spectrum of a second extracted sample had a smaller carbohydrate peak, and more closely matched spectra of natural resins than gum resins. Various ambers, which are also not found in the Americas, were among the closer matches. The shiny orange material from the center of a flake

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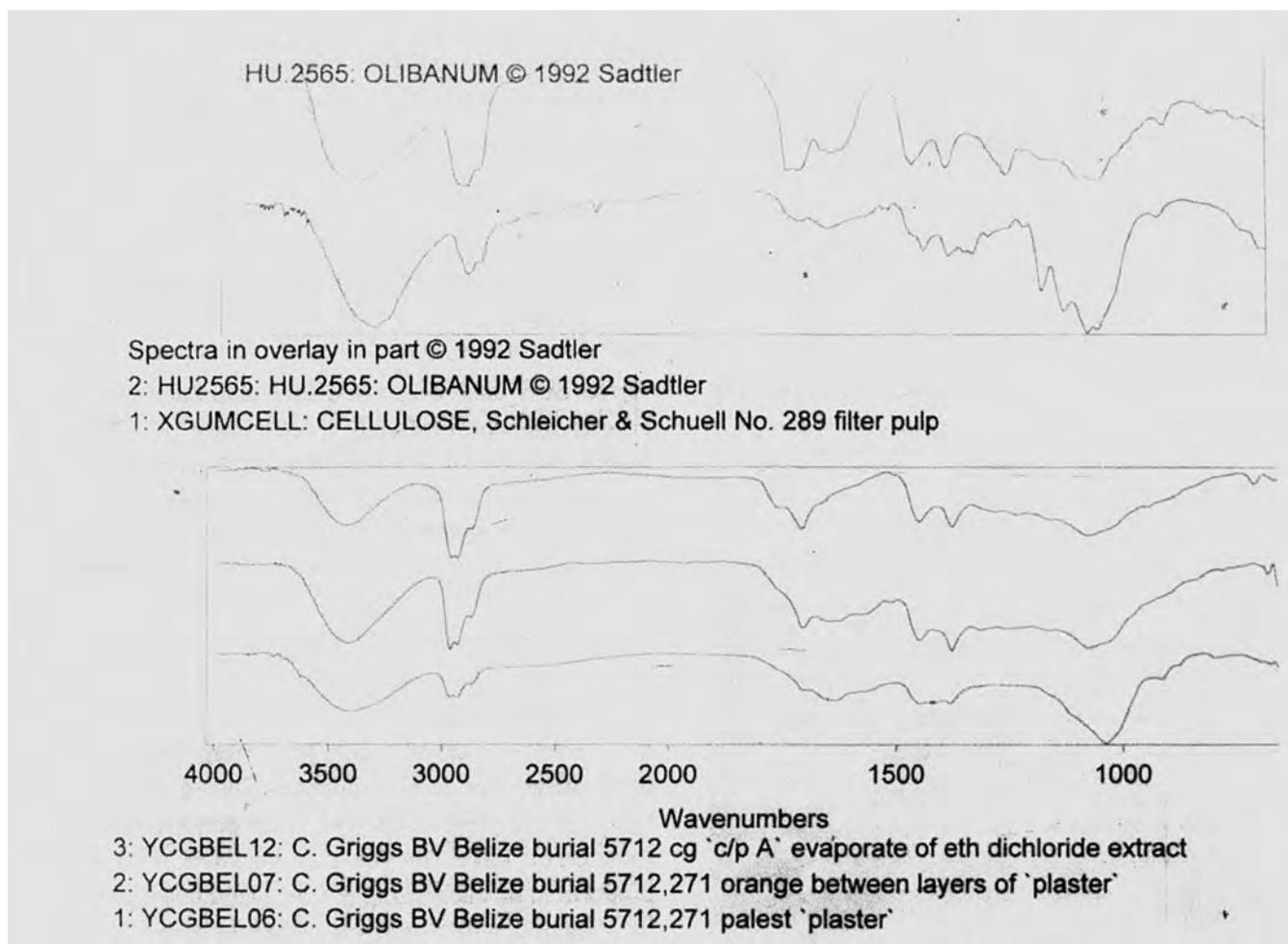


Figure 3. FT-IR spectra of flake material with comparison spectra.

was tested, with no chemical preparation. Its spectrum (fig. 3, #2 of bottom) was similar to the extracted samples, indicating a possible concentration of resinous material in the core of the fragments. Some material that was not soluble in the ethylene dichloride gave peaks in the 1600 cm^{-1} range and was thought perhaps to be cellulose (fig. 3, #1 of top).

To clarify the material's inorganic constituents, X-ray diffraction (XRD) was attempted but the

results were inconclusive. XRD data collected using a Gardolfi camera attachment produced a pattern matching quartz, while the powder diffractometer data seemed to indicate the presence of the clay montmorillonite.

Several microchemical spot tests also were performed. Because one FT-IR spectrum had a protein-like peak set, a sample was tested for sulphur using a biurite spot test (Odegaard et al. 2000). No significant protein component was found. An acid

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test using concentrated HCl applied by pipette to another sample resulted in no effervescing, ruling out the presence of a carbonate.

3.2 TEXTILE TYPE 1

Since it was unclear if the textile adherents were unrelated burial debris or components of the proposed shroud, these materials were closely examined. The most prevalent textile, called Textile Type 1 in the study, was found on many flake surfaces. It was also found standing alone as a coherent fragment or multi-layered bunch (fig. 4). Though brittle, the fragments were preserved well enough for visual examination and were present in sufficient quantity to justify some destructive



Figure 4. Multi-layered fragment of Textile Type 1

analysis. Under magnification, the textile appeared to be composed of buff to orange-colored, single-ply, Z-spun yarns in an open 1/1 plain weave. Warp and weft were not distinguishable, but each yarn measured between 0.4 and 0.7 mm in width. The thread count averaged 15 threads per cm for both warp and weft.

SEM was used to further explore the textile (fig. 5). Angle of twist was measured from SEM photographs and varied from 20° to 65°. Apparent plant fibers had diameters of 13-20 μ m, a slight inconsistent twist, and a somewhat ribbon-like appearance, all indicative of cotton. Cotton also was indicated by a review of published Maya textiles, principally Lothrop (1992) who documents similar plain weave cloth of Z-spun cotton found in dredgings of the cenote at Chichén Itzá.

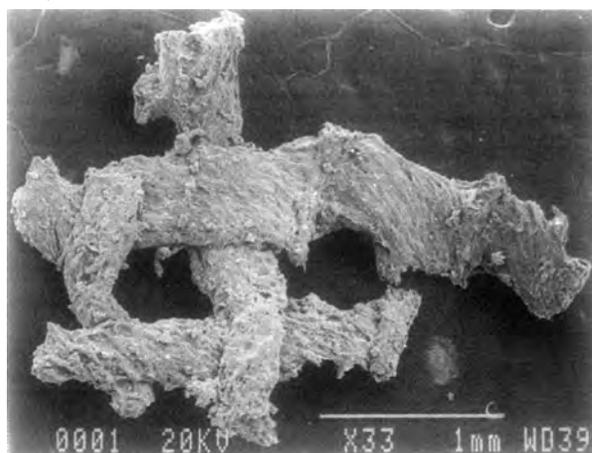


Figure 5. SEM image of Textile Type 1.

Polarized light microscopy (PLM) also was performed on samples of the textile. Though the fragments were highly degraded, numerous fibers per yarn and an overall yarn twist were seen in cross-sections (fig. 6), as were apparent plant cells with visible lumina. Under crossed polars, the material showed no birefringence, implying significant degradation of any cellulosic component.

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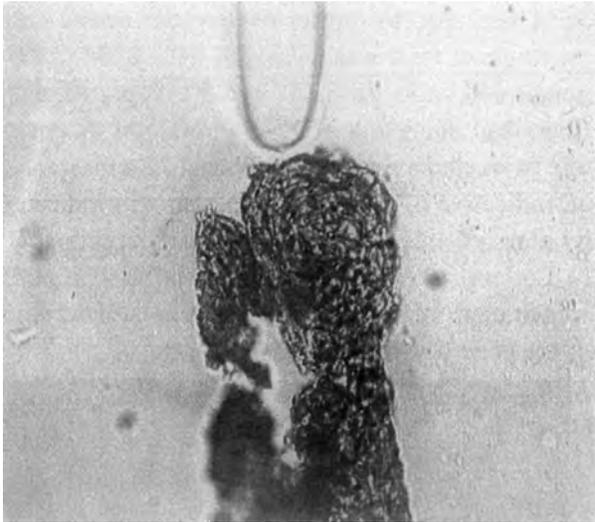


Figure 6. PLM image of Textile Type 1 cross-section.

A sample of the textile was analyzed by FT-IR. The resulting spectra were interesting as they showed strong resin-like as well as cellulose-like qualities. EDS spectra were similar to those of the flake material.

3.3 TEXTILE TYPE 2

Only two fragments of the second textile type were found (fig. 7), though it is possible that they were

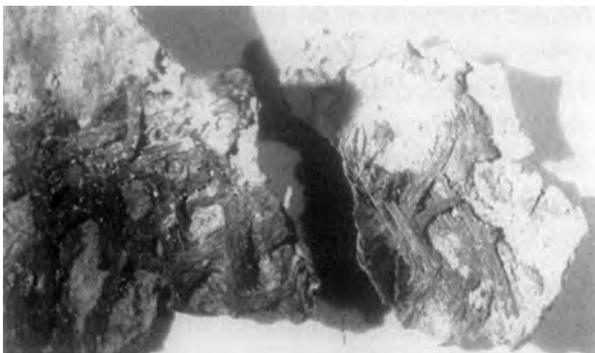


Figure 7. The two fragments of Textile Type 2.

related to a striped brown fibrous adherent also investigated (Griggs 2000). Both examples of Textile Type 2 were from an area of excavation near the skeleton's feet. Each was present as a single layer adhered to a flake.

The elements of this brownish textile measured roughly 1.3 mm wide, and appeared under magnification to be either unspun groups of several fibers or single, striated flat fibers. In places, the elements seemed to split in two, with each half bending in opposite directions. The fragments bore some resemblance to basketry twining and to gauzes. Comparison to the Chichén Itzá material revealed similarities to sandal sole fragments made of yucca (Medford 1992).

Because there was so little of this textile type, only one sample was taken, for SEM. This revealed possible individual fibers which appeared to be rectangular in cross-section and roughly 100 μ in diameter.

3.4 ADDITIONAL TEXTILE TYPES

The third and fourth textile types were extant only as one fragment each and both were found on the largest flake, which also had an adhered layer of Textile Type 1. Textile Type 3 was bunched within a curl of the flake and partially obscured by other adherents (fig. 8). It appeared to be an open 1/1 plain weave with elements about 1 mm wide. Each element seemed to be composed of two or more Z-spun yarns plied in an S-direction. A thread count of approximately 7 yarns per cm in each direction was estimated. Most yarns were a pale orange color, though a few were a bright reddish-pink.

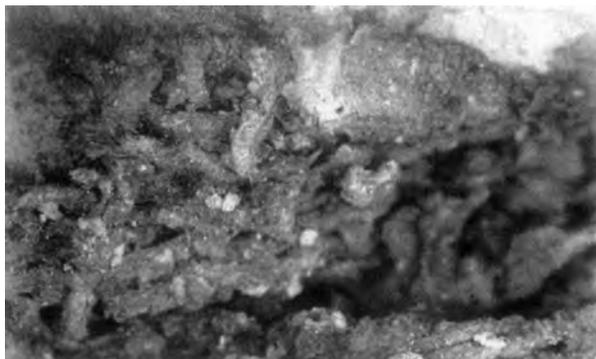


Figure 8. Textile Type 3, detail.

Type 4 was an extremely degraded textile or basketry fragment (fig. 9). It appeared to be fairly tightly woven, perhaps with a warp- or weft-faced plain weave, or weft-twined structure. Raking light revealed the elements to be made up of un-plyed pairs or perhaps multiples of yarns. The elements themselves were roughly 0.8 mm in diameter. The textile bore a resemblance to three cotton fragments from the Chichén Itzá cenote, which were plain woven with single yarns in one direction and paired yarns in the other (Lothrop 1992).

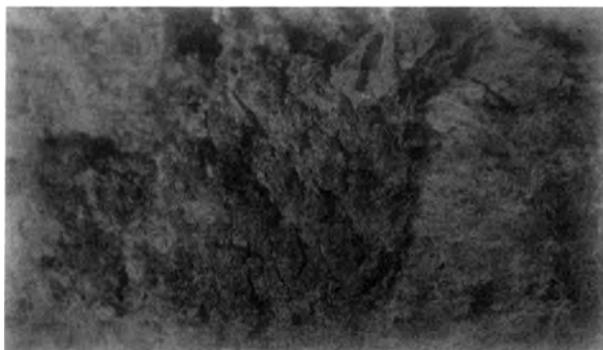


Figure 9. Textile Type 4.

Only one fragment of the highly degraded fifth textile type was found (fig. 10). It was partially obscured by an attached layer of Textile Type 1.

Though it was thought at first to be an intermediate layer between the Textile Type 1 and a typical flake, observation of the reverse revealed that Textile Type 5 continued throughout the fragment, and constituted the bulk of the flake itself.

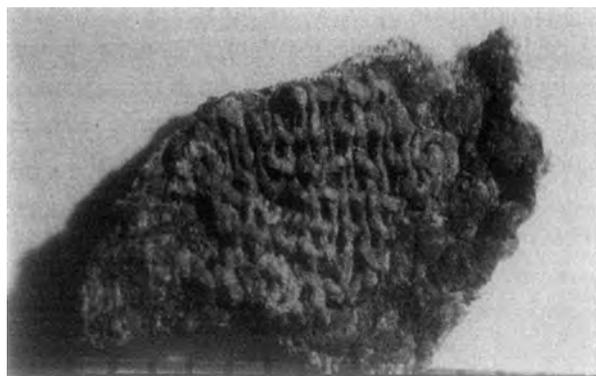


Figure 10. Textile Type 5 (below Textile Type 1).

The fragment was similar in appearance to Textile Type 4, and may have been a second example of this type. It seemed to have a twined, or tightly woven warp- or weft-faced structure, with elements made up of pairs or multiples of yarns whose twist is not discernable. The Type 5 surface below Textile Type 1 was a dark gray-brown, while the other side was paler, a mottling of gray and the typical pale flake color.

4. DISCUSSION

To summarize, it appears as if the pale flake material is made up primarily of a natural resin or gum resin which is perhaps most concentrated in the material's inner core. Though the resin source was not pinpointed, it is tempting to consider the natural resin copal, of which the ancient Maya made extensive ritual use. Though fresh copal is typical-

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ly translucent, ancient examples have been described as varying “from a fine dusty to a granular texture, and from creamy white to orange-brown in color...” (Coggins and Ladd 1992, 346), much like the flake material in this study. Only one FT-IR spectrum of an American copal, a Brazilian variety, was available for comparison but it was only vaguely similar. Spectral databases compiled since this study may allow the shroud’s resin, or gum resin, to be identified in the near future.

The inorganic constituents of the flake material also are not yet fully deciphered though a clay component, perhaps montmorillonite, is suggested. It is unknown whether the inorganic components were the result of accidental inclusion, perhaps from the tomb’s partial collapse, or were intentionally added during preparation of the shroud. Fillers or bulking agents might have been useful for extending a valuable or scarce resin, or might have been added to alter properties such as tack or viscosity.

Most perplexing is the presence, or absence, of a fibrous or textile component actually within the flakes themselves. Certainly, several aspects of the flakes’ appearance and distribution suggest that they once either contained or were adhered to a cloth. Wrapping the body with resin-soaked cloth, rather than pouring on of a liquid resin, seems to be evidenced by the position of the flakes upon excavation, their consistent thinness, and the undulating drapery-like effect seen in many examples.

One possibility is that the shroud was made by fully saturating a carrier cloth with the resinous mixture. That cloth would now exist within the

flakes, that is, as the flakes, in a highly degraded form. The material’s possible cellulosic component and apparently fibrous nature would fit with such a theory. Note figure 11, which seems to reveal a merging of textile and flake material.

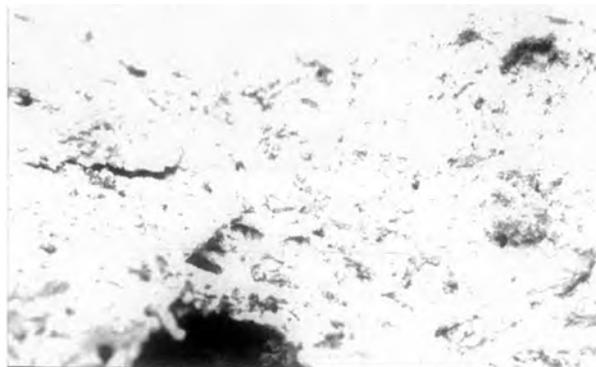


Figure 11. Yarns of textile (?) seen within flake

A second possibility is that the carrier cloth was not fully saturated with the resinous substance and with time has cleaved off from the now distinct, flake-like resin layer. This might be the case if the resin was applied at a relatively high viscosity and did not deeply impregnate the cloth. Thus, the flakes would be composed primarily of resin, with any cellulosic constituent being debris from previous contact with the cloth. The original carrier may be totally lost, or it may be present among the preserved textile fragments.

Of the textile remnants, Textile Type 1 is arguably the best candidate for the carrier cloth, due to its prevalence among the fragments and its highly resinous nature. Its relatively open weave structure also seems a useful form for the absorption of a viscous liquid. Currently it may be present both in less-impregnated form (as the distinct fragments studied here) and in its more fully impregnated

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and/or degraded form (the pale flake material itself).

It is also possible that more than one type of textile was used in the shroud, especially if strips rather than a large blanket-like piece were applied. The other textile fragments could be examples of this, or remnants of clothing or other burial goods. The discovery of Textile Type 2 in an area near the skeleton's feet, for example, may have no significance, though its similarity to the sandal soles found at Chichén Itzá is suggestive. Unfortunately, it was not possible to identify fiber content of the textiles. Cotton, agave, kapok, yucca, hemp, and sisal are all believed to have been exploited by the Maya since ancient times and are potential fiber sources.

As to why the body was prepared in this way, that is a question which this brief study did not attempt to answer. However, Balzer (1962) suggests, "aboriginal ... corpses were sometimes treated with resin in order to preserve them until sufficient time had passed to permit a secondary burial... An aromatic liquor ... obtained from some trees of a copal species ... [was used to] anoint ... corpses ... to avoid decomposition..." (376-377).

5. ADDENDUM

A few days prior to the presentation of this paper, interesting news was relayed by Drs. Ball and Taschek (Ball and Taschek 2002). Excavations at the site of Calakmul in Campeche, Mexico apparently had revealed a substance around a royal burial similar to the Buenavista del Cayo flakes. This

material had been analyzed and identified as a resin from the chicle tree.

6. CONCLUSION

It is hoped that further analysis of the Buenavista del Cayo material and other finds like it will expand our understanding of Maya interment practices. The dissemination of any resultant data may raise awareness among excavators for the possibility of fragmented shroud remains among an often confusing mix of materials in Maya burials.

NOTES

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TEXTILE FRAGMENTS ASSOCIATED WITH FLAKED STONE SYMBOLS FROM THE MAYA SITE OF ALTUN HA, BELIZE

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ABSTRACT—A technical study of two textile fragments found in association with flaked stone symbols (artifacts of a specialized but not tool form) from the Maya site of Altun Ha in Belize was undertaken. The study involved examining weave and yarn, characterizing the fibers and beginning the analysis of the green and pink colorants. This project provided information on textile materials and technology, adding to the limited knowledge available on ancient Maya textiles, as well as linking textiles to the usage and ideology of flaked stone symbols. The properties of the textiles were very similar. All system yarns were single and Z-twist and the fragments provided possible evidence of twill weave or float patterning. The cellulosic fibers of both textiles were characteristic of the *Bombacaceae* family, namely kapok (*Ceiba* spp.), or to a lesser degree tree cotton (*Bombax* spp.). Although this differed from fiber identifications made for other ancient Maya textiles, the physical and chemical evidence was supported by archaeological, ethnobotanical and cosmological sources. Initial investigation into the textiles' colorants was inconclusive and further analysis is intended.

TITULO—FRAGMENTOS TEXTILES ASOCIADOS A "LITOS EXCÉNTRICOS" O "PIEDRAS-HOJAS" SÍMBÓLICAS DEL SITIO MAYA DE ALTUN HA, BELICE. **RESUMEN**—Las "hojuelas líticas simbólicas" o "litos excéntricos" son un tipo de artefacto único dentro del mundo de los antiguos Maya. Con formas que varían desde lo abstracto a lo antropomórfico, estos objetos generalmente han sido recuperados de escondrijos funerarios cercanos a las tumbas o dentro de las estructuras, tal como aquellas espec-

taculares, encontradas en el sitio de Copán en 1991. Además del alto nivel de destreza y habilidad artística mostrada en los líticos de Copán, éstos eran también notables por las pequeñas piezas textiles adheridas a su superficie. Son raros los hallazgos de textiles arqueológicos en los sitios de los antiguos Maya, debido a las malas condiciones de preservación existentes.

Las excavaciones de 1964-1970 en el sitio Maya de Altun Ha en Belice dieron cuenta de una cantidad de escondrijos de "hojuelas líticas simbólicas", y de un interesante hallazgo de dos pequeños fragmentos textiles asociados a ellos. Se realizó un estudio técnico de estos fragmentos como parte de una investigación doctoral dirigida por R. Meadows sobre los piedras-hojas simbólicas de Altun Ha y Lamanai (Universidad de Texas, 2000-2001). Este estudio entregaría información acerca de la tecnología y el material textil, que podría relacionarse con el uso e ideología de estas "hojuelas líticas simbólicas". Adicionalmente, esta información se sumaría al limitado cuerpo de conocimientos disponibles acerca de los antiguos textiles Maya.

El estudio de los dos textiles implicó examinar sus hilados y tejido, caracterizar las fibras, y analizar las áreas de color verde y rosado encontrados en ellos. Uno de los aspectos más intrigantes de este proyecto fue la caracterización de las fibras textiles. A pesar que se le identificó como celulosa de acuerdo a sus propiedades físicas, ópticas y químicas, estas propiedades no correspondían a aquellas del algodón u otras fibras de líber, como suponíamos. Más bien, ellas sugerían el uso de fibras de la familia *Bombacaceae*, denominada

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kapok (*Ceiba* spp.) o del árbol del algodón (*Bombax* spp.). Aunque fibras de Bombacaceae no han sido previamente identificadas en tejidos arqueológicos Maya, las fuentes arqueológicas, etnobotánicas y cosmológicas si sugieren su uso.

1. INTRODUCTION

Archaeological excavations at Maya sites often turn up dedicatory or termination caches of artifacts that have been interred in burials or in buildings. Sometimes the finds include flaked stone symbols, artifacts of a specialized but not tool form that previously have been described as “chipped-stone eccentric”, “eccentric flint”, and “eccentric lithic” (Sharer 1994; Meadows 2000). Ranging in shape from esoteric to celestial to anthropomorphic, these artifacts probably were used for status and ritual (fig. 1). Notable assem-

blages of flaked stone symbols have been excavated from the sites of El Palmar in Quintana Roo, Mexico; Quirigua in Guatemala; and Copán in Honduras (Agurcia Fasquelle and Fash 1991; Sharer 1994). The latter symbols were of particular interest not only because of the high level of artistry and skill they exhibited but also because of the small pieces of textile found on their surfaces. Colored blue and green in places by malachite and azurite mineral pigments, these textile fragments were analyzed in the early 1990s at the Smithsonian Center for Materials Research and Education (SCMRE), Suitland, MD (Beaubien 1991; Kaplan 1994).

In July of 2000, Richard Meadows, a doctoral candidate at the University of Texas at Austin, contacted objects conservator Harriet (Rae) Beaubien at SCMRE regarding the characterization of two



Figure 1. Classic period flaked stone symbols and leaf-shaped blades from El Palmar, Quintana Roo, Mexico (Sharer 1994, 710).

textile fragments and 12 pigment samples found in association with flaked stone symbol assemblages excavated from Altun Ha and Lamanai, two Maya sites in Belize. Dr. Meadows' material cultural analysis of flaked stone symbols from several Belizean sites formed the basis of his dissertation, and he was interested in gathering data on the associated textiles and linking the information to technology, ideology and social relations (Meadows 2000). Additionally, a study of the fragments would add to the limited body of knowledge available on ancient Maya textiles. This project was undertaken as part of the author's 2001 postgraduate archaeological conservation fellowship at SCMRE; this paper discusses the results to date of the characterization of the textile fragments.

2. THE TEXTILE FRAGMENTS

Both of the textiles, designated Textile E and Textile G, belong to assemblages recovered from the site of Altun Ha during the 1964-1970 excavations directed by David Pendergast and sponsored by the Royal Ontario Museum, Toronto, ON (Pendergast 1982; Meadows 2000). Located approximately 30 miles north of Belize City, Altun Ha is a coastal Maya center of moderate size. Its history of occupation dates from the Early Preclassic period (1000 BCE) to the Early Postclassic period (1000-1150 CE) and it reached a population high of about 3,000 during the Classic period (250-900 CE) (Pendergast 1969; Sharer 1994; Meadows 2000). Although previously considered an unimportant center on the fringes of the lowlands, many important discoveries were made during its excavation, suggesting that the rulers of Altun Ha possessed significant wealth and power.

The finds included the tomb of the "Sun God", in which one of the largest known jadeite sculptures was uncovered, as well as 300 jadeite objects and the remains of a codex in another tomb (Pendergast 1969; Sharer 1994).

Textile E (fig. 2) was located on the medial surface of a notched crescent symbol recovered as part of a tomb cache in Structure B-4, the Temple of the Masonry Altars. This cache, one of three below the chamber of Tomb B-4/6, contained 11 flaked stone symbols and one ceramic polychrome vessel. Both tomb and cache date to the early part of the Late Classic period (600 CE) (Meadows 2000). Textile E was irregularly shaped, with maximum measurements of 21.0 x 13.0 mm. Soil and dirt particles were visible on the fragment and only parts of the weave still were intact. The fibers themselves were very fragile and degraded, with broken loose bits collected in the interstices of the weave. Most of the artifact appeared uncolored, with only a small area of green that corresponded on both sides and a tiny bit of pink on one edge, also visible on both sides. The area of green had a definite edge to it, cutting across the weave structure at an angle (fig. 3). Neither the green nor the pink color had a particulate appearance and they only were present on the surfaces of the yarns.

Textile G (fig. 4) was found on the medial surface of a disk-shaped symbol, which also was recovered as part of a Late Classic tomb cache in Structure B-4. This cache was the third of four found in Tomb B-4/7, also known as the tomb of the "Sun God". Located at the south end of the tomb, it contained five flaked stone symbols, several pieces of coral, shark and stingray bones, and

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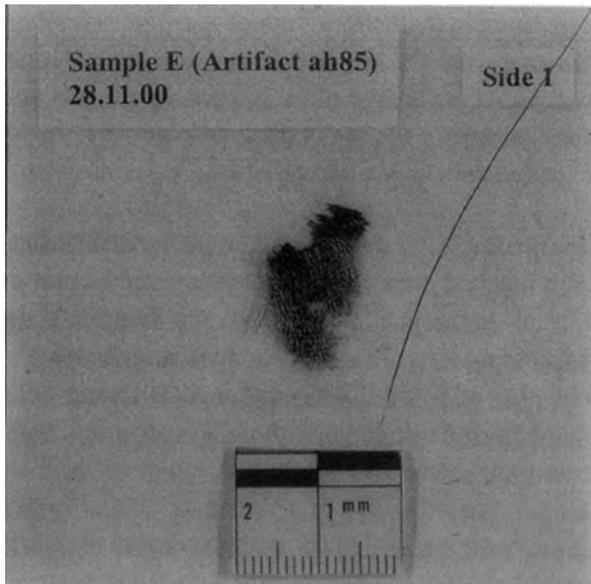


Figure 2. Textile E, side 1.

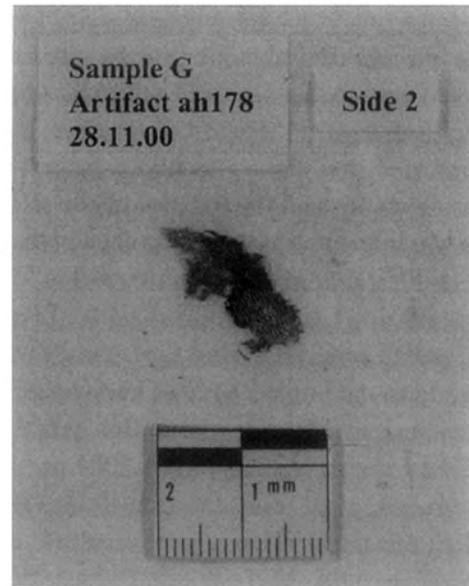


Figure 4. Textile G, side 2.

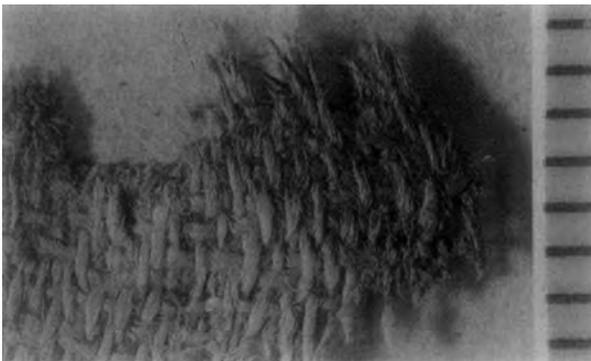


Figure 3. Textile E, side 1: close-up of green area.



Figure 5. Textile G, side 2: close-up of areas of color.

a small amount of chert debitage (waste material from stone tool production) (Meadows 2000). Similar to Textile E, Textile G also was irregularly shaped, with maximum measurements of 21.0 x 10.5 mm. Its fragile and degraded fibers had resulted in the breaking down of the weave structure and the separation of the fragment into three pieces.

Clumps of broken loose fiber bits also were visible in the interstices of the weave. Textile G had larger areas of green and pink color on it compared to Textile E, each of which corresponded on both sides of the fragment. The area of green was on the largest piece and it also had an edge to it, cutting across the weave structure at an angle (fig. 5). No

edge was visible for the area of pink as it was distributed all over another of the pieces. Like Textile E, both of the colors were present only on the surfaces of the yarns and neither had a particulate appearance. In addition, a superficial powdery white material was visible on each side, along with soil and dirt particles.

3. WEAVE AND YARN

Stereomicroscopic examination of the textile fragments revealed that they shared similar characteristics regarding weave and yarn. The fragments possessed simple structures, consisting of two interlaced elements running at right angles to each other (figs. 6, 7, 8, 9). As no selvages were present, none of the elements were definable as warp or weft in either textile and were referred to as system 1 and system 2 for each. The poor condition and small size of the fragments made recognizing any weave structure difficult. Floats were present in both Textile E and Textile G, although no particular arrangement was identified. Some hint of progressive floats in a diagonal alignment was visible in Textile E, suggesting the possibility of twill weave. Alternatively, the floats may have been part of a pattern derived from plain weave (Emery 1966). Both of these structures have been identified in archaeological Maya textiles, with twill weave and float patterning appearing in fragments of probably Postclassic date from the sacred cenote at Chichén Itzá, Mexico and float patterning appearing in Postclassic period textiles from Mayapán, Mexico (King 1979; Lothrop 1992). Either of these weave structures are possibilities for the textile fragments.



Figure 6. Textile E, side 1: close-up of weave structure.

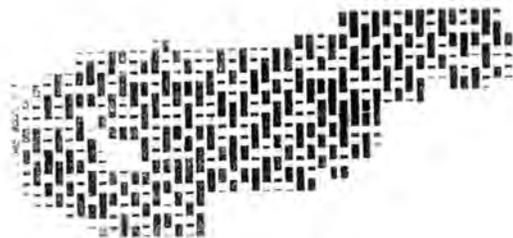


Figure 7. Textile E, side 1: point paper diagram, system 1 = vertical elements, system 2 = horizontal elements.

The structures of the yarns for Textile E and Textile G were very similar. Both sets of systems were made up of single Z-twist yarns with average diameters of 0.30 mm. Average twist angles ranged from 16.2 to 22.7°, giving all systems a medium tightness of twist. Both of the system 1 yarns from Textile E and Textile G had a thread count of 32 to 34 yarns per cm while the system 2 yarns were counted at 17 yarns per cm. Thus, the weaves from each fragment could be described as unbalanced based on the thread count.

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Figure 8. Textile G, side 2: close-up of weave structure.

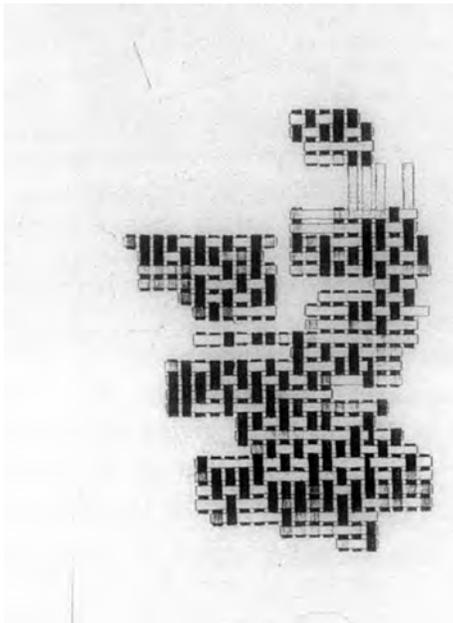


Figure 9. Textile G, side 2: point paper diagram, system 1 = vertical elements, system 2 = horizontal elements.

4. FIBERS

Fiber samples from each of the textile fragments were submitted to a number of investigative techniques including transmitted and polarized light microscopy (PLM), scanning electron microscopy (SEM), histochemical testing, energy dispersive X-ray spectrometry (EDS), and Fourier transform-infrared spectroscopy (FT-IR). The structural and optical properties observed during light and electron microscopical examination identified all system fibers in the textiles as cellulosic. This was confirmed by histochemical testing using toluidine blue-O and by infrared spectroscopy, which produced a typical cellulosic absorption pattern.

The appearance of similar characteristic features revealed that the same type of fiber was used in the construction of all system yarns for both Textile E and Textile G. The average diameter for the fibers was 11.6μ . Under transmitted light (fig. 10), the fibers appeared smooth and cylindrical, with wide lumina, thin walls and no visible dislocations or slits. The ends of the fibers often were very deteriorated and fraying. There also were frequent masses of highly degraded short fibers and an abundance of fungal hyphae and possible spores. Viewed under crossed polars with the red wave plate, the fibers appeared birefringent. Histochemical testing for lignin using phloroglucinol produced negative results and indeterminate results using toluidine blue-O. Fresh and resin cross-sections seen under transmitted light appeared as irregularly shaped circular to oval outlines with periodic indents (fig. 11). In the SEM, the fibers still appeared smooth and cylindrical, although covered with fungal material and debris.

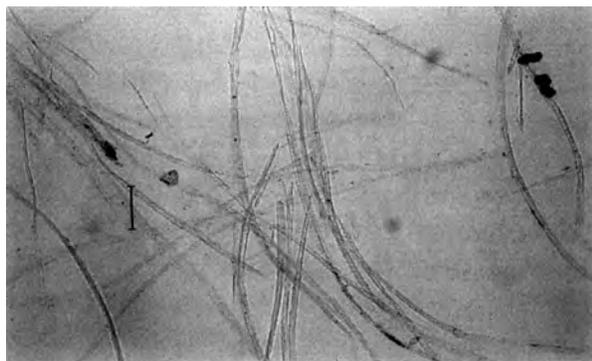


Figure 10. Sample E: whole fibers. 10 x 78 microns.



Figure 11. Sample G: resin cross-sections. 50 x 16 microns.

Most were splitting longitudinally and many transverse breaks were apparent as well. Large pieces also were missing, often making visible the wide lumina and thin walls of the fibers (figs. 12, 13).

Interestingly, these features did not correspond to those of cotton (*Gossypium* spp.) or bast fibers, but rather to fruit fibers of the Bombacaceae family, specifically the genus *Ceiba* or to a lesser degree the genus *Bombax*. The fibers grow from the epidermis lining the fruit pods of trees from these genera. They are characterized by their wide lumina, thin walls that contain lignin (sometimes undetectable with phloroglucinol depending on the

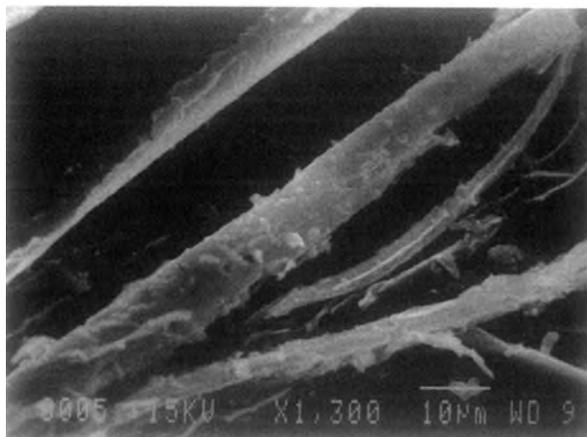


Figure 12. Sample G: SEM image of whole fibers (x1300).

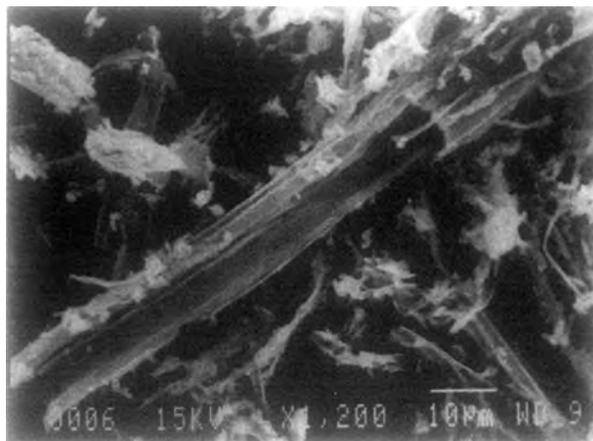


Figure 13. Sample G: SEM image of whole fibers (x1200).

degree of lignification), and circular to oval cross-sections (Mauersberger 1954). Additionally, *Ceiba* fibers appear as smooth, transparent, structureless tubes with an average diameter ranging from 10 to 30µ, features that were visible in the fibers from Textile E and Textile G (Mauersberger 1954; Ilvessalo-Pfäffli 1995). These observations were supported by comparative study of *Ceiba* specimens from the Smithsonian Institution's Botany

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Department, which were collected in Central and South America in the early- to mid-20th century.

Ceiba and *Bombax* fibers have been used for a variety of purposes from medicine to insulation to a stuffing material for mattresses and life preservers (Mabberley 1989; Encyclopaedia Britannica 2001). Although they can be spun into yarn to produce textiles, their brittleness and inelasticity makes this a difficult and thus expensive task that limits their use in modern textile production (Mauersberger 1954; Encyclopaedia Britannica 2001). Kapok, Java kapok, or Java cotton is the predominant commercial species in use and comes from *Ceiba pentandra*, the “silk cotton” tree. *Bombax malabaricum*, or tree cotton, produces a commercially inferior fiber called Indian kapok (Stoves 1958; Ilvessalo-Pfäffli 1995; Encyclopaedia Britannica 2001). The trees are found in various tropical regions throughout the world, including the Americas, Africa and Southeast Asia. They are immense, often 40 to 50 m tall, with a spreading crown, huge trunk, and large, palm-shaped leaves. In his reference work *Trees and Shrubs of Mexico*, Standley (1920-1926) lists the species *Ceiba pentandra*, *Ceiba aesculifolia*, and *Bombax ellipticum* as being present in the Maya area of Mexico and Central America. Their similarity in appearance has resulted in much past confusion regarding their identification and the various indigenous names that have been assigned to them (Standley 1920-1926). One of these names, *yax-che*, most often is used in reference to *Ceiba pentandra* and is significant because it means “green tree” or “first tree”. This term reflects Maya cosmological thought, which considers the *Ceiba* to be the symbolic “world tree” or



Figure 14. Sarcophagus lid from Tomb of Pacal at Palenque showing cross-shaped tree of life supporting the heavens (Sharer 1994, 283).

sacred tree of life. It represents the axis of the universe, linking the various levels of sky, earth and underworld (Friedel et al. 1993; Sharer 1994; Breedlove 2000; Grube 2001) (fig. 14).

The importance of the *Ceiba* tree in Maya cosmology suggests that in spite of the unsuitability of its fruit fibers for weaving, it may have been utilized for just this purpose because of its sacredness. Ethnobotanical sources record Maya usage of the fibers for cloth as well as for stuffing material (Lundell 1939; Voorhies 1982). Roys, in his 1931 publication *The Ethno-Botany of the Maya*, states "the silky fiber enveloping the seeds was employed for weaving cloaks in Uman up to the middle of the last century" (Roys 1931, 276). Although *Ceiba* or *Bombax* fibers previously have not been identified in woven archaeological textiles recovered from Chichén Itzá; Río Azul, Guatemala; Mayapán; Copán; or Altun Ha; they have been considered a possibility in past analyses (Haury 1932; Mahler 1962; King 1979; Carlsen 1986). This proposed identification of *Ceiba*, or possibly *Bombax*, in Textile E and Textile G offers evidence for the use of Bombacaceae fibers in ancient Maya textiles.

5. COLORANTS

The occurrence of the green and pink colors on only the surfaces of the yarns for Textile E and Textile G, along with the obvious edge of the green areas (figs. 3, 5), suggests that coloration occurred after weaving the textiles. It is unknown, however, if it was the result of deliberate application in the form of pigments or paints before or during interment or because of post-interment burial surroundings.

The identification of mineral pigments on the textiles from the Copán symbols and on two of the textiles from the site of Río Azul prompted an ini-

tial investigation of green and pink fibers from Textile E and Textile G using EDS. Previous analyses of green pigments from Maya archaeological materials such as wall paintings, ceramics, wood, stucco and calabashes have identified three predominant sources: malachite, green-earth types of pigments, and Maya blue, an attapulgitite-type of clay mineral colored by an organic substance considered to be indigo (Gettens and Stout 1966; Littmann 1973; Littmann 1980; Rice 1985; Beaubien 1993; Magaloni et al. 1995). Although the similarity of the EDS spectra produced for green fibers from Textile E and Textile G suggests that the same colorant likely was used for both textile fragments, it did not point conclusively to malachite or to a green earth, as variable quantities of copper or iron were identified in only half of the probes. X-ray diffraction (XRD) of green fibers from Textile G then was carried out, producing a pattern that did not match closely any known green pigment patterns, including several that have been produced by Maya blue pigment samples.

Pink pigments identified from Maya archaeological materials have generally consisted of a combination of a red pigment such as hematite or cinnabar and a white pigment such as calcite (Reents-Budet 1994; Sharer 1994; Magaloni et al. 1995). Fibers exhibiting pink colorant from Textile E and Textile G underwent EDS analysis as well and produced similar spectra, again suggesting that the same colorants were used for both textile fragments. Small peaks of iron appearing in most of the probes pointed towards an iron compound as the potential colorant, while the use of cinnabar was discounted as no trace of mercury was identified. X-ray diffraction of pink fibers from Textile

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G could not confirm the presence of an iron compound. Unfortunately, any further investigation into the green and pink colorants could not be completed at SCMRE due to time constraints and the characterization of the colorants remains unresolved.

6. CONCLUSIONS

The study of Textile E and Textile G has provided important details on weave structure, and yarn and fiber characterization, that will add to the information available on archaeological Maya textiles, especially as they relate to caches of flaked stone symbols. The yarns from both systems of the fragments were very similar and although a description of the weave structures beyond simple, unbalanced, and containing floats could not be made, the textiles presented possible evidence of twill weave or float patterning for the Late Classic period.

The fibers from both systems of Textile E and Textile G were characteristic of those from the Bombacaceae family, namely *Ceiba* or to a lesser degree *Bombax*. Although this differed from the cotton and bast fibers identifications made in other Maya archaeological textiles, the physical and chemical evidence was supported by Maya cosmology and ethnobotanical sources, as well as by the consideration that other researchers have given to the usage of *Ceiba* and *Bombax* fibers in woven structures.

The presence of the green and pink colorants was significant as few ancient Maya textiles have exhibited any color, and an even smaller number have been subjected to analysis. Although no pos-

itive characterization of the colorants was made, it is the intention of the author to pursue this further as part of a fellowship at the Textile Conservation Center, American Textile History Museum, Lowell, MA. At this time, the use of pigments is still a valid possibility, although dyes will be investigated as well.

NOTES

All yarn measurements were done in the fabric, making them only approximate.

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SEVERELY DEGRADED TEXTILES ON ARCHAEOLOGICAL ARTIFACTS AT THE AGORA EXCAVATIONS IN ATHENS, GREECE

JULIE UNRUH

ABSTRACT—Burial soil on the surface of excavated objects at the Agora Excavations, Athens, Greece occasionally exhibits patterns that strongly resemble metal pseudomorphic textile structures. These soil structures can be present even without associated pseudomorphic corrosion. The resemblance of the soil to textile pseudomorphs suggests that the soil structures also represent a form of ancient textile preservation. Initial investigations are presented to raise the possibility that evidence for archaeological textiles may exist in this form. The textile/soil structures can be documented with enough detail to provide significant information regarding ancient textile production and use. Three preliminary case studies are presented: a Mycenaean alabastron with a textile wrapping; textile remains associated with a 5th century BCE (Before Common Era) deposit; and a Classical paint palette cover. Probable fiber remains have been analyzed using Fourier transform-infrared spectroscopy (FT-IR) and found to be mineralized. However, mineralization does not seem to explain adequately the observed structures. Possible preservation mechanisms are discussed.

TITULO—TEXTILES SEVERAMENTE DAÑADOS EN ARTEFACTOS ARQUEOLÓGICOS PROCEDENTES DE LAS EXCAVACIONES DEL AGORA DE ATENAS, GRECIA. **RESUMEN**—En las excavaciones del Agóra en Atenas, los restos de textiles arqueológicos se preservan bastante más de lo que antes se reconocía. Se han encontrado restos muy dañados de bolsas, envoltorios, frazadas, vestuario y otros artefactos textiles asociados a diversos objetos arqueológicos inorgánicos que datan de la Edad del Bronce al Período Bizantino. Por lo general,

estos restos textiles no habían sido detectados dado que a primera vista parecían ser sólo suciedad adherida en la superficie de los objetos. Normalmente, estos textiles no podían ser removidos de los objetos, ni manipularse sin destruirlos. Sin embargo, aún en estas malas condiciones de preservación, los textiles pueden ser documentados.

Entre las evidencias que contribuyen a su caracterización se incluyen la presencia de material orgánico y el contenido de la fibra, la que puede ser identificada con análisis instrumentales. La suciedad circundante, la cual mantiene retenidos los detalles estructurales de un textil en forma de ranuras y protuberancias, que sigue patrones de tejido y vacíos dejados por los hilados, como impresiones negativas en la tierra, también provee información sobre ligamentos, cortes, diámetro del hilo y torsión, de textiles ya extintos.

El examen y la documentación de restos textiles severamente dañados serán ilustrados a través del estudio de varios casos: una tapa de alabastro Micénica; envoltorios para cerámica ritual Clásica; una cubierta pintada Clásica; y, un textil Bizantino no identificado, encontrado asociado a un fragmento de columna de mármol. Serán discutidos también los dilemas que surgen por la presencia de restos textiles que ocultan la superficie de los artefactos.

1. INTRODUCTION

Textile pseudomorphs (textile information retained in metals corrosion layers, produced via encasement or replacement of the textile with cor-

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rosion products) appear regularly on metal objects excavated at the Agora Excavations, Athens, Greece. While documenting bronze and iron textile pseudomorphs on objects from which the excavation soil had not been removed yet, it was observed that textile weave structures regularly seemed to extend beyond the pseudomorphic corrosion and continue into adjacent burial soil on the surface of the object (fig. 1). In some cases excavation soil alone, not in association with pseudomorphic corrosion, strongly resembled pseudomorphic textile structures. Features that would be considered to be textile evidence if seen in metal corrosion layers could be detected in burial soil associated with objects (fig. 2).

The resemblance of the soil to textile pseudomorphs suggests the possibility that the soil structures also represent a form of ancient textile preservation. Since this phenomenon was first observed at the Agora, approximately 50 excavat-

ed objects have been identified that potentially contain ancient textile evidence within surface soil structures. The majority of the textile/soil structures are not associated with metal pseudomorphs. They include not only bronze objects, which would be expected to provide a degree of biocidal protection to textile remains, but ceramics, stone, and other materials as well.

The textile/soil structures cannot be removed from the associated objects or handled without their destruction. In spite of their fragility, thread count, yarn diameter, twist direction, weave structure and other textile features frequently can be determined. These textile/soil structures can be a source of detailed and specific information, adding significantly to current understanding of ancient textile production and use.

It is widely assumed that textiles cannot survive in Mediterranean burial environments. Initial investi-

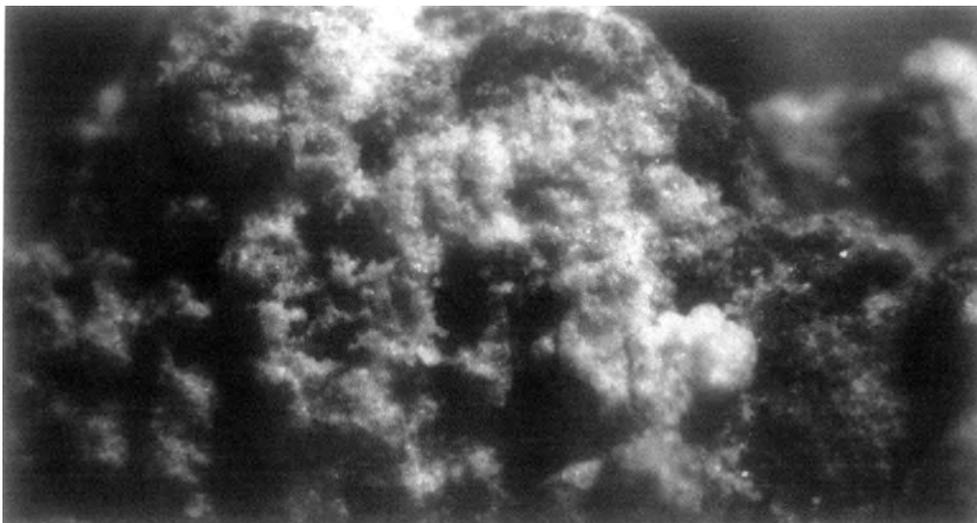


Figure 1. Bronze pseudomorphic textile with threads and weave structures continuing beyond the corrosion as soil features.



Figure 2. Textile-like structures within the soil on a body fragment of a bronze bowl.

gations and three preliminary case studies are presented to suggest that archaeological textiles may exist in this form. Because the investigation is in the initial stages, the extent to which this form of textile preservation is present at the Agora cannot yet be estimated. A preservation mechanism has not been explained satisfactorily (see section 3.1.a. below). However, preliminary observations suggest that the phenomenon should be given serious consideration, and the identification of a large group of potential material implies that the phenomenon may be widespread.

2. BURIAL CONDITIONS

Burial conditions at the Agora are not ones in which textiles customarily are expected to survive (Jakes and Sibley 1983, Jakes and Sibley 1984). The pH of the soil generally ranges between 6 and

8. The site is neither waterlogged nor desiccated, it does not contain high levels of salts, and the soil is aerobic. The environment is typical of most archaeological environments in the Mediterranean region. As Agora burial conditions do not seem to be extraordinary, it is expected that if this textile preservation phenomenon exists at the Agora, it should exist in other Mediterranean archaeological sites as well.

3. CASE STUDIES

3.1 MYCENAEAN ALABASTRON WITH TEXTILE WRAPPING

A Mycenaean chamber tomb dating to approximately 1400 BCE (Before Common Era) was excavated in 2001 (Camp 2001). The grave contained a small ceramic alabastron or pot, used to

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contain an ointment. This pot bypassed routine pottery washing to allow for the possible identification of its contents. Consequently, the alabastron arrived in the conservation laboratory with clumps of burial soil adhering to its surface. Close examination of the soil suggested the presence of a textile. In raking light, the soil covering the mouth of the pot exhibits what appears to be a weave pattern (fig. 3). The weave structure extends across the mouth and continues over the rim. Patterns which resemble a plain weave structure are apparent in the soil on the sides and across the base of the alabastron.

This pattern is not a negative impression. There appears to be a three-dimensional textile, replicated in soil, adhering to the surface of the pot. When it is viewed **under low magnification with a binoc-**

ular microscope what is visible is not textile fiber, but soil. Careful examination shows that the soil replicates not just the general appearance of a textile but explicit textile characteristics in good detail. A plain weave structure with an average of 6 threads per cm in both the warp and weft directions is visible with S-plyed yarns of a diameter of 1.5-2 mm which are composed of Z-twisted ply of diameters of 0.7 mm.

Three facts support the identification of this feature and similar features on other objects as the remains of textiles rather than naturally occurring soil features.

- The resemblance to a textile is not superficial, and it holds up under close examination.
- The soil of which the textile structure is composed often is different visually from the soil



Figure 3. Textile/soil structure covering the top of the Mycenaean alabastron.

surrounding the object in the burial context. Under magnification, the soil that exhibits textile features can be characterized as fine, fibrous, furry, homogenous and without small rocks. It sometimes has an overall yellow-brown or dark brown color that indicates the presence of organic material. It can contain tiny separate chunks of black or brown organic material. This seemingly organics-rich soil usually differs from the soil from which the object was excavated. In archaeology, the presence of a new soil type signals a new feature in the burial environment.

- In the case of the alabastron, within this distinctive soil are short segments of what appear to be spun fibers (fig. 4). The segments are regular in size, approximately 0.2 mm wide and dark brown or black. Visually, they do not resemble root segments that are found on Agora material. Because polarized light microscopy proved inadequate to identify these fibers, Fourier transform-infrared spectroscopy (FT-IR) was attempted (Thickett 2002). The FT-IR analyses gave spectra matching calcite and silicates, indicating that the samples are mineralized with less than 10% organic material present. Several research teams have identified cellulose within what were thought to be completely mineralized fibers (Gillard et al. 1994), so it is feasible that fiber identification will be possible with a different analytical method.

The detailed physical structure, the distinctive organic appearance of the soil, and the presence of what appears to be small mineralized spun fibers within the structure, support the theory that the soil

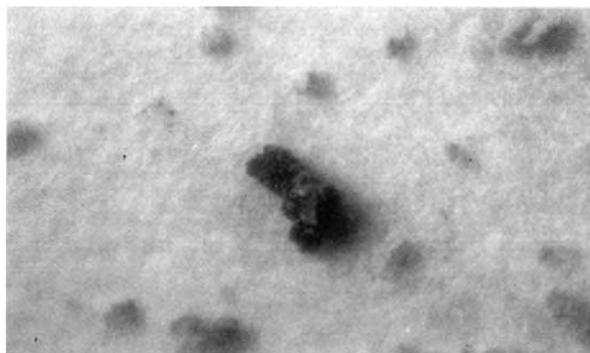


Figure 4. Segment of possible spun fiber, 25x magnification.

looks like a textile because it is the remains of a textile.

The overall placement of the textile remains on the surface of the alabastron indicates that the pot was wrapped in a cloth before being deposited in the grave. It appears the cloth is extant as soil clinging to the surface of the pot. In view of this proposition, a reexamination of the soil/textile structure suggested further details. There are channels in the textile/soil remains in several locations on the surface (fig. 5). Tracks extend out from these channels and continue around the pot. They differ from channels and tracks left by roots in that they do not branch, their diameters remain consistent, they follow direct rather than meandering paths straight across the surface and around the pot, and the textile/soil weave structures conform to the surface of the channels rather than being bisected by them. These markings in the soil seem to indicate the former presence of cordage wrapped over the cloth, presumably to tie up the package. The configuration of the cordage can be mapped.

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Figure 5. Channels in the textile/soil structures on the side of the alabastron.



Figure 6. "Drawstring holes" under the rim of the alabastron.

A series of holes in the textile/soil remains under the rim are fairly regular in diameter and fairly regularly spaced (fig. 6). Atypical of root holes, they are perpendicular to the pot and directly against its surface. If they are interpreted as being features of the textile, they suggest drawstring holes. It has been proposed that pots of this shape would have had textile lids wrapped over the top and tied on with a cord under the lip. In this context a drawstring under the lid makes sense. Mycenaean textile lids have been postulated, but have not been identified previously in association with excavated material.

3.1.a. PRESERVATION MECHANISM

The mechanism that has preserved the morphology of the textile has not been clarified. Mineralization apparently plays a role, but the mineralized objects identified by FT-IR are, volume-wise, a small component of the total visible textile structure. The remainder of the structure does not fit neatly into preconceptions of what mineralized textiles should be. In archaeological and conservation literature “mineralized” is generally used to designate textiles that remain coherent because they are encrusted with, infilled with, or chemically complexed with a mineral such as calcium carbonate or copper (Janaway 1985; Chen et al. 1998). The mineralization model involves the dissolution of specific ions and mineral replacement on a molecular level. This model inadequately explains the observed structure. The structure appears to be composed of macroscopic, fibrous soil which is a mix of organic material and minerals including iron, aluminum, silica, calcium carbonate and calcium sulfate. There is an apparent lack of replace-

ment by any one mineral in particular. The remains are not particularly solid or cohesive.

Two hypothetical preservation mechanisms have been proposed. One theory is that in spite of very advanced decomposition, enough fiber polymer chains are left to maintain the structural integrity of the textile. A second theory is that a soil replacement process rather than a mineral replacement process is in effect. Exactly what this process would entail has not been investigated.

3.2 TEXTILE ASSOCIATED WITH A PYRE DEPOSIT

At the Agora, miniature pots and charred animal bones have been uncovered within Classical and early Hellenistic (late 5th to 3rd century BCE) buildings. These “pyre deposits” have been interpreted as remains of building ceremonies, but the ritual is not well understood (Rotroff 1997; Camp 2001). One such 5th century BCE deposit was excavated in 2001. On the surfaces of many of the ceramic vessels from this deposit, one soil is aligned at right angles. The right-angled soil includes the visually distinctive organics rich soil described above. The soil exhibits additional textile-like features in moderate detail.

Microscopic examination revealed that the soil from at least two of the ceramics contained not just a few fiber segments, but numerous brown segments of approximately 0.15 mm in diameter (fig. 7). These segments are regular in length and periodically are themselves configured in right-angled patterns. Consultation with an archaeobotanist, an entomologist, and a soil geologist ruled out possi-

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Figure 7. "Right-angled" soil on the surface of a sherd from the pyre deposit.

bilities that they were plant remains, insect debris, or common soil aggregation features. Wood and charcoal break at right angles, and a considerable amount of charcoal exists on the surfaces of these pots. However, the charcoal fragments on these pots do not resemble these segments. Charcoal is a much glossier black, and it breaks into irregular rather than regular sized segments. The spongy interior structure of long bones can resemble a textile weave, and this deposit did contain charred animal bones. However, spongy bone masses tend to break into distinctive branched pieces rather than regular segments.

Again FT-IR analysis (Thickett 2002) gave mineralized spectra, so a fiber content is not confirmed. However, it is difficult to explain the right-angled geometry and the regular size of the segments as the result of a natural phenomenon. In light of the fact that the soil from which these fibers came mimics the structure of a textile, it is proposed that these segments are mineralized textile fiber segments. Their regular size is due to the regular structure of a textile weave; they broke at regular

intervals because they were stressed at regular intervals.

Soil which resembles a woven textile exists on the majority of the pots from this deposit. The textile/soil features indicate thread counts about 10 x 13 threads per cm with Z-spun yarns averaging about 0.6 mm in diameter, and a probable plain weave. The consistency of the measurements seems to indicate either one textile throughout the deposit or a group of textiles with very similar characteristics. The textile(s) may have been cloths used in the ritual, as wrappings or as a bag. Further study is needed to adequately interpret the textile remains.

Unfortunately, the ceramics themselves are poorly understood. The textile/soil remains obscure the ceramic materials, surface treatments, small variations in form, and manufacturing details, which are diagnostic features vital to the interpretation of the ceramic artifact. As a compromise treatment, the surfaces were largely, but not entirely, cleaned (fig. 8). Soil was documented

before removal and samples were retained. Where the textile/soil structures appeared to be particularly informative chunks of soil were left in place. This is not a very satisfactory compromise for anybody. From the standpoint of studying the textile/soil structures, there is little possibility of double-checking the initial assessment or examining remains in situ. From the standpoint of studying the pottery, portions of the ceramics remain obscured by the textile/soil structures. It is an ongoing struggle to find compromises that allow for maximum information retrieval without eliminating one set of data or the other.

3.3 CLASSICAL PAINT PALETTE COVER

A large Corinthian amphora base sherd dating to the 3rd quarter of the 5th century BCE was excavated during the 2000 season. The amphora base

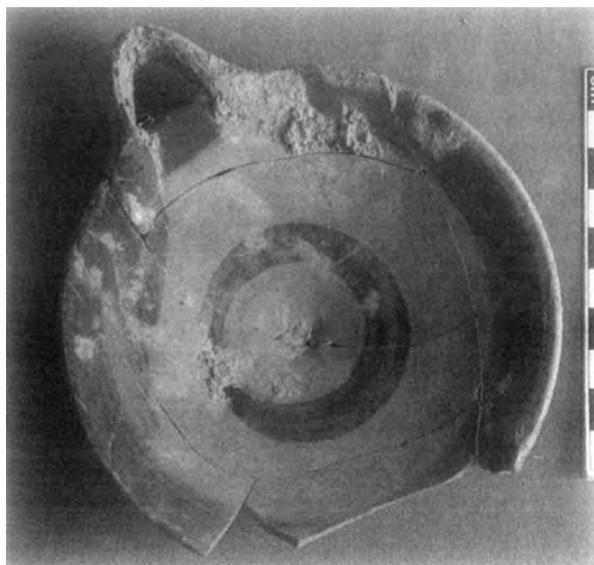


Figure 8. Ceramic plate from the pyre deposit, after treatment.

contains large amounts of red and yellow iron oxide pigments in the interior, suggesting that it was reused in antiquity as a paint palette (fig. 9). Two similar amphora base sherds and a group of amphora body sherds reused as paint palettes have been identified at the Agora (Lawall and Jawando, in press).

The surface of the object exhibits a number of textile-like features. A grid pattern appears in the red pigment and there are faint regular grid patterns in the soil covering the pigments in several locations on the surface. The soil hangs off the edges in a very thin, structurally cohesive, sheet resembling a piece of cloth (fig.10). None of these features are very definite, but they all match each other. The grid patterns line up in the same direction, and the dimensions of the patterns are the same. This consistency implies that they all are features of one object extending across the entire surface. The surface was reexamined more closely and an extant textile was discovered. A small brown feature ini-



Figure 9. Amphora base reused as a paint palette, top view with "grid pattern" in the red pigment (dark area lower right).

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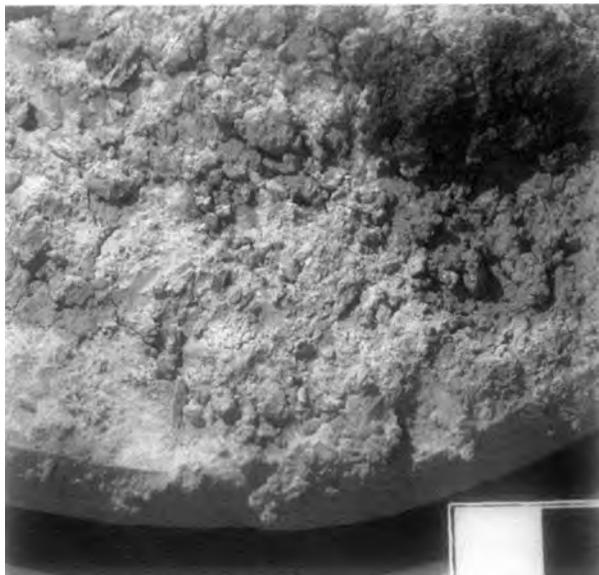


Figure 10. Thin sheets of soil extending over the edge of the paint palette.

tially thought to be a twig was found to be constructed of fibers running in both the horizontal and vertical directions (fig.11). This piece of textile runs just under the surface of the soil, and emerges again in a second location as a largely amorphous, brown mass. A closer look confirmed that the right-angled edges of this mass are composed of a series of yarns in alignment. Using polarized light microscopy, organic fibers from this mass have tentatively been identified as bast fibers, due to the presence of characteristic nodes. In this case, vague soil features were instrumental in locating and delineating organic textile remains that are not obvious or well preserved. It was also the clues in the soil which indicated that the textile extended across the entire surface of the palette and went over the edges, as opposed to being random scraps. This fact allows speculation as to the identification of the textile object: a cloth cover

over the pigments of the paint palette. This object provides unique evidence for the use of a textile cover on a classical paint palette. It is evidence that came primarily in the form of ephemeral clues in the soil.

4. CONCLUSIONS

In Mediterranean archaeology there may be a bias against the recovery of ancient textile information because it is believed that textiles are unable to survive burial. Consequently, ephemeral evidence for the presence of ancient textiles in the burial environment may be discounted as improbable. The discussed observations raise the possibility that soil features resembling textiles should be given more serious consideration as legitimate evidence for the presence of ancient textiles. In spite of their unconventional form, these remains contain valuable information about ancient textile production and use. Future work will pursue the confirmation of a textile fiber content within textile/soil structures, and an explanation of the preservation mechanism.



Figure 11. Textile fragment associated with the paint palette.

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THE CONSERVATION OF A CIRCA 3RD CENTURY BCE CHINESE BRONZE DAGGER-AXE WITH ORGANIC REMAINS

E.D. TULLY

ABSTRACT—A circa 3rd century BCE (Before Common Era) Chinese bronze dagger-axe, with organic remains and an unusually patterned blade was treated at the Department of Conservation and Scientific Research (DCSR) at the Smithsonian Institution's Freer Gallery of Art and Arthur M. Sackler Gallery, Washington, DC. The organic remains were degraded, making handling and examination difficult without causing further damage. This paper discusses treatment of these remains, and summarizes research undertaken on the history and technology of dagger-axes.

TITULO—LA CONSERVACIÓN DE UN HACHA-DAGA DE BRONCE CHINO DEL SIGLO III A.C. CON RESTOS ORGÁNICOS.

RESUMEN—Una hacha de bronce chino del 3er siglo a.C. con restos orgánicos y una hoja con una inusual decoración, fue tratada en el Departamento de Conservación e Investigación Científica del Arthur M. Sackler Gallery and Freer Gallery of Art. Esta hacha-daga es un objeto muy inusual tanto por el buen estado estado de preservación de

su lacado como por los restos textiles, así como por la decoración que ostenta su hoja o cuchillo.

Los restos orgánicos estaban extremadamente degradados haciendo difícil su manipulación y examen sin causarle nuevos daños. Esta ponencia discutirá el tratamiento de estos restos a través de la colaboración de un conservador textil y los temas que hubo que enfrentar para proteger este objeto compuesto. La ponencia también entregará un resumen de la investigación concerniente al inusual patrón decorativo de la hoja del hacha.

INTRODUCTION

A research and treatment project on a circa 3rd century BCE (Before Common Era) bronze dagger-axe from China was undertaken by the author during a third year internship at the Department of Conservation and Scientific Research (DCSR) at the Smithsonian Institution's Freer Gallery of Art and Arthur M. Sackler Gallery, Washington, DC. The dagger-axe has remnants of its original silk, lacquer and bamboo handle (fig. 1).

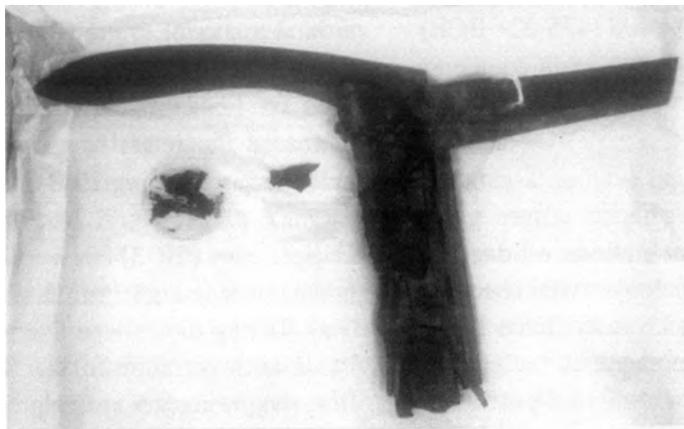


Figure 1. Singer dagger-axe, overall, before treatment.

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Figure 2. Singer dagger-axe, detail, blade patterning and corrosion lines.

Part of the collection of Dr. Paul Singer, the dagger-axe was given to the Arthur M. Sackler Gallery in 1997, and henceforth will be referred to as the Singer dagger-axe. It has a bronze blade and tang (see fig. 3), both of which are decorated with an unusual and well-preserved geometric pattern (fig. 2). Remnants of the original handle consisting of a woven silk textile wrapped over a lacquered bamboo substrate survive. The textile is threaded through holes in the bronze and is knotted in the front. Although there is no known provenance for the piece, based on stylistic evidence it has been dated to the Warring States period (475-221 BCE) and likely comes from the Chu state in southeast China (Su 2001).

2. HISTORIC CONTEXT

Dagger-axes, modified combinations of daggers and battle-axes mounted on long shafts, became prominent during the Shang Dynasty (circa 1600-1022 BCE) with the development of the chariot and the ensuing need for longer, hand-held weapons (Chen 1994). One of the most common forms of weapons in Bronze Age China, they

remained a popular weapon type throughout the Western and Eastern Zhou periods (1027-771 BCE and 770-221 BCE). However, by the end of the Eastern Zhou period, double-edged iron swords started to become a more important weapon type, and by the end of the Western Han Dynasty (250 BCE-8 CE), iron had replaced bronze for all but the highest-ranking officers (Chen 1994).

In close combat, infantrymen armed with dagger-axes and often a shield and staff, would group around a chariot to protect the archers and spear throwers inside (Dien 1996). Dagger-axes were used for hooking and stabbing. The long shaft increased the reach from other common hand-held weapons (Wang 1993).

Dagger-axes (fig. 3) consist of a horizontal blade (*yuan*), a tang (*nei*), and a vertical blade or haft (*hu*). Taking their shape from the thick and wide battle-axes common in the Shang Dynasty, the first dagger-axes were relatively stubby with a short, triangular *yuan* and little or no *hu*. Over time the shape of the dagger-axes was refined,

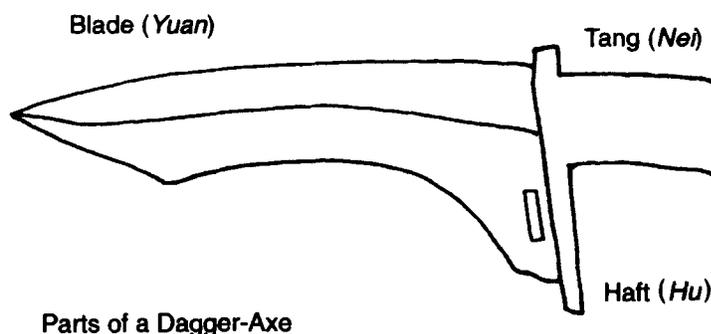


Figure 3. Parts of a dagger-axe.

culminating in the graceful designs of the Warring States period, with slender, curved blades and sharpened tangs as seen in the Singer dagger-axe.

Although dagger-axes were a common weapon, they also were symbols of prestige and power. Weapons were ritual objects of great importance both to the state and to the individual; as a result much effort went into making them useful and aesthetically pleasing (Chen 1994). While most blades were plain, those of weapons belonging to high-ranking officials often were decorated. Many were inscribed or inlaid with designs in gold, silver, malachite or turquoise. Others had surface patterning such as silver mottling or the geometric diaper patterns seen on the Singer dagger-axe (Loehr 1956; Cheng and Zhong 1990; Yang, H. 1992; Wang 1993; Chen 1994). This type of diaper patterning, also called *lingxing angewen* (Wang 1993), was more common on double-edged swords and spearheads than on dagger-axes, and only about 20 dagger-axes with similar patterning are known (Su 2001). The Chu state in southeast

China, where the Singer dagger-axe is thought to originate, was known for manufacturing weapons with this particular type of pattern.

The decoration and the quality of the casting and design suggest the Singer dagger-axe belonged to a high-ranking person. The blade patterning and relative richness of the preserved organic remains make it likely that this weapon was designed for ceremonial use and was buried with an important nobleman or politician.

3. CONSTRUCTION AND MANUFACTURING TECHNIQUE

Dagger-axes have heavy bronze heads attached to long shafts, usually over one-meter in length. Often, the end of the shaft was split and the tang inserted into the split. A finial was used to cap the split, while thong or cord lashings were laced through several perforations in the *hu* to hold the blade in place. Decorative ferrules were also common (Yang, H. 1992).

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The staffs were usually composite objects, constructed with a core of wood, often oval in section, covered with thin, vertically laid strips of bamboo. These were wrapped with a thong, cord or other lashing and covered with black lacquer (Yang, H. 1992). The Singer dagger-axe no longer has the central wooden shaft, but the bamboo strips are clearly visible in the remains (fig. 4). It appears that the vertical bamboo strips were wrapped with thin sheets of bamboo or other wood, rather than the more typical thong or cord.

Bronze weapons like dagger-axes generally were cast in piece molds and usually were cast in one piece until the late Eastern Zhou period when lost wax casting and the use of solder began to replace previous casting techniques (Chase 1999; Su 2001). The metallic composition of dagger-axes is fairly consistent and tends to be high in copper with low tin and lead and is usually non-ferrous. The *Kao Gong Ji* (the Artificers' Record) written during the Eastern Zhou period records bronze formulas for several types of artifacts, including dagger-axes, other weapons and mirrors and gives a recommended ratio of copper to tin of between 3:1 and 4:1. This corresponds to a range of about 75-80% copper and 20-25% tin (Yang, H. 1992).

Published compositions of dagger-axes range between 73-88% copper and 8.4-14% tin (Gettens et al. 1971; Yang, H. 1992; Kossolapov and Twilley 1994). This is consistent with the Singer dagger-axe, which has an average copper content of about 81%, an average tin content of about 17%, and low amounts of lead, about 2%. The composition was determined through X-ray fluorescence analysis (XRF) using an Omega Five X-ray fluo-

rescence spectrometer (a modified Spectrace 6000). Because of the corrosion on the metal, the analysis was semi-quantitative.

Geometric patterning on the blade of the Singer dagger-axe appears to be the result of a surface treatment rather than an inlay. The exact production method is not known, although many theories have been proposed, including the application of a tin-rich paste to enrich the surface or mercury amalgam tinning (Kossolapov and Twilley 1994; Tan et al. 2000; Lian and Tan 2001).

The materials and construction of the organic portion of the Singer dagger-axe are consistent with published reports with the exception of the organic remains over the *hu*, and are undoubtedly original. In the Singer dagger-axe the textile covers the *hu* (fig. 4), which is not consistent with published reports of similar pieces where the *hu* is uncovered (Cheng and Zhong 1990; Yang H. 1992; Yang X. 1999). This could be due to either regional differences, or to changes made during the restoration process.

TREATMENT

When the Singer dagger-axe arrived at the conservation laboratory, it was resting on its side. The metal portions of the piece appeared to be in good condition with little surface corrosion and minimal soiling. Along the lower portion of the piece were vertical strips of bamboo, covered with a dark brown layer of lacquer. A finely woven, plain weave silk textile was wrapped around the lacquer and bamboo and knotted just



Figure 4. Singer dagger-axe, detail, handle, before treatment.

beneath the blade. Portions of the textile could be seen extending through holes in the *hu*.

The surface of the object was extremely dirty overall. The lacquer was cracked and lifting, and many pieces were lost. Although the textile retained some strength and flexibility, it was extremely fragile with brittle edges that shredded to the touch. The textile retained some strength and flexibility, and portions of it could be manipulated.

The piece had been treated before coming to the Sackler, although there is no known record of treatment. Some of the textile and lacquer pieces had been adhered and/or consolidated using a thick, hard, milky adhesive, probably polyvinyl acetate (PVA). Although unattractive in appear-

ance, the repairs were stable. The metal appears to have been cleaned as there is little corrosion. The buffered paper it originally rested on was discovered to have slightly raised portions which etched lines onto the metal (fig. 2). In order to improve the appearance of the previous treatment, attempts were made to reduce the adhesive on the surface of the repairs. While the adhesive softened in a variety of solvents, extensive mechanical action was required to reduce the adhesive and the lacquer appeared to be damaged through contact with the solvents. Attempts to reduce the adhesive were confined to the stronger pieces of both the lacquer and the metal.

The treatment of the fragile textile was developed in consultation with Christine Giuntini of the

THE CONSERVATION OF A CIRCA 3RD CENTURY BCE CHINESE BRONZE DAGGER-AXE WITH ORGANIC REMAINS

Metropolitan Museum of Art, NY. The object was micro-vacuumed using a water aspirator, pipette and small brush under a stereomicroscope, successfully cleaning the textile, lacquer and metal. Japanese paper bridges were used to support the loose pieces of lacquer and several pieces of stiff, knotted textile. These were constructed from small pieces of a fairly thick Japanese paper cut into strips and coated with about a 30% solution of Acryloid B-72 in acetone (w/v). The strips were adhered to the underside of the loose pieces by reactivating the Acryloid B-72. Any portions of the strip that would be visible were tinted with Golden acrylic paints.

The textile was stabilized using a dark brown silk crepeline overlay. It unobtrusively holds the fragile textile in place and allows the dagger-axe to be exhibited without further damage or loss to the

organic remains. The overlay, shaped to cover the textile on the handle, has an adhesive strip about 0.6 cm (1/4") wide made by coating the edges with a 20% solution of Acryloid B-72 in acetone (w/v). This adhesive strip helped prevent the fine fabric from unraveling, and provided a way to adhere the crepeline to the metal.

The crepeline was put in place over the handle and the Acryloid B-72 was reactivated with acetone. A small spatula heated on a hot plate was used to tack the crepeline more firmly in place. Where the overlay crossed the handle, the Acryloid B-72 was left inactivated and was toned to match the color and sheen of the lacquer using dry pigments and a small amount of acetone.

After treatment the dagger-axe is stable enough to be handled gently, although it is still extremely

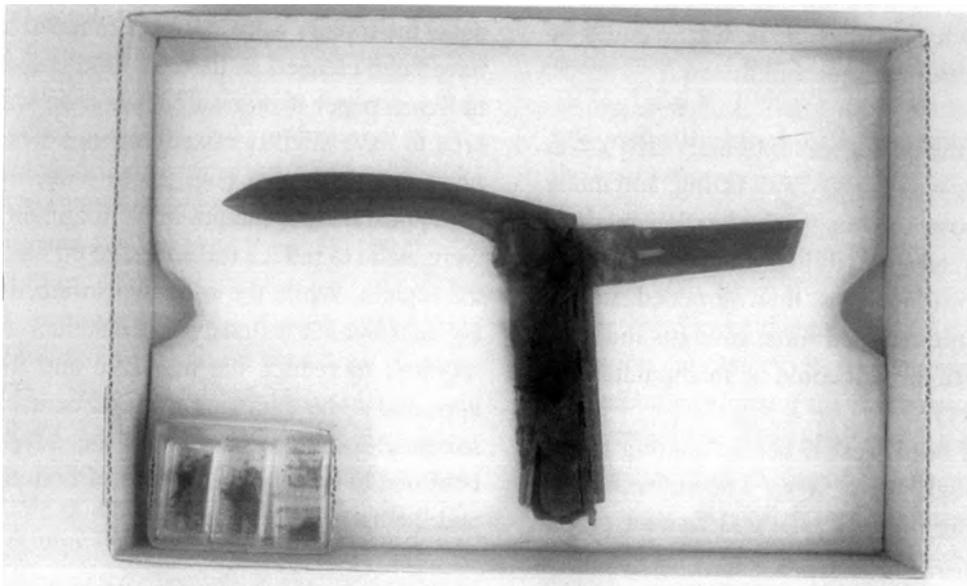


Figure 5: Singer dagger-axe, overall, after treatment.

fragile. The crepeline holds the textile in place and prevents it from moving, but small fragments of the edges can still be dislodged and lost. Since the object has the potential to be included in future exhibitions, and will therefore need to be assessed for inclusion, a storage box with a removable inner liner was designed that would allow for visual assessment with minimal handling (fig. 5).

CONCLUSION

Research into the history and technology of dagger-axes has given a clearer picture of how the Singer dagger-axe fits into the historical structure of the Eastern Zhou dynasty. Collaboration with conservators from different disciplines proved invaluable for this treatment.

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SOURCES OF MATERIALS

Japanese paper, Acryloid B-72, Silk crepeline
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www.talasonline.com

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RHAPSODY IN BLUE: KINGFISHER FEATHER CLOISONNE IN THE ARTHUR M. SACKLER GALLERY

ELLEN SALZMAN CHASE AND BLYTHE M^cCARTHY

ABSTRACT—Feathers from the kingfisher bird have been used to decorate headdresses, hairpins, earrings and other types of personal ornament, as well as larger items such as bed hangings, screens and lanterns. Kingfisher feathers were also used to decorate costumes in Chinese opera. In this paper the materials and techniques used in the manufacture of kingfisher feather jewelry are discussed. In particular, approximately 35 pieces of jewelry in the Paul Singer collection of the Arthur M. Sackler Gallery, Smithsonian Institution, Washington, DC, that are decorated with kingfisher feather were studied. Comparable pieces in other collections were also examined. The types of feathers, the methods of preparation, and of adhesion to the substrate materials are discussed, as are the types of substrate materials and associated decorative media. The objects were examined for their physical characteristics of substrate type, feather texture, cloisonné form and support structure. More detailed examinations were carried out on Singer collection objects including identification of the feathers, metal substrates, types of adhesives used and general working methods.

TITULO—RAPSODIA EN AZUL: EL CLOISONNÉ DE PLUMAS DE "MARTÍN PESCADOR" DEL ARTHUR M. SACKLER GALLERY. **RESUMEN**—Las plumas del martín pescador han sido utilizadas para decorar tocados, horquillas para el pelo, aros y otros tipos de adornos personales, así como también para objetos de mayor tamaño como doseles de cama, pantallas y faroles. También han sido usadas para decorar los vestuarios de la opera China. En esta ponencia se discutirán los materiales y técnicas utilizadas en la manufactura de la joyería con plumas de martín

pescador. En particular, se estudiarán 35 piezas de joyería pertenecientes a la colección de arte chino del Dr. Paul Singer de la Arthur M. Sackler Gallery, que están o estuvieron decoradas con plumas de martín pescador. Se examinarán también piezas comparables de otras colecciones. Se tratarán los tipos de plumas encontradas en los objetos, los métodos de su preparación, y formas de adhesión a los materiales de soporte, así como los tipos de soportes utilizados y otros medios decorativos asociados. Los objetos serán investigados por las características físicas del tipo de soporte, por la textura de las plumas, la forma del cloisonné (alveolado) y la estructura del soporte. Se llevaron a cabo exámenes más detallados de los objetos de la colección Singer, incluyendo la identificación de las plumas, del sustrato de metal, de los tipos de adhesivos usados y sobre los métodos generales de manufactura.

1. INTRODUCTION

Feathers from the kingfisher bird have been used in Chinese culture to decorate headdresses, hairpins, hair combs, earrings and other types of personal ornament, as well as larger items such as bed hangings, screens and lanterns. Kingfisher feathers also were used to decorate costumes in Chinese opera. The iridescent colors of the feathers were highly prized in the court and later among the larger population.

A collection of Chinese kingfisher feather jewelry, recently acquired as part of the Paul Singer collection by the Smithsonian Institution's Arthur M. Sackler Gallery (AMSG), Washington, DC, was examined in terms of its materials and techniques.

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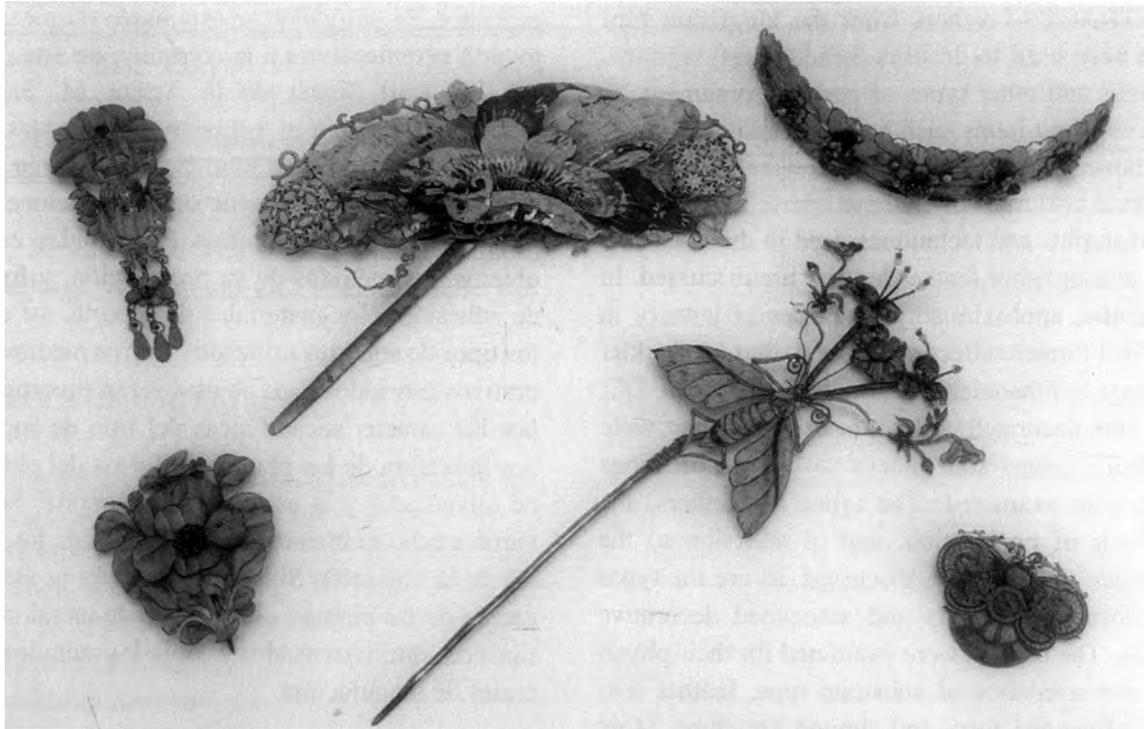


Figure 1. Jewelry from the collection of the AMSG with applied feather decoration (clockwise: S2001.3, RLS1997.48.4644, S2001.4, RLS1997.48.4625, RLS1997.48.4645, RLS1997.48.4635).

The jewelry, several of which are shown in figure 1, has no known provenance. Most is placed stylistically in the Qing Dynasty, 1644-1911 CE (Common Era), with several possibly from the Ming Dynasty (1368-1644 CE). Kingfisher feather objects belonging to the Smithsonian Institution's National Museum of Natural History (NMNH), Washington, DC, were also examined in this study and included objects used for opera, and a chandelier.

The first ornamental use of kingfisher feathers occurred during the Han Dynasty (206 BCE-220 CE) (Hirth and Rockwell 1966; Hulsewé, 1969; Chambers et al. 1981; Liu 1991; Gyllensvard

2001), but in general, references did not mention their specific use in jewelry prior to the Tang Dynasty (Schafer 1963; Garrett 1994). First used by the court alone, by the late 19th century jewelry decorated with kingfisher feathers was available widely in China as well as for export to Europe.

Guangzhou or Canton is the most frequently cited place of production and is where the last major consignment of kingfisher jewelry was supposed to have been manufactured during the 1930s (Hartman 1980; Garrett 1994). Chang'an (Xian) was listed as a source of manufacture, but only in the context of royal artisans in the Tang Dynasty

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(Schafer 1963). Beijing is most frequently noted as a modern day source, although in one instance it also was mentioned as a place of manufacture in the 18th to 19th century (Untracht 1982). Although newly made kingfisher jewelry is still available, it is not found as readily as in the past.

2. SUPPORTS

The feathers are applied to metal, paper or wood substrates. They are cut and set into cells bound by cloisons in a manner similar to enamels. In the case of the metal substrate, the cloisons are virtually identical, frequently formed of twisted wire. In the case of non-metal substrates, the delineation of the cell is maintained, but with materials such as string or gold colored paper.

The metal substrates of the AMMSG pieces were analyzed with X-ray fluorescence spectroscopy (XRF). An OMEGA FIVE X-ray fluorescence spectrometer (a modified Spectrace 6000) was used. The majority of the pieces contain mainly copper or silver or an alloy of the two metals (McCarthy and Chase, in press). Two of the objects are primarily gold. Most of the objects are gilded, many on both the front and back, but on others limited to the front surface. Gilding extends over the wires and across the entire cloisonné surface. No correlation was seen between feather type, style of piece and alloy type. This suggests that the objects were manufactured in different workshops or even geographical areas over a lengthy time span. Makers marks stamped into the metal substrates were found on some of the jewelry. A few publications list marks of this type, correlating them to workshop and place of production

where possible. Of the marks noted in this study, the majority are not among the published marks.

A series of small cuts was used to shape the outline of the metal. The majority of the objects examined have excess metal on the edge of the cut near the reverse of the piece, suggesting that the cuts were made from front to rear. In several instances, marks characteristic of scissor cuts also were observed. In some cases the metal substrate was cut prior to forming the cloisons, but in others the substrate was cut or trimmed after applying the twisted wires.

The majority of the objects have some form of support structure of plain wires attached to the back. This varies from a single wire soldered to the center of the substrate, to a complete outline of the shape. Two wires were twisted together to form the majority of the cloisons, most easily seen in areas where the wire has unraveled. The wires are uniform in thickness and most likely were drawn, but in many cases the surface is obscured by gilding. Where analyzed, it appears silver solder was used.

The hairpin in figure 1 (No. RLS1997.48.4644) is the only Singer piece in this study that does not have a metal substrate. The support is several layers of paper built up in a manner like papier-mâché. As on the metal objects, there are still support wires, but they are placed in-between layers of paper. The black surface visible on the reverse of the piece is tarnished silver leaf. This is of note as many of the metal substrates are silver alloys or silver colored metals that are not gilded on the reverse. There were numerous examples of paper

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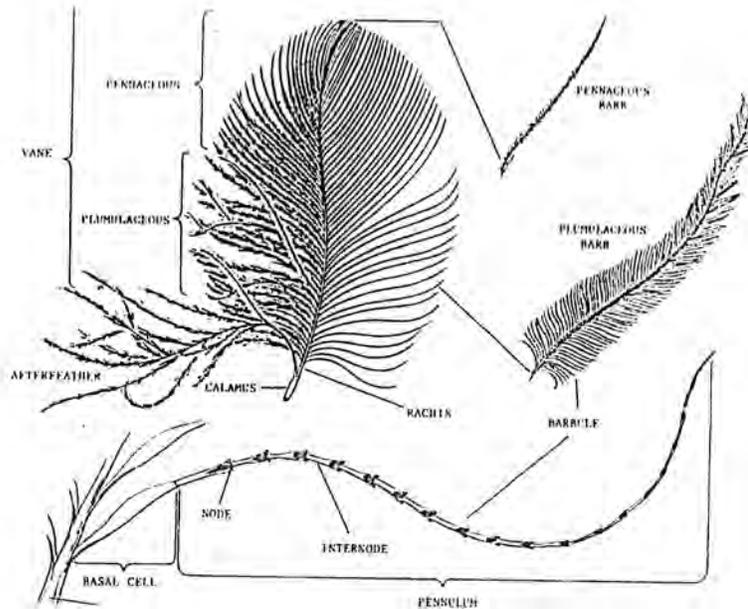


Figure 2. Feather terminology (Laybourne, Deedrick, and Hueber 1994).

substrate at NMNH, but they were larger and more crude in construction.

3. FEATHERS

There are two main forms of blue feathers found on the objects, one very fine and the other a more coarse type with visible black barbules (fig. 2). In addition to blue feathers, there are purple, magenta and green feathers on the objects examined, although generally in comparatively small amounts and in conjunction with blue feathers.

3.1 FEATHER TYPE

The blue feathers used in Chinese kingfisher jewelry have been attributed to several different types of kingfishers including both Alcedinidae (water dwelling) and Halcyonidae (forest dwelling) types.

Figure 3 shows specimens of both of these bird types. Although there is a distinction in Chinese between the alcedinine kingfishers (*cui niao*) and

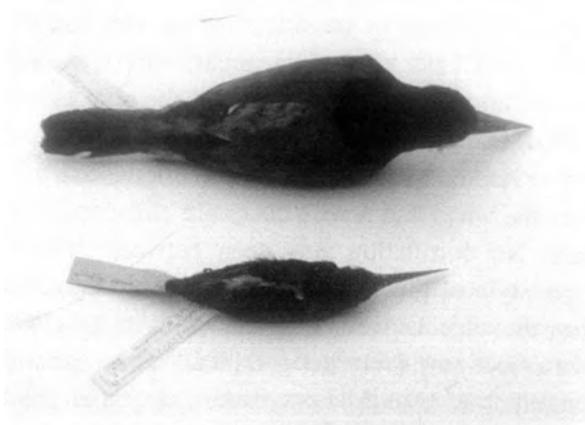


Figure 3. Bird specimens from the collection of the NMNH. The upper bird is a halcyon kingfisher, *Halcyon smyrnensis*, (NMNH 303072) and the lower bird is an alcedinine kingfisher, *Alcedo meninting proxima* (NMNH 179775).

the halcyon kingfishers (*fei cui*), it is apparently a relatively recent linguistic differentiation (cjlvang.com/birds 2001) and this could have contributed to confusion about their source.

Of the forest kingfisher group, two bird types were mentioned frequently: *Halcyon chloris*, the white-collared kingfisher (Jenyns 1967), and *Halcyon smyrnensis*, the white-breasted kingfisher (Untracht 1982). After comparing bird reference specimens at NMNH with the objects under study, none of the feathers seemed to correspond to the *Halcyon chloris*, however all of the pieces with the coarse blue feather type were comparable to the wing or tail feathers of the *Halcyon smyrnensis*. The finer type of feather was identified as the back feathers of the *Halcyon smyrnensis*. There is a certain amount of variation seen in the color of *Halcyon smyrnensis*, depending on the subspecies or geographic area of the particular specimen. Both the male and female, however, seem to exhibit similar pattern and coloration.



3.2 FEATHER SOURCES

Several places are discussed as areas of origin for the kingfisher feathers on the jewelry, including Cambodia, India and Vietnam, as well as places in southern China (Schafer 1963; Hirth and Rockhill 1966; Jenyns 1967; Schafer 1967; Untracht 1982; Chou 1992). Numerous references mentioned that the birds were hunted to extinction in China due to the popularity of the jewelry in the late 19th to early 20th century (Hartman 1980; Chambers et al. 1981; Liu 1991). However, *The Animals of the World Database on the Convention of International Trade in Endangered Species* (CITES) website lists *Halcyon smyrnensis* as being present and breeding in China (CITES.org 2001).

3.3 FEATHER USAGE

The more coarsely textured feathers seen on some of the objects are from the tail and wing of the

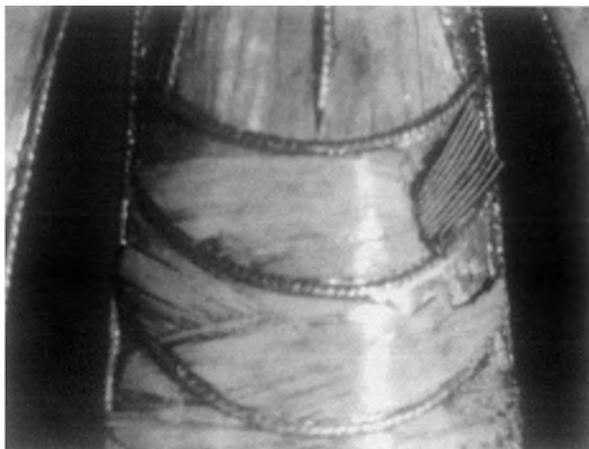


Figure 4a. *Halcyon smyrnensis* feather types: at left is a coarse textured feather. Figure 4b. At right is a fine textured feather with small coarse feather repair along right side.

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Halcyon smyrnensis. Figure 4a shows this type of feather, as well as the finer textured type. These feathers have an iridescent turquoise upper side and a black under side. More of the tail feather is usable than the wing, as the wing feather has a portion that is black on both front and back. The rachis (fig. 2) on the tail and wing feathers is black with a blue rachilla and black barbules on the barbs of the feather.

The second, finer type of feather seen on the jewelry is from the back of the *Halcyon smyrnensis* (fig. 4b). The back feathers are finer and somewhat less green in color than the wing and tail. The overall appearance of the back feathers is quite different, with only the tip of the feather colored blue and the remainder brown. The tip of the back feather is blue on both sides, not black on the underside like the wing and tail feathers. The small and sparse barbules are light brown in color.

The barbules from the wing feather are larger and denser than those of the back feather. They can more easily act on their own to hold the barbs of the cut feather pieces together, and are a more visible component on the jewelry. The blue color and the iridescence of both types are caused by structural properties of the feather and will disappear temporarily when a sample is immersed for a few minutes in ethanol.

In addition to blue feathers, Singer five pieces have purple feathers applied to their surface. Two purple feather types were identified: *Corracias garrulous benghalensis* (Indian roller) and *Irena puella* (fairy bluebird).

3.4 FEATHER APPLICATION

The barbs were cut off the black rachis of the wing and tail feathers for use in the jewelry, while only the tip of the back feather was used. In general, the back feather was cut so that the very end of the rachis was included in the cut, to avoid separation of the barbs. The black rachis is visible in many areas when examined closely. The tips of the back feather point towards the interior of the cell, with the back edge cut to fit the contour. Where possible, they are overlapped to cover the small part of the rachis that is holding them together. This type of application seems consistent for the back feather, although accomplished with varying degrees of skill.

The feather pieces were probably set in place with forceps or another type of fine grabbing instrument (Chin 1991). Circular toolmarks were observed on one of the pieces where the feathers were pushed onto the surface. Fourier transform-infrared spectroscopy (FT-IR) shows that the adhesive used is a protein glue. A Mattson FT-IR spectrometer with a diamond cell in a SpectraTech IR Plan Advantage microscope was used. The feather may have been attached to a facing, such as a thin sheet of paper before cutting. Once in place on the object, the facing could be removed. Many of the objects examined show evidence of adhesive on the top surface of the feather, but many also seem to have been coated with some type of material as part of a later treatment, making confirmation of a facing problematic.

4. OTHER DECORATIVE MATERIALS

Glass beads, synthetic pearls, carved stones, wrapped threads and wires, and pompoms have been observed in conjunction with feathers. Silk floss sheet, made from leftover silk and from inferior cocoons, was inlaid between the cloisons further increasing the palette of colors beyond the

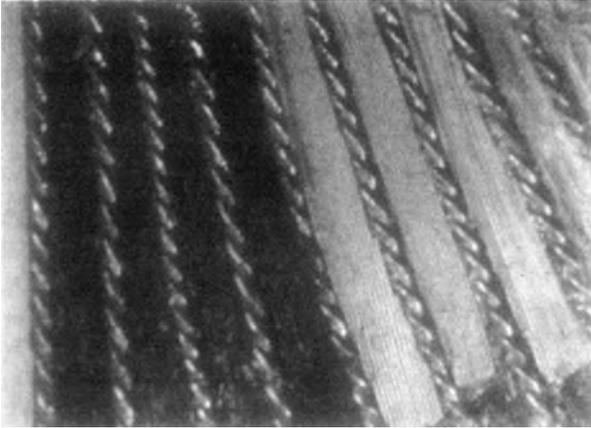


Figure 5. Detail of RLS1997.48.4625 feather and silk floss inlaid areas.

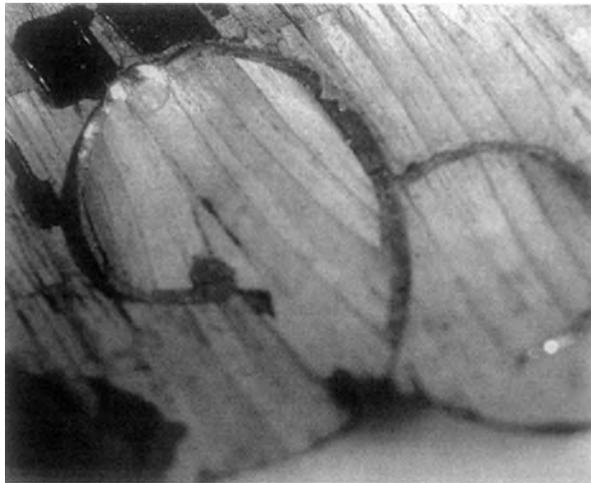


Figure 6a. Detail of RLS1997.48.4644 paper cloisons.

kingfisher blue (fig.5). The structure of the floss in some areas is in a linear arrangement that closely mimics that of the fine textured feather. Analysis of floss on one piece indicates the use of organic colorants for the green, yellow and red. The green is a mixture of indigo and an unidentified yellow dye. The red appears to be a modern organic dye. Analysis of colorants was carried out by fiber optic reflectance spectrometer (Varian Cary 50) in the visible range and by three-dimensional fluorescence spectroscopy (Perkin Elmer LS50B) with the assistance of Jennifer Giaccai of the Freer and Sackler Galleries. Christine Giuntini of the Metropolitan Museum of Art, NY, assisted with identification of the fibers.

5. HAIRPIN WITH PAPER SUPPORT

A variety of techniques were used in the hairpin with paper substrate some of which are not seen in the other pieces in the collection. In addition to

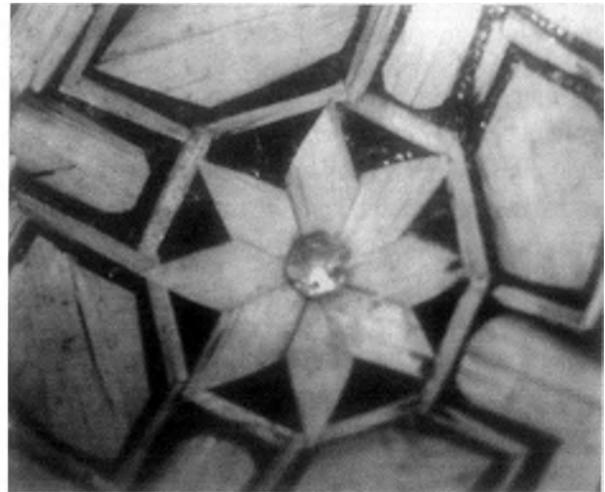


Figure 6b. Detail of RLS1997.48.4644, "paper cut" feather.

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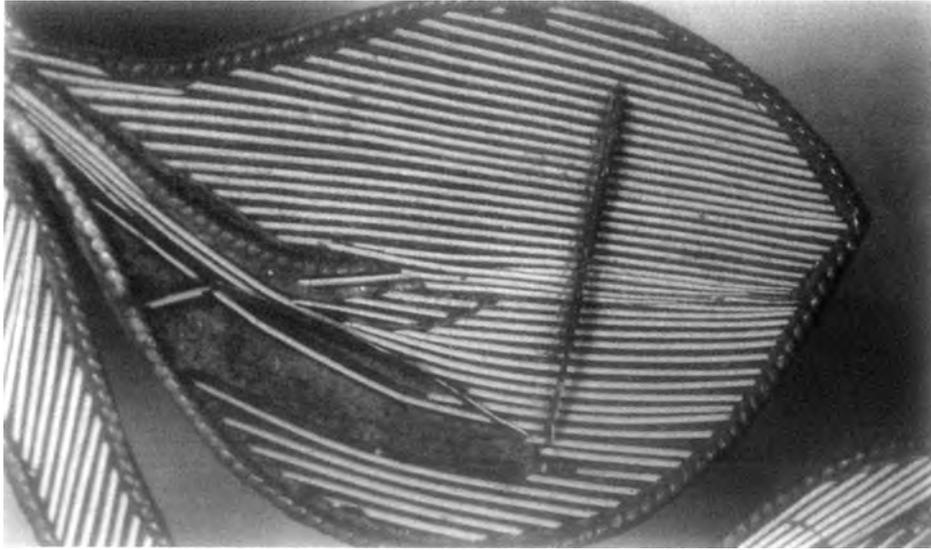


Figure 7. Area with lifting feather

blue, the hairpin has feathers that appear purple, magenta and green in color. Like objects with metal substrates, feathers are adhered with a protein glue. Figure 6 shows close-ups of this object highlighting some of the different techniques used.

Gold colored paper outlines areas of blue feather, forming pseudo-cloisonné as seen in figure 6a. The gold paper only continues a few millimeters underneath the feathers. XRF analysis of the paper indicates that the metal leaf on the surface consists mainly of copper and zinc with some gold and iron.

This object also has kingfisher feathers applied in a manner similar to paper cut designs (fig. 6b). Here the feather is laid down on a black background, in one area a piece of black paper saturated with a protein glue and in others a black colored wax. Although no traces of residual paper or other

materials were seen, a method utilizing a facing material or a consolidating adhesive prior to cutting the shapes is highly probable.

The magenta areas consist of purple Indian roller feathers which are applied to a red underlayer of pigmented protein glue. XRF analysis confirms the presence of mercury in the red underlayer, making it likely that the pigment is cinnabar (HgS). The red material is present on several pieces and the amount of red visible through the feather results in varying shades of purple through magenta.

6. EXAMINATION OF MODERN PIECES

Modern examples of kingfisher feather jewelry from the Freer and Sackler Gallery shops were analyzed. As with some of the older pieces, the feather type appears to be *Halcyon smyrnensis*

wing or tail feathers⁽¹⁾. The modern pieces use a much larger overlap of feather that mimics the appearance of the older pieces where feathers were applied with light and dark edges adjacent. The metal substrate, a copper nickel alloy, is unlike any of the older jewelry and seems slightly thicker or heavier in appearance. Both front and back are gilded and there are no support wires. Excess adhesive, most likely a modern resin, is very common on the surface of the feathers.

7. CONDITION AND TREATMENT

The condition of the kingfisher feather jewelry covers a range, although none are in extremely poor condition. Physical damage to the feathers appears as darker blue where the feather structure is compacted. Feather loss, insect damage and lifting are common (fig. 7). Treatment of the lifting areas consisted of tacking down the feathers with approximately 30-40% of Acryloid B-72 in acetone (w/v), in some cases applied with a syringe. The relatively thick concentration of the Acryloid B-72 was used only in small areas and did not affect feather color.

Previous repairs are visible on a number of the pieces accompanied by excess adhesive. In some cases, replacement kingfisher feathers have been applied to the surface (fig. 4b), sometimes of a different feather texture and sometimes of significantly different color. Repairs made from non-kingfisher feathers dyed blue were not observed.

The AMSG kingfisher objects were covered with a layer of house dust and cigarette residue which was reduced with a small soft brush sometimes

used with a micro-vacuum. Some of the metal is lightly tarnished, although in a few instances there is some heavier localized corrosion which preserves the structure of deteriorated feathers.

8. CONCLUSIONS

This study has identified a broad range of materials and techniques used in kingfisher ornaments. The jewelry was popular for a long time and produced in many different workshops for various purposes including personal adornment, theatrical use, as decorative arts and for export goods. The diversity of the objects and the scarcity of published sources make provenancing and dating them difficult.

NOTES

1. Sale of non-North American birds and parts from birds that are imported is legal, provided that they were properly imported to the US, they were properly exported from the country of origin, they are not considered endangered by the US, and they are not listed by CITES as endangered.

ACKNOWLEDGEMENTS

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Joanna Humphrey, Beverley Jackson, Donna Strahan, Jan Stuart, Su Rongyu, Susan Wilkerson and Jodi Zeppelin. Barbara Chu's donation of a kingfisher headpiece for use in this study, and to the Freer and Sackler Gallery Shops' loan of the modern jewelry are also greatly appreciated.

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SOURCES OF MATERIALS

Acryloid B-72[®]
Conservator's Emporium
18124 Wedge Pkwy. Suite 458
Reno, NV 89511

Tel: (775) 852-0404
Fax: (775) 852-3737

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CONSERVING THE WRIGHT BROTHERS' 1905 FLYER III

DEBORAH BEDE AND MALCOLM COLLUM

ABSTRACT—A team of four conservators treated the Wright Brothers' 1905 Flyer III in 2000-2001. The plane had been restored in the late 1940s under Orville Wright's supervision, and had been on continuous display at Carillon Historical Park in Dayton, Ohio since 1950. Humidity fluctuations, light exposure, vandalism and airborne soil had all taken their toll on the materials of the Flyer. The interactions of incompatible materials of the plane had contributed to the damage and would complicate the treatment. The team worked together and separately to clean, stabilize and protect the materials of the Flyer, as well as to improve its appearance. The textile treatments included *in situ* wet cleaning of the fabric cover and removal of iron corrosion staining from the fabric. Treatment of the propulsion system involved the removal and disassembly of the engine and other components in order to effectively clean and relubricate moving parts and apply surface coatings. Wooden elements of the airframe were surface cleaned and waxed. For this project, conservators from three very different specialties successfully collaborated to treat a large and complex artifact.

TITULO—CONSERVANDO EL AEROPLANO "FLYER III" DE LOS HERMANOS WRIGHT DE 1905: UN DESAFÍO INTERDISCIPLINARIO Y LOGÍSTICO. **RESUMEN**—Pocos artefactos presentan el desafío de conservar un amplio rango de materiales a tan gran escala, como es un aeroplano. Con una estructura de madera tapada por una amplia extensión de tela de algodón, que soporta una variedad de metales que forman el motor y el sistema de propulsión -todas amarradas juntas con una red de cables tensionados-, se hace necesario que cada elemento individual sea tratado

por un equipo de expertos conservadores, cuidadosamente coordinados.

El Wright Flyer III fue restaurado a fines de los años '40 bajo la supervisión de Orville Wright, y ha estado en exhibición desde ese tiempo en el Wright Hall del Carillon Historical Park en Daytona, Ohio. Hasta el año 2000, el edificio no estaba climatizado y aparte de las limpiezas de rutina y algunos tratamientos menores, al aeroplano no se le había realizado ningún tipo de tratamiento de conservación por más de 50 años. Los aceites de lubricación se endurecieron, las superficies de metal expuestas comenzaron a corroerse, los elementos de madera a quebrarse y la tela de algodón descrudado estaba sucia, amarillenta y manchada. Esta presentación explorará los desafíos del tratamiento de conservación que plantea este proyecto y se describirán sus soluciones.

1. HISTORY

Wilbur and Orville Wright constructed the Wright Flyer III in Dayton, Ohio in 1905 and first flew it at Huffman Prairie outside Dayton on June 23. The Wrights had achieved the first powered flight in 1903 with their first Flyer, but the longest flight with that aircraft was only 57 seconds. Their work in 1904 with the Flyer II produced little improvement. The first flight of the Flyer III was only 19.5 seconds, but further modifications to the design of the airframe resulted in the historic flight of October 5, 1905 which lasted over 39 minutes (fig. 1). These modifications allowed greater control of the plane, sustained flight that was limited only by the amount of fuel on board, and con-

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Figure 1. The 1905 Wright Flyer III in flight over Huffman Field, Dayton, OH, September 29, 1905.

trolled takeoffs and landings. The 1905 Flyer was also later altered to become the first aircraft ever to carry a passenger. It was so successful that the Wrights hid their invention for three years until they had secured a patent and found serious buyers. Unfortunately, the Wrights did not see the value in preserving their early experiments. In 1908 the Flyer was abandoned at Kitty Hawk, NC after numerous practice flights and it languished in a shed until it was salvaged in 1912.

In 1946 Colonel Edward A. Deeds, a friend of Orville and the Chairman of National Cash Register, conceived the idea of a historical park to commemorate Dayton's contributions to the development of industry and transportation, with one of the Wright's planes as a centerpiece of the park.

Orville suggested the 1905 Flyer and he supervised the operation until his death in 1948. The restoration was completed in 1950 for the opening of Carillon Historical Park, and the Flyer III was displayed in Wright Hall.

2. THE TREATMENT PROJECT

The Flyer has been on continuous display since 1950 and has been exposed to wide fluctuations in temperature and relative humidity, to direct sunlight and has suffered several accidents and acts of vandalism. The staff of Carillon Historical Park sought to improve the condition of the plane in anticipation of the celebration of the centennial of flight in 2003. In 1999, conservators from the National Park Service and the National Air and Space Museum conducted a condition assessment of the Flyer and Carillon Park was awarded a Save America's Treasures grant. In 2000 a treatment team was assembled under the direction of

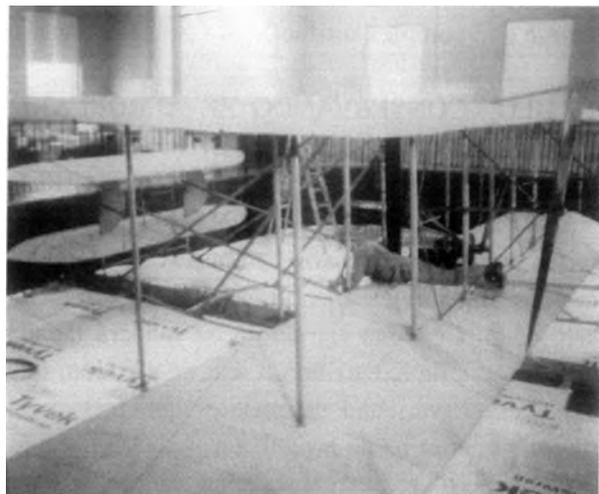


Figure 2. Overall view of the Flyer before treatment.

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Deborah Bede: Malcolm Collum, conservator at the Henry Ford Museum and Greenfield Village, would conserve the propulsion system, Dan Kurtz and Tom Heller of Lexington Conservation Associates would treat the exposed wood and metal components of the plane, and Deborah would conserve the fabric covering. A part-time intern, Laura Wahl, assisted all four conservators.

The Flyer has a wood framework, and the wings, rudders, elevators and blinkers are covered with cotton fabric (fig. 2). Steel guy wires and brackets hold the various parts together, and the propulsion system is constructed of several different metals. The aircraft consists of an upper and a lower wing, with two vertical rudder panels behind the wings; in this early design, the two horizontal elevator panels are in front of the wings and two vertical blinkers are located between the elevators. The pilot lay on the lower wing next to the engine; he operated the controls of the plane with both hands and by sliding a moveable cradle underneath his hips.

The conservation team and the staff at Carillon Park conferred on treatment goals. Since the restoration was initially directed by Orville Wright, it was agreed that the appearance of the conserved flyer should reflect his intentions and that the materials from the restoration were to be treated with the same level of care as the original materials. The goals of the treatment were to stop active deterioration, stabilize surfaces, correct some of the damages caused by accidents and vandalism and bring the surfaces closer to how they were intended to appear. Another important aim of the treatment was to minimize the need for repeat-

ed maintenance procedures due to the small size of the staff at Carillon Park.

As with any *in situ* treatment of a large and complex artifact, this project required a great deal of advance planning and coordination of resources.

3. THE TREATMENT OF THE TEXTILE COMPONENT

3.1 DESCRIPTION

The wings, elevators and blinkers are covered with a finely woven long-staple unbleached cotton fabric. The covers make excellent use of the bias grain of the fabric, and are stitched by machine.

3.2 CONDITION

Because the fabric dated from the restoration and had never flown on the plane, it was essentially intact. There was a liberal coating of embedded and loose particulate soil on the horizontal components of the Flyer due to past heating with oil furnaces, outside air entering through the doorway, and construction in Wright Hall.

Iron components of the plane had corroded, staining and damaging the adjacent fibers. The trailing edges of the wings were severely stained where they passed over the steel wires; this staining was more pronounced in the center of the wings. Some fiber deterioration could be observed in the areas of worst staining.

Other instances of damage were caused by human intervention. There are several tears in the lower

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elevator where control wires pass through the fabric; a Wright relative reportedly caused these by operating the controls of the plane for visitors. Two patches on the lower wing are said to cover cigarette burns in the fabric. Extensive scattered staining on the wings and elevators is the result of two young docents having a fire extinguisher fight over the plane.

The two major goals of this treatment were overall cleaning of the fabric and removal of the corrosion staining. Treatments were specifically developed for the Flyer that may also have wider application.

3.3 TREATMENT

Wet cleaning tests on the fabric of the Flyer itself were performed during initial visits to Carillon Park. Potential risks to the various materials of the plane were evaluated and discussed among the team and with Park staff. A variation of a commonly used contact cleaning method utilizing distilled water was developed as a result of both testing and accidental observation. The entire plane was cleaned using this technique, including the undersides of the wings.

The results of this cleaning technique were gratifyingly positive. A large amount of gray soil and yellow color was removed, and there was a visible improvement in the appearance of the cotton fabric (fig. 3). The fire extinguisher and other staining unfortunately was reduced only minimally by the cleaning treatment.

The corrosion staining on the trailing edge of the wings was of great concern, not only as an aes-

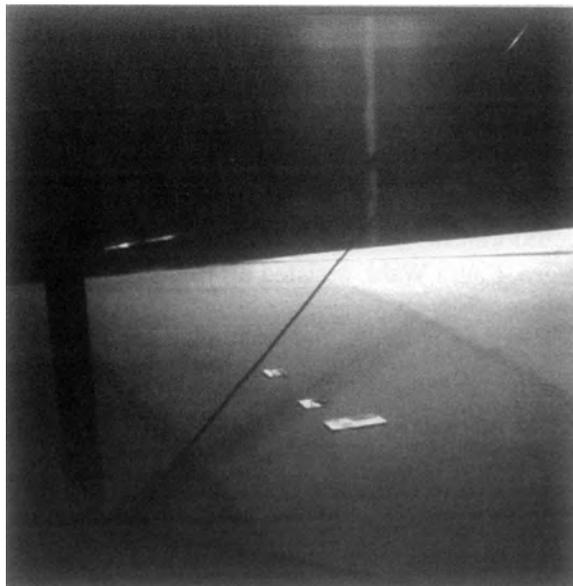


Figure 3. Flyer before treatment.

thetic issue but also as the cause of eventual splitting of the fabric along this line. The treatment of the fabric also interacted with the wire beneath it, and a plan was developed in consultation with the other conservators on the team as well as Carillon staff. Removal of the corrosion staining from the fabric without attempting to access or treat the wire was chosen as the best option for the Flyer at this time.

Once again a treatment was developed specifically for the Flyer. Immersion techniques for corrosion stain removal were modified to allow local application. The fabric of the Flyer was treated with a solution of a reducing agent and a chelating agent made into a stiff gel with methyl cellulose. This solution was used to treat the trailing edges of both wings and other scattered corrosion stains throughout the aircraft (figs. 4, 5).

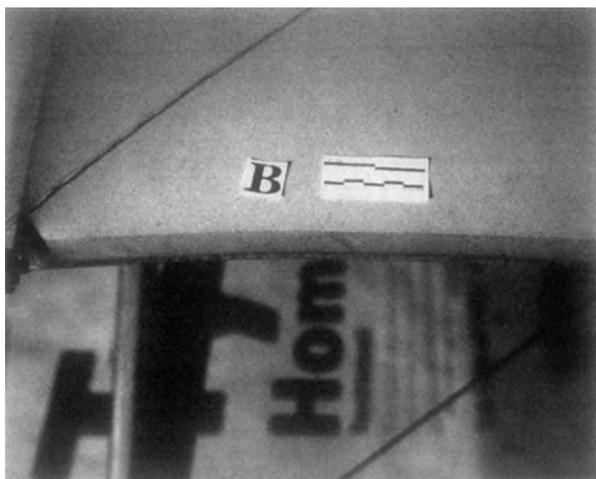


Figure 4. Corrosion staining before treatment.

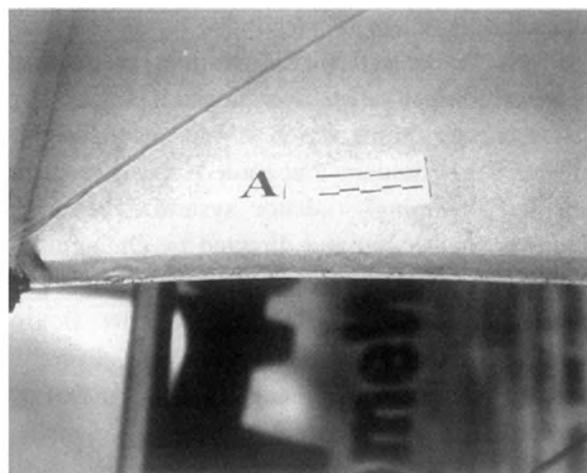


Figure 5. Corrosion staining after treatment.

4. PROPULSION SYSTEM

4.1 DESCRIPTION

The propulsion system was designed and built by the Wright brothers and their mechanic Charlie Taylor. It is composed of an engine which powers two propellers via a pair of chains and drive axles (fig. 6). The engine is a horizontal, in-line, four cylinder design with cast iron cylinders and com-

bustion chambers which are screwed together and fitted into a cast aluminum crankcase. The pistons are made of cast iron and are connected to the crankshaft by hollow steel connecting rods and babbeted bronze main bearings. The crankshaft is fitted with a steel flywheel and a pair of sprockets which drive the propellers' chains. The fuel is carried by a copper and steel tank and is vaporized by a "hot-plate" system with atmospheric intake valves. The exhaust is released by rockers off a

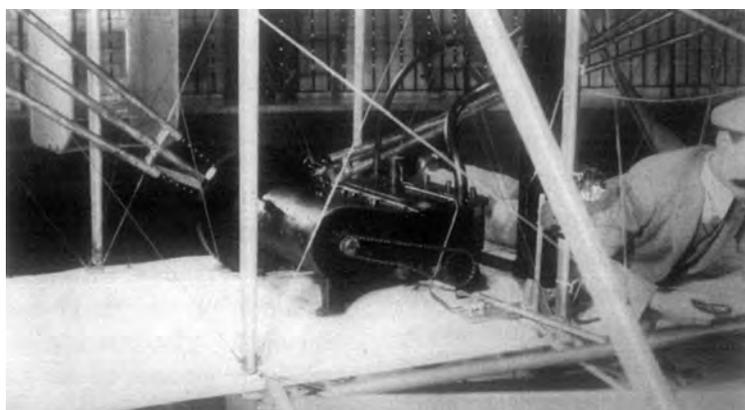


Figure 6. Location of engine in center of the lower wing with the chainguides extending to either side.

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chain-driven camshaft which also drives the linkage for a "make and break" ignition system with variable timing. The ignition current is supplied by an electric generator which is driven by the flywheel. The cylinders are cooled by water in a "thermal-siphoning" radiator system. The drive chains are tensioned and directed by chainguides which are constructed of brazed-steel tubing.

4.2 BACKGROUND

During the 1950 restoration, the entire propulsion system had been disassembled, cleaned and reassembled with lubricating oils (fig. 7). However, over the last 50 years these oils had not been replaced and they eventually became degraded and hardened, causing parts to seize and corrosion to develop. Inside the engine, the oil film had oxidized to the point that only highly polar solvents would remove it. The engine is complete and can still be considered functional. Stopping active degradation was the primary focus of the treatment but preserving the Flyer's intended function was also considered to be a major objective. If the degraded oils were not removed and replaced, the engine might have become permanently seized.

4.3 TREATMENT

In order to thoroughly clean the propulsion system, it was necessary to remove the engine and chainguides. The engine was only disassembled as far as necessary to remove corrosion and inhibit surfaces. Exterior surfaces showed the most corrosion, since these areas were subject to extremes of humidity, dust accumulation and periodic cleaning. Corrosion was also discovered inside the engine

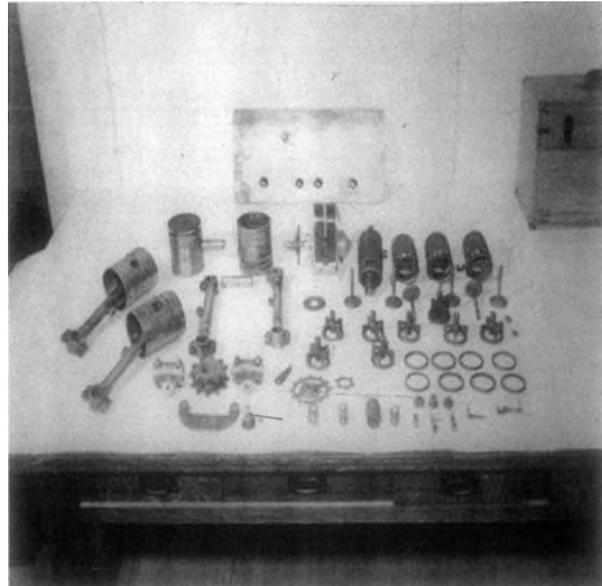


Figure 7. The various internal components of the engine during the 1947-50 restoration.

since some of the exhaust valves remained open and the crankcase had never been sealed.

All of the ignition parts were removed, disassembled and treated to stop corrosion and free seized parts. The treatment of the iron surfaces typically involved mechanical reduction of corrosion followed by treatment with tannic acid and either a hot microcrystalline wax or synthetic oil coating. Since it had been agreed that the overall appearance of the Flyer should be as an old but well maintained aircraft, none of the originally bright metal surfaces were polished and the naturally developed patinas, such as the dark greenish-gray oxidation on the intake manifold, were merely waxed (fig. 8).

Severe corrosion was discovered in some of the joints on the chainguides. The chainguides are

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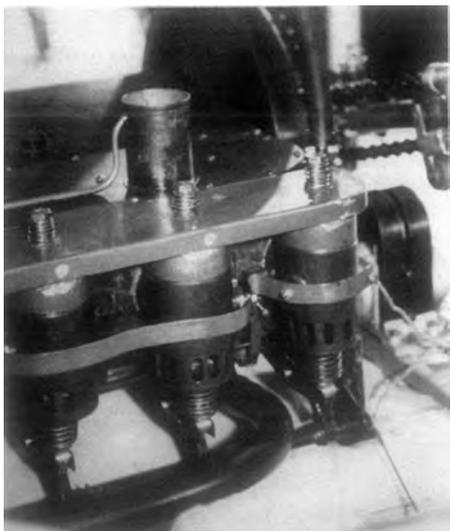


Figure 8. After treatment appearance of the engine with corrosion removed but naturally patinated surfaces left undisturbed.

constructed in the same manner as a bicycle frame, with steel tubes which are brazed together. The corrosion was probably caused by flux residues that were not completely removed and have continued to corrode the steel under the paint. These areas were cleaned and color corrected with Magna acrylic paints. Links in the chains were beginning to stick so they were degreased with solvents, relubricated with synthetic gear oil and manipulated by hand until they were all free to pivot.

The only component that was polished was the anemometer, composed of an aluminum fan in a nickel-plated brass frame which drives a dial indicator that counts the fan's revolutions. Anemometers were attached to all of the early flyers and were used to record the amount of air that the Flyer passed through during its flight. The anemometer appeared to be intact but the nickel-

plated surfaces were badly tarnished. After disassembly, it was determined that the dial component was a non-functional mockup made for the restoration. The nickel-plated brass components of the fan were lightly polished and lacquer coated to prevent tarnish.

During reassembly, all mechanical surfaces and pivots were coated with synthetic lubricants. Typically, it is recommended that an engine should be relubricated and manually rotated every year. Limited staff at the park and the position of the engine over fabric made this an ill-advised requirement. In order to keep the mechanical parts maintenance free for as long as possible, a synthetic grease, Krytox, was used to coat the pistons and all of the bearing surfaces. Krytox is composed of synthetic oil with corrosion inhibitors and is thickened with Teflon. It is designed to be chemically inert and was chosen because of its long-term stability properties. If the synthetic oil component of the grease ever separates from the Teflon thickener, the Teflon will continue to act as a lubricant.

5. AIRFRAME

5.1 DESCRIPTION

The airframe is composed of wooden spars and ribs inside the wings with wooden frame elements supporting the rudder, elevator and landing skis. Tensioned steel guy wires hold the structure together with steel hardware and fittings at the joints. All of the exposed wooden elements are painted silver and have been artificially "distressed" by the application of black paint in the recesses.

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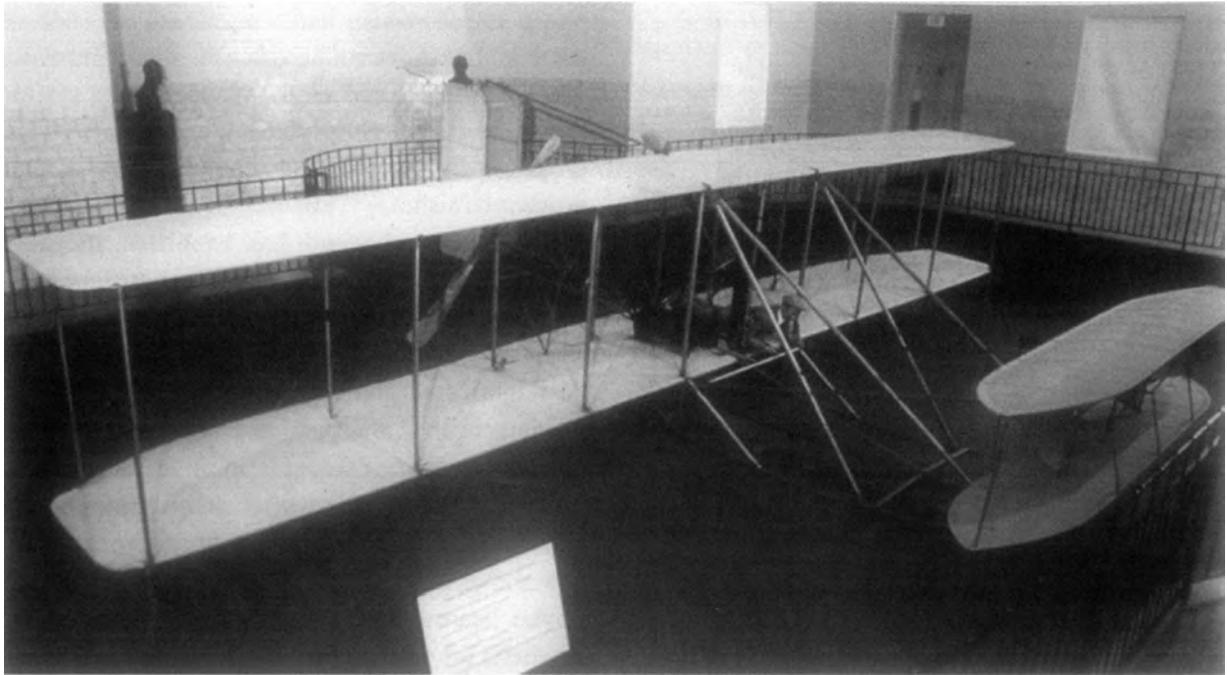


Figure 9. The Flyer III after treatment.

5.2 CONDITION AND TREATMENT

Exposed wooden elements were cleaned with a dilute detergent solution and then given a coating of paste wax. All of the guy wires showed varying degrees of corrosion. After covering the fabric surfaces, the wires were lightly cleaned with abrasive pads to remove loose corrosion. Care was taken not to polish the metal. Microcrystalline wax was chosen as a coating since it would be easy to apply, provided corrosion protection and would not leave a reflective surface.

One of the ribs on the lower wing was broken, and the end was putting strain on the fabric. The team discussed options for repair of the rib and relief for the fabric. Direct access to the rib would have

involved the removal of a large amount of stitching to open the fabric cover. As smaller pieces of the broken rib could be extracted through the opening in the trailing edge it was decided not to repair the rib itself. To relieve the strain on the fabric, a thin strip of acrylic was inserted through the opening so that it slid over the protruding end of the rib. After wet cleaning, the fabric returned to its original shape.

6. RESULTS OF THE TREATMENT

The treatment was successful on several fronts (fig. 9). The active deterioration of the metal components was stopped, and the applied coatings will protect these elements from future corrosion. Soiling and degradation products were

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removed from the fabric, and the removal of the corrosion staining should significantly retard fiber damage. As part of the project, Wright Hall was also fitted with a climate control system that will prevent the dramatic humidity fluctuations of the past. An air filtration system and improved traffic patterns will reduce the amount of airborne soiling.

Although the staff of Carillon Park wholeheartedly supported a conservative approach to the preservation of the Flyer, they were very pleased that the treatment also produced a marked improvement in its appearance. The intensive treatment also allowed the team and outside scholars to examine the plane closely, revealing many details that were previously unknown. Timing marks in the engine's flywheel, small inscriptions on the wood frame, and pencil lines on the fabric were examined and documented.

7. CONCLUSIONS

This project required collaboration, innovation, and patience, and it challenged and rewarded each of the members of the team. The confluence of different specialties enhanced the creation of a team approach to the treatment of this large and complex artifact, and allowed the achievement of the goals of stabilization and aesthetic improvement for the Flyer.

ACKNOWLEDGMENTS

It was a privilege to work on this seminal artifact. The conservators who performed the initial assessment of the Flyer for the National Park Service, Jane Merritt, Larry Bowers and Ed McManus, led

the way for this treatment, and the staff of Carillon Historical Park provided invaluable support.

FURTHER READING

For more details of the textile treatment, see:
Bede, D. 2002. Conservation of the Wright Flyer III: Serendipity and substantiation. In *Strengthening the bond: science and textiles, preprints of the North American Textile Conservation Conference 2002*, compiled by V. Whelan. North American Textile Conservation Conference. 15-24.

SOURCES OF MATERIALS

Propulsion System Treatment:
Agateen Lacquer #2
Agate Lacquer Mfg. Co.
11-13 43rd Road
Long Island City, NY 11101
Tel: (800) 452-4735

Autosolâ Metal Polish
Dursol-Fabrik
42655 Solinghen
Germany
Tel: (800) 314-5545

Bear-Tex Abrasive Pads
Norton Company
Worcester, MA 01615
Distributed by Grainger
Tel: (800) 472-4643

Kryto® GPL 226, Synthetic Grease
DuPont

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Deepwater, NJ 08023
Tel: (800) 424-7502

Magna, Acrylic Resin Paint
Bocour Artists Colors/Golden Artists Colors
188 Bell Rd.
New Berlin, NY 13411
Tel: (607) 847-6154

Mobil 1 Synthetic Gear Lubricant, 75W-90
Mobil Oil Corp.
Fairfax, VA 22037
www.mobil.com

Renaissance Microcrystalline Wax
Talas
568 Broadway
New York, NY 10012
Tel: (212) 219-0770

Tannic Acid, 5% aqueous solution
Aldrich Chemical Company
Milwaukee, WI 53233
Tel: (800) 325-3010

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THE CONSERVATION OF FREDERIC E. CHURCH'S LEATHER ARM CHAIR

DEBORAH LEE TRUPIN

ABSTRACT—This paper details the problems faced and methods used in the treatment of a circa 1870 leather-covered armchair in the collections at Olana State Historic Site, Hudson, NY. The leather cover had significant losses that led site curators to suggest recovering the chair. Textile, objects, and furniture conservators at Peebles Island Resource Center, north of Albany, NY convinced the curators that conserving the original upholstered form and leather cover was a better option. Treatment included compressing and resealing springs, and mending tears and filling losses in the leather.

TITULO—LA CONSERVACIÓN DEL SILLÓN DE CUERO DE FREDERIC E. CHURCH. **RESUMEN**—Frederic E. Church, un sobresaliente pintor de la Escuela Hudson River, construyó su hogar, Olana (cerca de Hudson, NY) entre 1870 y 1874, al que le sumó un "estudio" que data de 1889-1891. Hoy en día, Olana es considerada por los estudiosos de Church como su último gran trabajo. Cuando Olana fue comprada por el Estado de Nueva York en 1967, conservaba un importante archivo de materiales escritos y fotográficos, así como gran parte de sus colecciones y amoblado originales.

Entre este amoblado había un sillón forrado en cuero de *circa* 1870, con un respaldo móvil y un brazo-mesa para escribir. El sillón aparece en las fotografías históricas que se exhiben en la Galería de Cuadros y Comedor de Olana. Fue traído a los laboratorios de conservación de Peebles Island para que fuera restaurado y pudiera ser incluido en el arreglo del amoblado de dicha sala. El sillón era un objeto clásico del tipo compuesto, con su marco de madera, telas y fibra bajo el tapizado, la cubier-

ta de cuero y pasamanería que cubre el remachado. Entonces, los conservadores tanto de objetos, textiles y cueros de Peebles Island examinaron en conjunto el sillón. La cubierta de cuero tenía pérdidas significativas, rasgaduras y una superficie muy frágil, pero no a un nivel alarmante. Mucho más significativa era la cubierta original sobre la tapicería original. Los tres conservadores estuvieron de acuerdo en que la cubierta original de cuero no debía ser removida ni reemplazada. Por el contrario, y con la guía del conservador textil, sugirieron un tratamiento que mantuviera el cuero existente.

El equipo aceptó esta aproximación. El tratamiento, que fue lento y un gran desafío, finalmente fue exitoso. El sillón retuvo todos sus materiales originales. Estos han sido estabilizados y protegidos y la apariencia del sillón es aceptable para ser exhibido en la Sala Comedor y Galería de Cuadros de Olana.

Esta ponencia describirá el tratamiento seguido, el que incluye las siguientes etapas principales: documentación acerca de los materiales y métodos originales (así como su condición), estabilización de la forma de la tapicería, estabilización y reparación de la cubierta de cuero y "minimización" de choque visual.

1. INTRODUCTION

Frederic E. Church was a leading painter of the mid-19th century Hudson River School of landscape painting. He built his home, Olana, near Hudson, NY between 1870 and 1874, with a studio addition dating to 1889-1891. Today, Church

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scholars interpret Olana as the artist's last great work. Olana was much visited, admired and photographed during Church's life. When purchased by New York State in 1967, Olana retained a significant archive of written and photographic materials as well as most of its original furnishings and collections.

Among these furnishings was a circa 1870 leather-covered chair with a moveable back and a writing arm. (A similar chair is illustrated on page 230 of Grier 1988.) The Olana chair (OL.1982.1781),

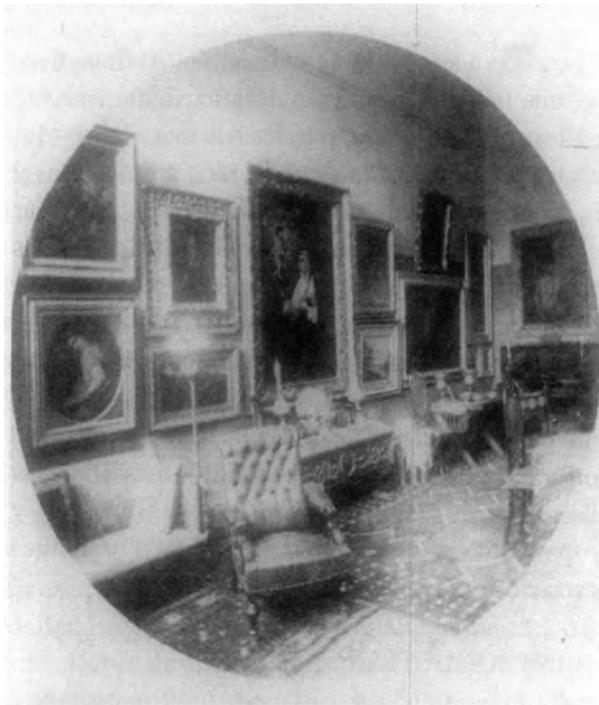


Figure 1. View of Dining Room-Picture Gallery at Olana, showing Frederic Church's leather arm chair. Photograph by H.F. Childs, September 30, 1891 (OL.1991.1.205). Courtesy New York State Office of Parks, Recreation and Historic Preservation Olana State Historic Site.



Figure 2. Frederic Church's leather arm chair (OL.1982.1781) before treatment. Courtesy New York State Office of Parks, Recreation and Historic Preservation Olana State Historic Site.

shown in historic photographs of the Dining Room/Picture Gallery (fig. 1), was brought to the New York State Bureau of Historic Sites conservation labs at Peebles Island, Waterford, NY⁽¹⁾ with the request from Olana site curators that it be recovered for inclusion in the furnished setting of the Dining Room/Picture Gallery (fig. 2). Once in the textile laboratory, objects conservator Heidi Miksch and furniture conservator David Bayne also examined the chair and agreed that the original leather cover should not be removed and replaced but rather conserved.

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The surface of the leather was abraded and/or flaking in many places. The leather had significant losses in the seat and outside back, and was fairly brittle in the outside back. However, it showed no signs of "red rot," and it was the original cover for the chair. The three conservators recommended the less invasive approach of conserving the existing leather and upholstery, and Olana site staff accepted this proposal.

The treatment project became a collaboration between the New York State conservators and Derek Balfour, then upholstery conservator at the Victoria and Albert Museum in London, as part of a previously planned work exchange. The author and Balfour, in consultation with Miksch and Bayne, developed the treatment plan and began treatment of the chair. Following common conservation goals and methods as well as those specific to the upholstery specialty, the treatment focused on documenting original materials and methods and their condition, stabilizing those materials using minimally intrusive techniques, and minimizing the visual impact of past damage and losses to create an appearance appropriate for a furnished room setting at Olana.

2. STABILIZATION OF THE UPHOLSTERED FORM

2.1 SEAT

At some point in the past, the webbing and springs of the seat had failed and the seat bottom had been repaired with two boards nailed into the bottom of the seat rails. This resulted in stress on the frame and on the leather of the seat as the improperly tied

springs created too high a dome on the seat. Much of the damage to the leather on the seat can be attributed to the loss of proper spring compression.

At the beginning of the treatment, the repair boards were removed, revealing a rather rough attempt at recompressing the springs, and the weakened condition of the jute spring cover. To permit reshaping the seat and recompressing the springs, the springs were cut free from the upholstered "cake" above them. An Ethafoam block with polyester batting covered with Reemay was put into the seat as a temporary support for the cake. With the historic photographs and the shape of the tears in the leather seat and the cotton under-cover as guides, a large thin sandbag (custom made for the project) and smaller lead-shot weights were used to provide gradual pressure to reshape the seat. The torn cotton under-cover was conserved with a cotton fabric underlayment secured by stitching. Once the shape of the seat was correct, a new polyester knit fabric was placed over the original under-cover and secured by stitching it to the original. The polyester was stretched just enough that it provided a small amount of compression on the seat to maintain the desired profile.

Meanwhile, the springs were compressed with coated steel cable ties about 2.5 cm (1") lower than their original compressed height and stitched to a polypropylene mesh that had been stapled to a plywood frame made to fit into the seat rails. This plywood frame, with the springs on it, was secured into the seat rails with glue blocks, a technique developed by Peebles Island furniture conservator David Bayne. Hide glue holds the glue blocks to

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the frame and can be softened with hot water, making this aspect of the treatment reversible.

2.2 BACK

The back had two springs in the lumbar area. The tension on these springs had loosened somewhat, so that they were pressing on the outside back leather. After consideration of the benefits and losses of further intervention in the upholstery structure, it was decided that further intervention was necessary to secure and stabilize these springs. Without intervention the leather cover was at risk of damage from the springs. In addition, lifting the outside back leather would facilitate repairs to the leather cover.

The decorative nails and patent leather trim were removed from the outside back stiles and the leather was lifted to permit access to these springs. The two springs were secured *in situ* with coated steel cable ties and with linen cords. Further shaping was not needed for the back. However, to help maintain the shape and to protect the outside back leather from future puncture damage, a piece of fairly heavy Nomex was secured to the outside back stiles with Beva film.

Once all repairs to the outside back were completed, including repairing tears and losses, the decorative nails and patent leather trim were replaced. The decorative nails were pressed into their original holes so the trim needed no further attachment method.

3. STABILIZATION AND REPAIR OF THE LEATHER COVER

3.1 TEAR MENDING

Jade 403 on goldbeaters' (2) skin was selected as the best method for repairing tears. A small piece of goldbeaters' skin was coated with Jade 403, allowed to dry for a minute or so, then pressed into place behind a tear in the leather. Small flat magnet strips were used as clamps, with silicone-release Mylar used as a barrier between the leather or goldbeaters' skin and the magnets.

3.2 FILLING LOSSES

There were two large losses on the chair, a triangular one on the outside back measuring about 15 x 25 cm (6 x 10") and an irregularly shaped oval one covering most of the seat and measuring about 50 x 66 cm (20 x 26"). For these, an undyed, vegetable-tanned hide was obtained from a local leather tannery. The tannery also skived or thinned the leather to the desired thickness overall. A patch slightly larger than the size of the loss was cut from the leather. The conservator then skived the edges of the patch paper-thin, to avoid creating a bulky outline and possible deformation of the original leather at the edges of the patch. The prepared patch was dyed with Ciba-Geigy Sellaset leather dyes; the dyeing was deliberately done in an irregular and blotchy manner to mimic the uneven color of the aged original leather. Finally, the patch was secured to the loss, again using Jade 403. In most areas, there was a solid support behind the patch so that pressure could be

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placed on the patch with appropriately sized sand or lead-shot weights.

4. MINIMIZING VISUAL DISRUPTION

Insertion of the dyed leather patches provided considerable improvement in the appearance of the chair. However, edges of the holes remained a distracting light color. Using an isolating layer on the original leather and then in-painting the edges of the holes was considered. In part because of existing documentation that Church desired a patina of age in the dining room, and in part because the back of the chair, where the light colors of edges were most visible, would not be seen by the public, this additional intervention was rejected. Instead, to improve the appearance and to protect the surface where the original finish of the leather was flaking and vulnerable, the seat and arm pads were covered with Stabiltex sheer polyester fabric, a suggestion of conservator Gwen Spicer. The Stabiltex was lightly adhered to the top of the trim with Jade 403.

5. CONCLUSIONS

The treatment of Church's leather chair was slow and challenging. Ultimately, however, it was successful. The chair retains all of its original materials which have been stabilized and protected. The appearance of the chair is acceptable for display in the Dining Room/Picture Gallery at Olana (fig. 3).

NOTES

1. The Peebles Island Resource Center is a museum support facility for the 35 New York State



Figure 3. Frederic Church's leather arm chair (OL.1982.1781) after treatment. Courtesy New York State Office of Parks, Recreation and Historic Preservation Olana State Historic Site.

Historic Sites. Located just north of Albany, NY, its facilities include five conservation labs.

2. Goldbeaters' skin is made from the lining of the small intestine of sheep or goats. As its name implies, it was traditionally used in pounding gold leaf; today it is used in pads for wind instruments.

ACKNOWLEDGMENTS

The author thanks her collaborators on this project, Derek Balfour, David Bayne, Heidi Miksch, and Gwen Spicer, for their ideas, assistance and encouragement during the course of this treatment.

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Zukowski, K. 2001. *The historic furnishings report for Olana state historic site*. Hudson, NY: The Olana Partnership and NYS Office of Parks, Recreation and Historic Preservation Olana State Historic Site.

SOURCES OF MATERIALS

Beva™ film (ethylene vinyl acetate), Jade 403® (poly (vinyl acetate) adhesive), Reemay® (spun-bonded polyester), Stabiltex® (plain weave polyester fabric)

Talas
568 Broadway
New York, NY 10012
Tel: (212) 219-0770

Ciba-Geigy Sellaset® leather dyes
The Leather Conservation Centre
University College Campus
Boughton Green Road
Northampton, NN2 7AN

United Kingdom
Tel: 44 (1604) 719766

Coated steel cable ties
Panduit MLT 4H-LP
Local electrical supply house

Ethafoam™ (expanded polyethylene)
George H. Swatek, Inc.
PO Box 356
Ridgefield, NJ 07657-0356
Tel: (201) 941-2400

Goldbeaters' Skin
Ed Myers Co.
1622 Webster Street
Omaha, NE 68102
Tel: (800) 228-9188

Leather
Capital Leather
PO Box 509
Johnstown, NY 12095
Attn: Dave Simek
Tel: (518) 762-7100

Nomex® (007 Nomex 410) (polyaramid paper)
Active Industries, Inc.
Clifton Park Division
20 Solar Drive
Clifton Park, NY 12065-3401
Tel: (518) 731-2020

Polyester knit fabric (Texturized Dacron 56T Interlock)
Testfabrics, Inc.
PO Box 26

DEBORAH LEE TRUPIN

West Pittston, PA 18643
Tel: (570) 603-0432

Silicone release Mylar®
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190-1746
Tel: (800) 482-6299

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SUMMARY OF POTENTIAL ARTIFACT DAMAGE FROM LOW TEMPERATURE PEST MANAGEMENT

ELLEN CARRLEE

ABSTRACT—Preventive freezing for pest control during the relocation of the ethnographic collections of the Smithsonian Institution's National Museum of the American Indian, Suitland, MD afforded the opportunity to undertake an observational study of the potential damage to vulnerable categories of materials and to investigate the possible causes. The observational study revealed no visible damage to any of the materials frozen, although minor changes on a molecular level are likely. Moisture issues are less of a threat than effects related to low temperature alone, such as shrinkage, embrittlement, and molecular alteration. While many of these changes are reversible upon warming, the danger of cumulative effects from repeated preventive freezing of objects is questioned. The conservation tradition of borrowing information from other fields proves difficult to apply to a low-temperature, low-moisture content closed system. This study contributes to an informed approach for the freezing of composite objects, cracked objects, lamellar objects, and waxy or oily objects. Concepts of condensation, moisture content, concentration effects, glass transition temperature, coefficient of thermal expansion, polymorphism, lipid autoxidation, protein denaturation, ratcheting and shakedown are reviewed.

TITULO—IDENTIFICACIÓN DE POTENCIALES ALTERACIONES EN OBJETOS ETNOGRÁFICOS AL APLICAR CONTROL DE PESTES CON BAJA TEMPERATURA.

RESUMEN—Durante el proceso de relocalización de las colecciones etnográficas del Museo Nacional del Indio Americano, se aplicó a los objetos un control de pestes preventivo por conge-

lamiento. Esta actividad nos ofreció la oportunidad para realizar un estudio acerca de los daños potenciales que este tipo de tratamiento puede provocar en materiales vulnerables, e investigar sus posibles causas. La etapa de observación, no reveló daños visibles en ningún tipo de materiales que hubieren sido congelados, aunque si se notaron cambios menores a nivel molecular. El efecto que produce en los objetos, el cambio de las relaciones de agua y humedad relativa en un congelador y que se asume como su mayor amenaza, parece haber sido extrapolada de observaciones realizadas a temperatura ambiente bajo circunstancias distintas al de un ambiente congelado. El tema de la humedad es una amenaza mucho menor que los efectos relacionados con las bajas temperaturas, tales como el encogimiento, que se vuelva quebradizo o la alteración molecular. Mientras muchos de estos cambios son reversibles a través del entibiamiento, se cuestiona el daño que se produce en los objetos por efecto acumulativo de sucesivos congelamientos preventivos.

La información que prestan otras disciplinas a la conservación resultan difíciles de aplicar en sistemas cerrados de bajas temperaturas y humedad. Este estudio contribuye, entonces, con un enfoque bien informado, a comprender los efectos del congelamiento en objetos compuestos, objetos quebrados, objetos laminados y objetos oleosos o aceros. Se revisan conceptos tales como condensación, contenido de humedad, quema por congelamiento, efectos de concentración, transición de temperatura en vidrio, coeficiente de expansión termal, polimorfismo, auto-oxidación de lípido, desnaturalización proteica, ratcheting y shakedown.

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1. INTRODUCTION

The Smithsonian Institution's National Museum of the American Indian (NMAI) is in the process of moving its collections from facilities in the Bronx to the new Cultural Resources Center in Suitland, MD, just outside of Washington, DC. The old facilities had many insect infestations, and the current move protocol includes preventive low temperature treatment of most organic materials before entering the new facility. Objects are sealed in a close-fitting polyethylene bag with padding and cooled below -20°C for at least five days. This situation afforded the opportunity for an observational study of the potential changes to ethnographic artifacts from low temperature pest management.

2. BACKGROUND

Several categories of artifacts are thought to be cause for concern at low temperatures. One category is composite objects. Materials generally not exposed to low temperature treatments, such as glass and metal, may be attached to materials appropriate to treat, such as wool. Composite objects may also have built-in tension, and one material may restrict the movement of a different material. A second category is cracked objects. Concern here lies in possible propagation of the cracks or potential structural weakness implied by the presence of cracks. Delamination of lamellar objects is another area of concern. Examples include tooth and horn as well as layered constructions such as painted wood or adhesive systems. The fourth category includes waxy or oily objects

which sometimes demonstrate bloom or crystallization.

3. DISCUSSION

The possible causes of artifact damage divide into those related to water and those not related to water. Moisture-related issues include freeze-thaw cycling, dehydration, condensation and swelling. Conservation scientist Mary-Lou Florian has written extensively about these issues, but moisture remains a persistent concern for many museum professionals. A well established understanding of damage from fluctuations in relative humidity (RH) leads to the extrapolation that artifacts may suffer from swelling and condensation in cold environments since RH increases as temperature decreases. Standard operating procedure for pest management at low temperatures involves sealing the object in a close-fitting polyethylene bag with a buffering material such as tissue paper. The total amount of moisture inside the bag is finite and in fact very low (Florian 1990ab, 1992). Buffering materials compete with the object for humidity the air can no longer hold, and porous organic objects have the ability to accommodate small increases in RH. The bag itself prevents condensation on the object after removal from the freezer.

Experience in the kitchen also influences the understanding of organic materials at low temperature. Water is critical to issues of food preservation. Ice formation causes the 9% expansion in water volume responsible for freeze-thaw damage (Franks 1985). An increase in membrane permeability at low temperature causes loss of turgor pressure and wilting of fresh plant materials (Reid

1987). Removal of water from a solution via ice formation causes the remaining solutes to increase in concentration. These so-called "concentration effects" can drastically alter pH, viscosity, oxidation-reduction potential, salt concentration and enzymatic reactions (Taylor 1987).

The fact of the matter is, most museum objects do not possess sufficient moisture content to form ice. Most organic artifact materials in a museum environment have between 8% and 12% moisture content (Florian 1986). Artifact material with an equilibrium moisture content (EMC) of up to 28% does not form ice at the temperatures used for pest control (Zachariassen 1985). It is for this reason that some conservators avoid the term "freezing" and its implication of ice formation when discussing museum pest management. It is also worth noting that many materials can take weeks or months to reach EMC at room temperature, and cold temperature tends to slow the process even further (Grattan and Barclay 1988; Howell 1996; Adelstein et al. 1997). The low moisture content in the closed bag situation at approximately -20°C is in fact rather unique and analogies are not easily found in the literature from other fields.

Dr. Dana Elzey, research assistant professor of materials science at the University of Virginia, Charlottesville, VA consulted on the potential problems related to low temperature exclusive of moisture issues. These areas of concern include shrinkage, embrittlement, thermal shock, polymorphic phase change and molecular alteration. Shrinkage may serve to counteract that small amount of swelling mentioned earlier. Practically all materials shrink as temperature is lowered

because of reduced vibration on the molecular level. The coefficient of thermal expansion (CTE) is a measure of this change and is dependent on the strength of interatomic bonds. Materials with weaker bonds, such as many organics, shrink more than those with stronger bonds, like metals. At low temperature, composite objects may be at risk for damage from "CTE mismatch". There are published tabulations for expansion coefficients on some common materials, but there may be no data for many materials in aged or altered condition, no data in the appropriate temperature range or simply no data at all. Often materials are simply categorized as high or low relative to each other. During cooling, the low CTE material goes into tension and risks cracking or delaminating while the high CTE material is in compression and in danger of deformation or crushing. CTE mismatch can also be seen within a single material, particularly one that demonstrates anisotropy. The bonds in anisotropic materials are direction dependent and expand differently in different directions. Examples include materials that tend to crack in a preferential direction, such as wood, bone, tooth and lamellar structures. Cracking is not the only manifestation of CTE mismatch. If the high CTE material is sandwiched between two layers of low CTE material, it may be extruded by pressure from the surrounding material. While many materials have the ability to deform elastically and then recover, at sufficiently high stress some materials may lose the ability to deform elastically, resulting in non-reversible plastic deformation or failure.

Embrittlement is another area of risk that may be reversible upon warming if elastic deformation is

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not exceeded. Embrittlement occurs at low temperature because molecules are resistant to motion. The glass transition temperature (T_g) is an indicator of material flexibility. Below T_g , applied stress may cause brittle fracture; above T_g , elastic deformation is more likely to occur. Examples of materials that become brittle at temperatures used for pest control include rubber, oil paint, synthetic polymers, acrylic paint and soft vinyl (Michalski 1991). Vibration from a faulty freezer or rough handling before the object returns to room temperature are two sources of stress. Embrittlement is usually reversible upon warming.

Any discussion of the risk for damage from shrinking and embrittlement should include an introduction to the terms "ratcheting" and "shakedown." Ratcheting describes the accumulation of plastic strain. A ratcheting crack grows each time it is exposed to the same stress. Damage evolution due to this kind of cycling is known as fatigue and will eventually lead to macroscopic failure. The other option, shakedown, involves a reduction of the incremental strain per cycle. Most of the damage in this process occurs the first time the object is exposed to stress, and each subsequent cycle results in less damage per cycle (Elzey 2001).

Thermal shock is the condition in which rapid temperature change leads to excessive internal stress resulting in damage or failure. It is the phenomenon that causes a hot ceramic plate to shatter under cold water. Several factors influence magnitude of stress: overall change in temperature, rate of cooling, size of the object, coefficient of thermal expansion, elastic stiffness, conductivity, and strength. Objects most at risk for thermal shock

have high CTE, high elastic stiffness, low thermal conductivity and low strength. A large, rapid change in temperature increases the risk of thermal shock. Although most organic materials possess high coefficients of thermal expansion, conduct heat poorly, and are held together by low strength secondary bonds, they have the advantage of very low elastic stiffness and are comparatively resistant to the effects of thermal shock. It is the inorganic components of certain composite objects that are of concern here.

Polymorphic phase change is another factor to consider in low temperature pest management. Phase change involves a change in state, such as from solid to liquid or liquid to gas. Polymorphic phase change involves a solid-to-solid phase change from one crystalline arrangement to another. In some cases, one polymorphic form may be more stable than another at low temperature. Tin disease is one such example. At room temperature, pure tin is a shiny white metal. As temperature decreases, a non-metallic crumbly gray powder becomes the more stable form, reaching a maximum stability at -30°C . Tin disease is inhibited by most of the common alloying metals used with tin. Most of the museum's tin artifacts, such as cone tinklers on Native American artifacts from the Great Plains, are alloys and therefore safe from polymorphic phase change in the freezer. However, the textbook example of tin disease involves Napoleon's attempted 1812 winter invasion of Moscow, which failed in part due to the disintegration of the pure tin buttons on the soldiers' clothing. Low temperature is also a factor in structural change because some materials, such as rubber and some

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fats and waxes, become crystalline at low temperature. This phenomenon seems to be at least partially reversible upon warming (Baker 1995).

The final area of concern addressed here is molecular alteration, particularly regarding protein denaturation, lipid autoxidation and loss of moisture regain in materials demonstrating hysteresis. Conformational stability in protein is dependent on a complex energy balance involving a variety of intermolecular forces. Cooling weakens some forces, such as hydrophobic interactions, but enhances others, such as hydrogen bonding (Taylor 1987). The technology to study proteins at low temperature in the absence of ice formation has only been developed in the past decade. The formation of ice and the concentration effects that occur when water is removed as ice forms continue to be at the center of scientific research, making the question of permanent denaturation of proteins from low temperature alone difficult to resolve (Taborsky 1979; Fahy 1995; Franks 1995).

The Arrhenius equation states that the rate of chemical reactions tends to slow with decreasing temperature. The oxidation of lipids is sometimes an exception. Lipids contain a wide variety of fatty acids that differ in chemical and physical properties as well as their susceptibility to oxidation. Some follow the Arrhenius equation and oxidize more slowly at room temperature. However, low temperatures can accelerate autoxidation of unsaturated fatty acids (Karel 1985). Mechanisms for this are frequently described in the literature as "enzyme-catalyzed". Since enzymes are proteins produced by living organisms functioning as biological catalysts in living organisms, it is doubtful

that there are any active enzymes remaining in museum artifacts.

Because enzymes function nearly to perfection in living systems, there is great interest in how they might be harnessed to carry on desired reactions of practical value outside living systems. The potential value in the use of enzymes (separate from the organisms that synthesize them) is undeniable, but how to realize this potential is another matter. (Roberts and Caserio 1977, 1270).

Furthermore, solute concentration effects that allow enzymes and substrates to come into contact influence some enzymatically-catalyzed oxidation in lipids (Reid 1987). Museum objects that cannot form ice are not subject to concentration effects.

The loss of moisture regain ability due to changes on the molecular level is another potential concern. Many organic materials are able to absorb and desorb moisture to keep in equilibrium with environmental humidity. Taking up moisture brings them to a more stable energy state and generally occurs faster than desorption, as the material is reluctant to give up that moisture. This relationship between water activity and moisture content is illustrated by a sigmoidal curve known as the moisture sorption isotherm. For example, room temperature wool at 55% RH has a lower moisture content if it is in the process of getting wetter that it does under the same conditions if it is getting dryer. At low temperatures, molecules with potential water-holding sites may draw closer together and bond, creating a reduced capacity to hold water in the future (Tímár-Balázs and Eastop 1998). The conservation literature suggests there may be a distinction between damage from long term cold storage and

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short term low temperature exposure for pest control (Wolf et al. 1972; Williams et al. 1995; Pool 1997).

4. CONCLUSIONS

Exploration of the literature and consideration of materials science issues raise two areas of concern. One involves the likelihood of repeated freezing cycles for some objects, particularly those actively loaned or exhibited and therefore subjected to low temperature treatments with each re-entry into the museum collection or new venue. Data involving wood (George et al. 1992; Erhardt et al. 1996), textiles (Holt et al. 1995; Jansson and Shishoo 1998; Peacock 1999), synthetic fishing gear (Toivonen 1992), paper (Björdal 1998) and insect collections (Rawlins 2001) suggest no significant structural damage with repeated low temperature treatment for pest control. Theoretically, however, embrittlement, shrinkage, and thermal shock have the potential to cause damage if the limits of elastic deformation are exceeded, or if ratcheting occurs within the elastic range and leads to fatigue (Elzey 2001).

The second area of concern involves the permanent physical changes that are likely to occur (and perhaps accumulate) on a molecular level but remain invisible to the naked eye, such as loss of strength, loss of elasticity, distortion, crystallization, molecular alteration, protein denaturation, and loss of regain ability. In some cases there may be synergistic effects in which interrelated damage mechanisms combine to cause further problems.

In summary, it might be helpful to state this information plainly. Based on this investigation which involved freezing several hundred artifacts, reviewing the literature, and discussing the topic with many museum and scientific professionals, a list of factors has been prioritized from highest-to-lowest concern. On the whole, low temperature pest control appears to be safer for artifacts than might have been suspected.

- 1. Freeze-thaw and dehydration should not occur because there is not enough moisture in museum objects.
- 2. Condensation should not happen if artifacts are bagged properly.
- 3. Swelling probably happens a little bit, but not much because there is so little moisture available inside the sealed bag.
- 4. Polymorphic phase change does happen with some materials, especially fats and waxes, but is usually reversible upon warming except in rare cases such as tin disease.
- 5. Thermal shock is not an issue for most organics because the temperature change is not drastic or sudden enough. Inorganics are at greater risk, but no reports of this kind of damage were found.
- 6. Shrinkage undoubtedly occurs, but at this temperature it's fairly minor and perhaps counteracted by the small amount of swelling. The reason it is placed higher on the list is because of CTE mismatch danger. Drums are one of the few objects not frozen at the NMAI.
- 7. Embrittlement is also very likely to happen, but is usually reversible upon warming,

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and objects are mainly at risk from vibration or rough handling until they warm up.

- 8. Molecular alteration is a bit of a wild card. Protein denaturation may occur, but it may be reversible upon warming. As far as lipid autoxidation goes, this may not happen at all without enzymes and sufficient moisture content. Loss of moisture regain ability appears to be more of a danger with long term cold storage.

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COLLABORATIVE TREATMENT OF A NATIVE AMERICAN ROBE FROM THE MIAMI COMMUNITY WITH SILK RIBBONWORK AND METAL DECORATION

MIKA TAKAMI, SUSAN HEALD AND JESSICA S. JOHNSON

ABSTRACT—Textile and objects conservators at the Smithsonian Institution's National Museum of the American Indian (NMAI), Suitland, MD collaborated on the treatment of a woman's robe made from a large, black wool tradecloth and decorated with numerous white metal buttons, ring brooches, ball and cone danglers and silk ribbonwork. The object had been requested for loan by the Eiteljorg Museum of American Indians and Western Art in Indianapolis, IN. The NMAI conservation staff felt that the return of this robe to the Miami community justified the exceptionally long hours required for this treatment. The major problem was copper corrosion on the white metal and associated staining on the wool and silk. There also were tarnished silver components and deteriorated silk ribbonwork. Although no treatment records exist, conservators suspect that during a previous treatment the metal was cleaned with a proprietary polishing compound and then coated with a lacquer, which left residual staining on the wool around the decorated areas. Nearly the entire conservation department assisted in the time-consuming cleaning of each individual metal component. Localized solvent cleaning using a hand-held vacuum suction plate successfully reduced associated staining of the wool fabric. Creases in the silk ribbonwork as well as in the wool fabric were flattened in a separate treatment phase.

TITULO—TRATAMIENTO EN COLABORACIÓN DE UNA MANTA MIAMI CON TRABAJO DE CINTAS DE SEDA Y DECORACIÓN DE METAL. **RESUMEN**—Los conservadores de textiles y objetos del Museo Nacional del Indio Americano a menudo trabajan en conjunto en tratamientos de conservación, pero el tratamiento

de esta pieza en particular requirió de una aproximación más interdisciplinaria que lo usual. Esta manta de mujer está hecha de una tela comercial de lana negra, larga y rectangular (164 x 165 cm), ricamente decorada con numerosos botones de metal blanco, broches de anillos, pendientes en forma de bolas y conos, así como con trabajo de cintas de seda aplicadas en los bordes laterales e inferior. El Museo Eiteljorg de Indianapolis solicitó el préstamo de la pieza para su nueva exhibición permanente de la Cultura Indígena Woodland, la cual incluye a los indígenas Miami que son originarios del noreste de Indiana. Los indígenas de la Nación Miami local están trabajando con el Museo Eiteljorg en la exhibición y ellos están muy entusiasmados de ver que muchas de sus piezas retornan a su lugar de origen.

El mayor problema con esta manta es la corrosión del cobre sobre los elementos de metal blanco y el manchado asociado a la lana y seda. También hay componentes de plata que han perdido el lustre. Los conservadores sospechan que el metal fue limpiado con un compuesto industrial para pulir y luego cubierto con una laca, dejando ambas manchas residuales en la lana alrededor de las áreas decoradas, aunque no hay registros de tratamientos previos. Los conservadores e internos del Departamento, de las especialidades de objetos y textiles, trabajaron en conjunto para establecer la estrategia de tratamiento. El Departamento de Conservación casi completo colaboró en la lenta limpieza de cada pieza de metal. Este esfuerzo conjunto permitió reducir satisfactoriamente la corrosión y remover la laca sin dañar los componentes textiles adyacentes. Se hizo limpieza manual y localizada con solventes, y placa de succión

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que permitió la reducción de las manchas asociadas a la tela de lana. Las arrugas de los flecos de las cintas de seda, así como las de la tela de lana, fueron alisados en una fase de tratamiento separada.

Los conservadores del NMAI sintieron que el retorno de esta manta Miami al museo vecino a la comunidad Miami, justificó plenamente las largas horas de trabajo que requirió este existoso trabajo de conservación conjunto.

1. INTRODUCTION

Collections at the Smithsonian Institution's National Museum of the American Indian (NMAI), Suitland, MD consist of approximately 800,000 archaeological and ethnographic objects from Native American cultures throughout the Western Hemisphere. The conservation department, located in the Cultural Resources Center (CRC) in Suitland, MD is responsible for the care and preservation of the collections.

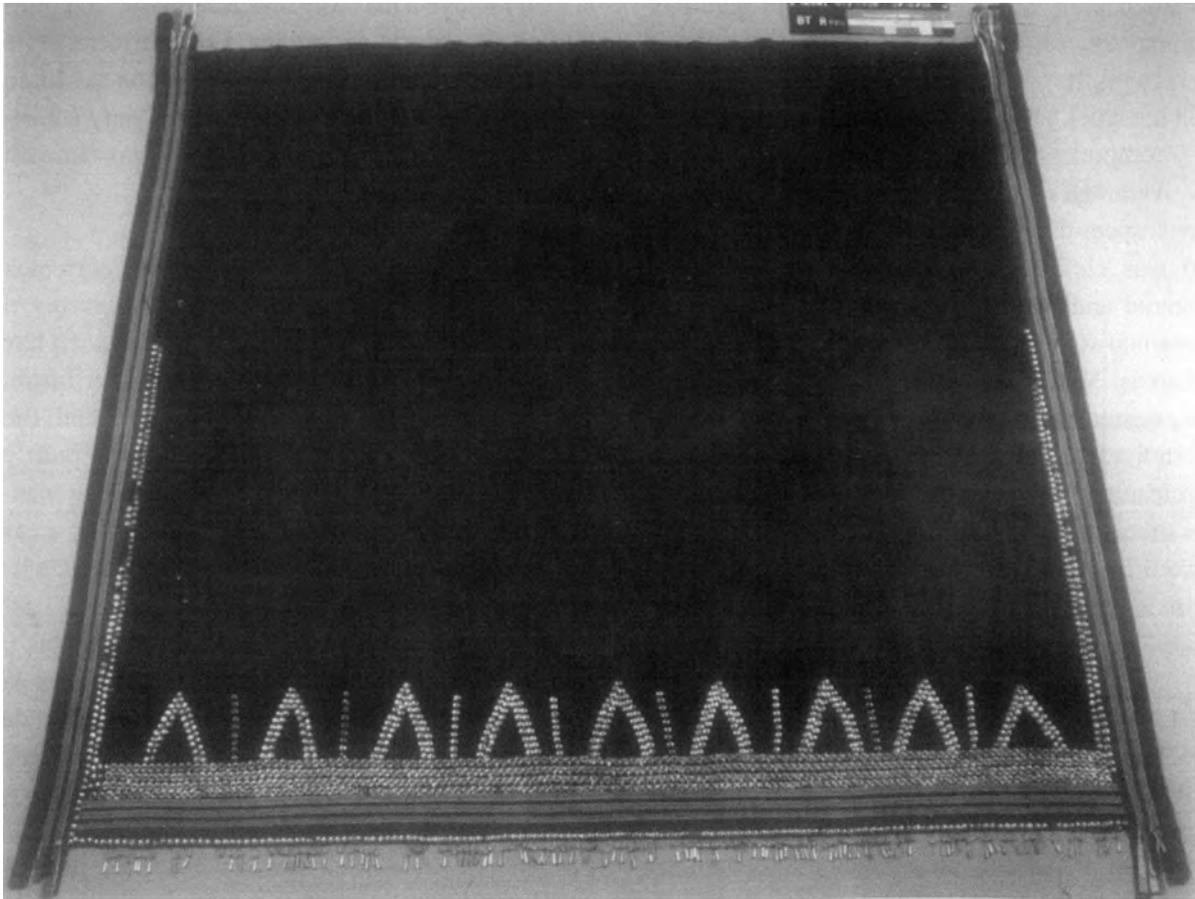


Figure 1. Miami woman's robe (NMAI 02/7958) before treatment.

Textile and object conservators often collaborate on treatments, but the treatment of this piece called for a more interdisciplinary approach than usual. This paper describes the preparation of a woman's robe for loan to the Eiteljorg Museum of American Indians and Western Art in Indianapolis, IN. It is a private museum with close ties to a local Native constituency, the Miami Nation of Indians of Indiana.

2. DESCRIPTION

The robe (NMAI 02/7958) is made from a large, rectangular, black wool fabric (commonly called tradecloth) measuring 164 x 165 cm (64 1/2 x 65") in size which is richly decorated with colored silk ribbonwork and white metal ornaments applied in a band and triangle motif (fig. 1). The construction of the robe is hand-sewn and all the metallic ornaments are stitched to the wool fabric using cotton thread.

The metal ornaments include two types, buttons and ring brooches (fig. 2). The triangular motif—alternating pointed and straight lines—is constructed with metal buttons and is a typical design for Miami pieces (Hamilton 1995; Gonyea 2002). Below these lines the textile is adorned with four horizontal rows of ring brooches which are neatly aligned along the bottom edge. The ring brooch, a circle with a flat point bar that serves as a tongue, is one of the unique silver trade ornaments commonly found in Native artifacts. Among several sizes available, the small, 1 cm (3/8") diameter size often is used in a row to embellish wool or silk (Hamilton 1995).

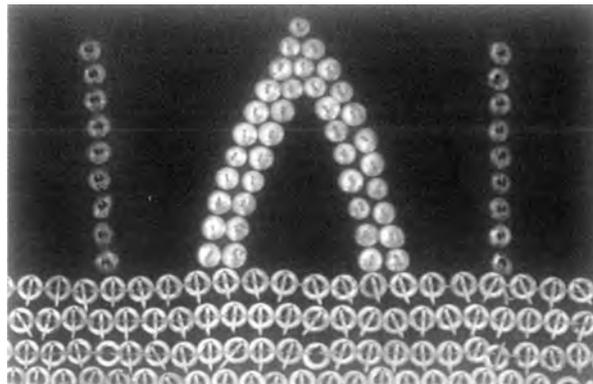


Figure 2. White metal decorations (buttons and ring brooches) before treatment.

The sides and bottom edge are decorated with colorful stripes of silk ribbon that extend from each corner (fig. 3). Silk ribbonwork on wool, varying from simple stripes to more complicated designs, is a unique indigenous technique to decorate clothing and originally developed in the Northeastern

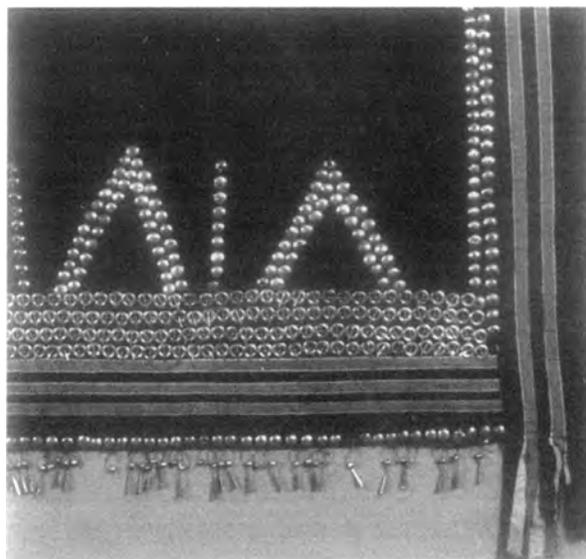


Figure 3. Silk ribbonwork and ball and cone dangles before treatment.

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woodlands (Pannabecker 1996). The bottom edge is ornamented with numerous ball and cone dangles (fig. 4). These also are common trade items, usually used as earrings but sometimes as pendants or fringes as seen on this robe (Hamilton 1995).



Figure 4. Diagram showing the structure of a ball and cone dangle.

Figure 5 shows a picture of two Omaha women wearing robes of a similar style. It shows how the NMAI robe probably was worn: with the top edge folded over and the robe put around the shoulders. The silk ribbon stripes are aligned at the front, the metal decoration is visible along the lower edge, and the ball and cone dangles hang from the bottom.

3. CONDITION

The robe was in fair condition. It was acquired circa 1910 and was unsympathetically displayed in the collection's original facility at 155th Street and Broadway in New York until 1995. There the piece was on display tacked to the wall in a densely



Figure 5. *Omaha* women wearing a robe (courtesy of Mr. Benson Lanford).

packed, sealed exhibit case for about 35 years. The wool was supple but generally faded and in some areas sharply creased from previous storage, and there were some small tears and insect holes.

The white metal (a silver-plated copper alloy) had corroded, appearing greenish and dull, and there was associated greenish and beige staining in the wool and the silk ribbonwork (fig. 6). Many buttons and ball and cone dangles were deformed due to the relatively soft metal used. Approximately 80 ball and cone dangles had been lost completely and many of the remaining ones were partially broken.

The silk ribbonwork was the most fragile component. It was soiled, faded, creased and torn. The teal blue and pale yellow ribbons in particular, pos-



Figure 6. Copper corrosion products on a white metal button before treatment.

sibly weighted silk, were especially vulnerable to further damage.

4. PHILOSOPHY AND JUSTIFICATION FOR TREATMENT AND LOAN

In February 2001, the Eiteljorg Museum requested the loan of several Indiana Miami pieces for a new permanent exhibition. The exhibition focuses on the cultures of northeastern Woodlands Indians, including the Miami Indians, who originally are from northeastern Indiana. One of the objects requested was this woman's robe.

An object in such condition rarely is approved for loan. Despite its conservation complications and the anticipated long hours for treatment, NMAI decided to loan the robe because the Eiteljorg Museum is accessible to Miami people living in and around the Indianapolis area.

The Eiteljorg Museum has an in-house Native American Council and organizes museum activities with Native constituencies. In addition to their

established community liaison, the planning and design of this Woodland exhibition had been executed with the direct involvement of the local Miami Nation of Indians of Indiana. The local Miami community is excited to see many of their artifacts return to the area and the tribal council supports the Eiteljorg Museum's efforts to borrow or acquire Miami artifacts for the exhibition.

Providing access to NMAI collections for Native American communities is one of the museum's essential functions, fulfilled through a variety of programs. This loan served the interconnection of the collection and the Native community, represented institutional consensus between the two museums on access to collections, and served the missions of both institutions.

The robe is one of the finest Miami textile pieces in the NMAI collection and it bears the characteristic designs of metallic and ribbon decoration. It plays an important role in the permanent exhibition, contributing to the community's appreciation of its own cultural traditions. The return of this object to its area of production therefore was considered highly significant and justified the long conservation treatment.

5. CONSERVATION STRATEGY

Due to the composite nature of the robe, a collaborative approach to establishing a conservation strategy was adopted. Both textile and object conservators worked together to identify the materials and determine a treatment method. The treatment requirements were to make the robe safe and pleasing for display. It was important to improve the

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visual appearance because the white metal buttons, ring brooches and ball and cone dangles are important embellishments in Miami clothing.

The major problem was copper corrosion on the numerous white metal components and associated staining on the wool and silk. Objects conservators suspected that the metal once was cleaned with a proprietary polishing compound and then coated with a lacquer, both of which left residual staining on the wool around the decorated areas. No previous treatment records exist. However, there were fine, whitish deposits along the metal decoration and the surface of the metal had directional fine line scratches which supported this hypothesis.

Microscopic examination also revealed a thin, transparent coating on the surface of the metal. The coating was identified as cellulose nitrate through a diphenylamine spot test and observation under ultraviolet (UV) radiation. This lacquer appeared to have yellowed and no longer functioned as a protective layer. A soft waxy copper corrosion product, possibly copper stearate, already had emerged from the coating and caused staining in the wool and silk.

6. TREATMENT

The main issue in formulating a treatment strategy was cleaning the metal without causing adverse affects to adjacent textile components. Solvent cleaning was considered most appropriate to remove the lacquer and copper corrosion products. However, all the metallic components were directly sewn to the wool and so it was essential to isolate the solvent from the fabric. Treatment options

were discussed and a consensus was reached to carry out a rather time-consuming cleaning of each individual metal component as a team effort.

The robe first was vacuumed to remove particulate soiling. Then the metal components were cleaned. Acetone was found more effective than ethanol in removing both the cellulose nitrate coating and the copper corrosion products. A team of four or five members at a time worked on the robe section by section (fig. 7). Several fume extractors were set up above the piece to ensure the conservators' health and safety, and a respirator also was used when necessary.



Figure 7. Cleaning bee.

Treatment involved inserting a small piece of Tyvek underneath the metal using a pre-cut slit at one side and swabbing the metal with a solvent, so as to prevent excess cleaning solvent from migrating to the fabric. Tyvek was chosen because it is impermeable, has a slippery surface, and is soft compared to Mylar. This Tyvek barrier method simplified the process of cleaning metal components sewn to a textile.

Once the barrier was inserted, each individual metal component was swabbed with acetone. The

slippery surface of the Tyvek allowed smooth insertion and only minor manipulation was necessary to lift the metal component (figs. 8a, 8b).

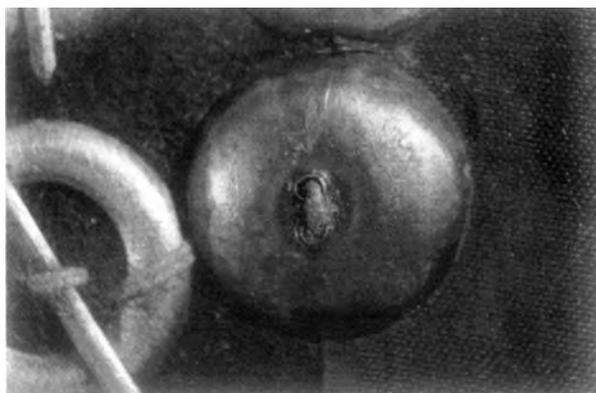


Figure 8a. White metal button and ring brooch before treatment.

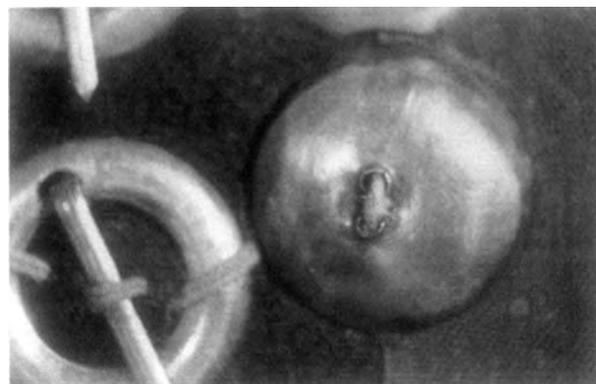


Figure 8b. White metal button and ring brooch after treatment.

With the ball and cone dangles, immersion in an acetone bath was tested to facilitate quick removal of the lacquer coating. Although the acetone bath turned yellow with dissolved cellulose nitrate, an unacceptable opaque surface layer was left when it dried. Therefore, the immersion method was abandoned and the individual swabbing method was carried out, which resulted in a shiny appearance.

For each individual metal component, the removal of copper corrosion was visually assessed and the removal of lacquer confirmed under UV radiation.

In total, it took 89 person hours over four days to complete the cleaning of metal components. The collaboration between textile and objects conservators led to successful reduction of corrosion products and removal of lacquer without damage to the adjacent textile. The loose buttons and dangles also were cleaned with acetone, and then were reattached to their appropriate locations.

The distorted ball and cone dangles mechanically were re-shaped and the dangles neatly aligned. During handling, a wire and a joint of the ball and



Figure 9. Solvent cleaning of wool using a hand-held vacuum suction plate.

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cone dangler often bent or flexed with a slight movement of the robe, which resulted in undesirable tangling and distortion of the elements. To reduce potential damage, an additional support was provided along the bottom edge. A strip of black cotton was stitched to the back of the bottom of the robe, leaving a 1 mm extension from the edge. The loops of the danglers were stitched to the cotton support. After the cleaning and stabilization treatment, a strip of Pacific Silvercloth was placed on the metal components to inhibit further corrosion during storage and travel before installation.

Next came removal of the associated staining of the wool fabric. Localized solvent cleaning using a hand-held vacuum suction plate was proposed to remove or at least reduce the staining (fig. 9). The surface of the perforated plate was covered with a sheet of Mylar with a small hole. Filter paper was placed on the hole and the plate inserted under the fabric. Acetone was applied locally from the front to reduce staining. No wicking was observed. The cleaning effectively removed green staining but did not reduce the beige discoloration.

The next treatment phase involved the silk ribbonwork. Creases were flattened via localized contact humidification carried out layer by layer because of the overlapping structure. Stitch failure in the ribbon stripes was repaired using a similar silk thread. A detached small fragment of a teal blue ribbon at the bottom right corner (fig. 10) was re-attached using a Stabilitex support coated with 15% v/v Lascaux 360 and Lascaux 498 HV (1:2) in water and reactivated with acetone vapor.

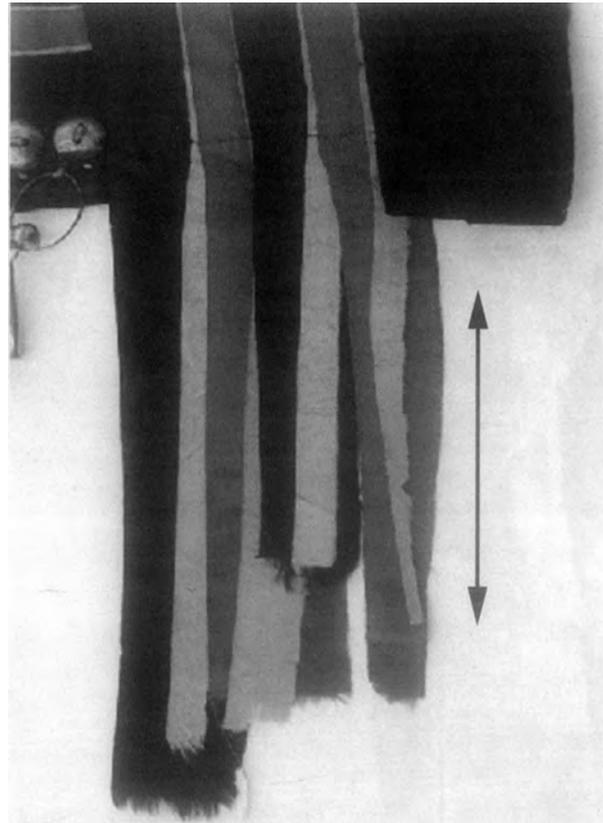


Figure 10. Detached teal blue silk ribbon fragment indicated with an arrow.

Finally, creases in the wool tradecloth were flatted by humidification. To ensure the stability of the fabric for handling and display, slits and tears in the wool were secured with couching and herringbone stitches using cotton thread.

7. CONCLUSION

For exhibition, a 45° slant board in a sealed case was recommended. The upper quarter of the robe

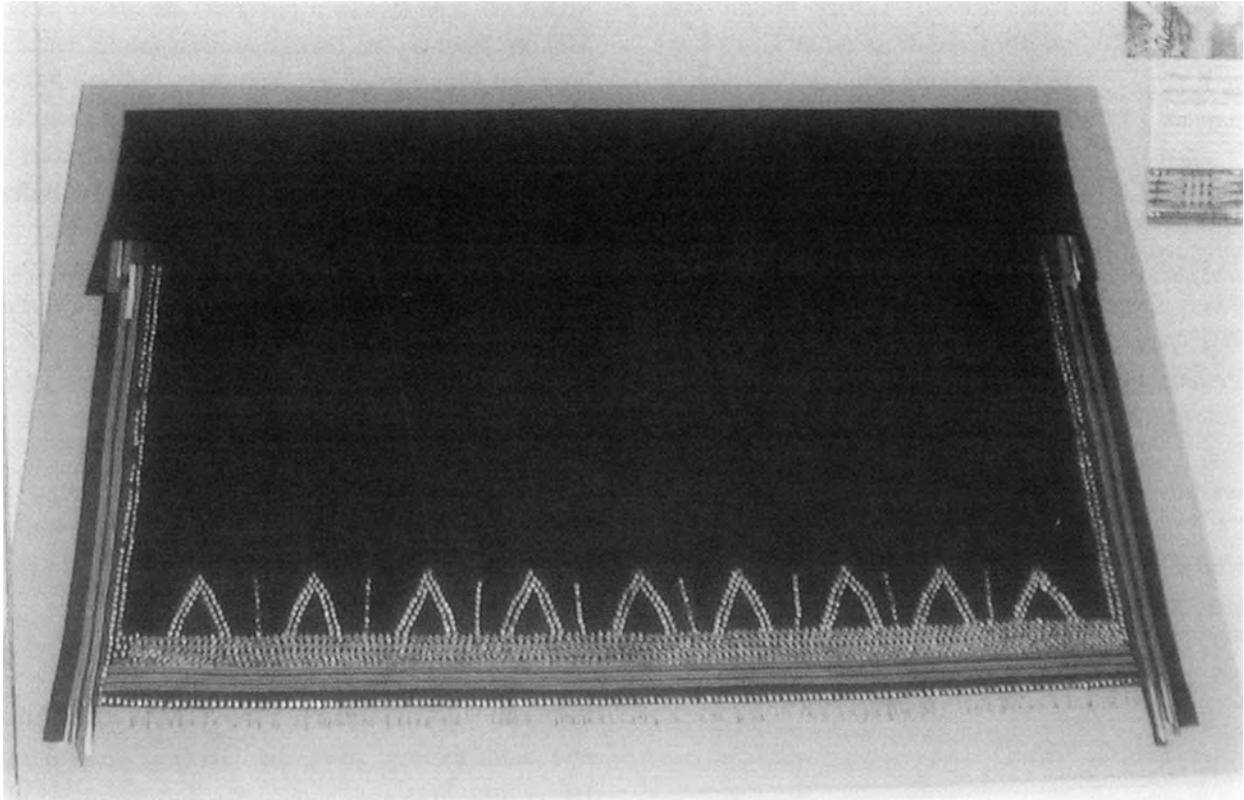


Figure 11. Front view of the robe on display at the Eiteljorg Museum. The upper quarter is folded back as it would have been worn.

was folded back as it would have been worn. To support the robe, a pinning band was stitched 1.5 cm (1/2") below the fold. Figure 11 shows the object after installation at the Eiteljorg Museum, where it is now available to members of the local Miami Nation.

ACKNOWLEDGEMENTS

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information on the robe, and encouraged us throughout the treatment.

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Pannabecker, R.K. 1996. "Tastily bound with ribands": Ribbon-bordered dress of the Great Lake Indians, 1735-1839. *Clothing and textiles research journal* 14 (4):267-275.

SOURCES OF MATERIALS

Tyvek® (high density spunbonded olefin sheet)
Avery Dennison, Fasson Division
7670 Auburn Road 15-H
Painesville, OH 44077
Tel: (440) 358-6507
Fax: (800) 513-7117
www.averydennison.com

Mylar® (100% polyester film)
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Lascaux 360 HV, 498HV (butyl acrylate thickened with methacrylic acid)
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Tel: (212) 219-0770

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University Products
517 Main Street
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SAVING AMERICA'S TREASURES: THREATENED ARTIFACTS FROM THE APOLLO ERA

LISA YOUNG

ABSTRACT—The Smithsonian Institution's National Air and Space Museum (NASM), Washington, DC has the world's largest collection of spacesuits and related components from the United States space program. In addition to mission suits worn during spaceflight, the museum houses a large number of non-flight, experimental and developmental suits. Two-thirds of the collection is in storage and the remaining suits are on display at NASM or on loan to other museums. While many of the suits are similar in construction and materials, each suit was custom made for an individual astronaut or a particular experiment, making each one unique. Little documentation remains regarding the development of these suits. Information on their materials, construction, and past history can be found only by studying each suit.

TITULO—SALVANDO LOS TESOROS AMERICANOS: ARTEFACTOS DE LA ERA APOLO BAJO AMENAZA. **RESUMEN**—En Enero de 2000, la División de Historia Espacial del Museo Nacional del Aire y el Espacio comenzó la tarea de salvar artefactos del programa Espacial Apolo en peligro de conservación. Este proyecto está siendo financiado a través del programa de becas "Salvando los Tesoros Americanos" y el Hamilton Sundstrand. Los objetivos principales de este proyecto interdisciplinario son el preservar los trajes espaciales de la Era Apolo de la colección del Museo Nacional del Aire y el Espacio (NASM) y compartir con otros museos los resultados de nuestra investigación acerca del deterioro y preservación de los trajes espaciales.

Fase I: Cada traje espacial de la colección del NASM fue completamente documentado y examinado. Se realizaron análisis no destructivos con el fin de establecer su condición básica y permitir monitorear futuros cambios. Se realizaron CT Scans de los trajes para poder examinar y registrar la morfología en tres dimensiones de sus capas interiores. Conservadores profesionales y expertos en este campo realizaron análisis de los materiales específicos y los productos de su degradación.

Fase II: Se organizó y mantuvo un grupo de apoyo de materiales para asistir y aconsejar al equipo del proyecto en temas relacionados con el deterioro y preservación de los materiales de trajes espaciales. Los trajes del Apolo están compuestos de 20 a 24 capas de materiales modernos, los que incluyen Dacron, Mylar, nylon, textiles de fibra de vidrio cubiertos de Teflon, polivinilo de clorido, gomas naturales y sintéticas, plástico y metal. Fue muy necesaria la consulta extensiva a este equipo de apoyo, debido a la escasez de información publicada y confiable acerca de este tema.

Fase III: Fue diseñado e implementado un sistema de depósito y manipulación y se implementó para ser usado en la colección de trajes espaciales del NASM. Se han establecido los parámetros medioambientales para el depósito de estos modernos materiales basados en la investigación llevada a cabo durante este proyecto.

Fase IV: Fueron establecidas las líneas de base y los estándares de práctica, sintetizando la información y la investigación reunida durante el proyecto. Estas guías conforman un plan detallado para futuras investigaciones, y sirven como las directri-

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ces más actualizadas para la preservación, el depósito y la exhibición de los trajes espaciales.

1. INTRODUCTION

The Smithsonian Institution's National Air and Space Museum (NASM) in Washington, DC has the world's largest collection of spacesuits and related components from the United States space program (fig. 1). Mission suits, non-flight, experimental and developmental suits are in storage or on display. While suits are similar in construction and materials, each was custom-made for an astronaut or particular experiment, making each unique. Little documentation of the developmental history, materials and construction, and past history exists and can only be learned by studying each suit.

In March 2000, the Division of Space History began a two-year project to save threatened artifacts from the Apollo space program. Funded by a Save America's Treasures (SAT) grant, matching funds came from Hamilton Sundstrand of Windsor Locks, CT, manufacturer of the Apollo life support system. The project's primary goal is to record the condition of each suit in the NASM collection and stabilize it for storage and exhibition. Research into the degradation mechanisms of spacesuit materials is planned.

The project goals are to (1) document the current condition of the Apollo spacesuits and stabilize them; (2) establish a materials advisory group composed of museum specialists, industry experts and material scientists to research the complex issues of spacesuit deterioration and preservation; (3) design, test and implement procedures for the



Figure 1. Astronaut Edwin "Buzz" Aldrin, Jr., lunar module pilot, on the surface of the Moon during the Apollo 11 mission. Courtesy of NASA.

long-term storage of the spacesuit collection; (4) and produce guidelines and standards for the storage, display and preservation of spacesuits.

Today NASM has approximately 100 spacesuits and spacesuit components relating to the Apollo era, the most notable being the 12 Apollo lunar suits. Two of these suits, worn by Apollo 11 astronauts Neil Armstrong and Edwin "Buzz" Aldrin, are on permanent display at NASM. The next most

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significant suits reside in the preservation collection, which contains suits that were developmental or associated with a particular historical event.

Spacesuits are very complex yet fragile objects, composed of more than 20 layers of natural and synthetic materials (fig. 2). The extra-vehicular

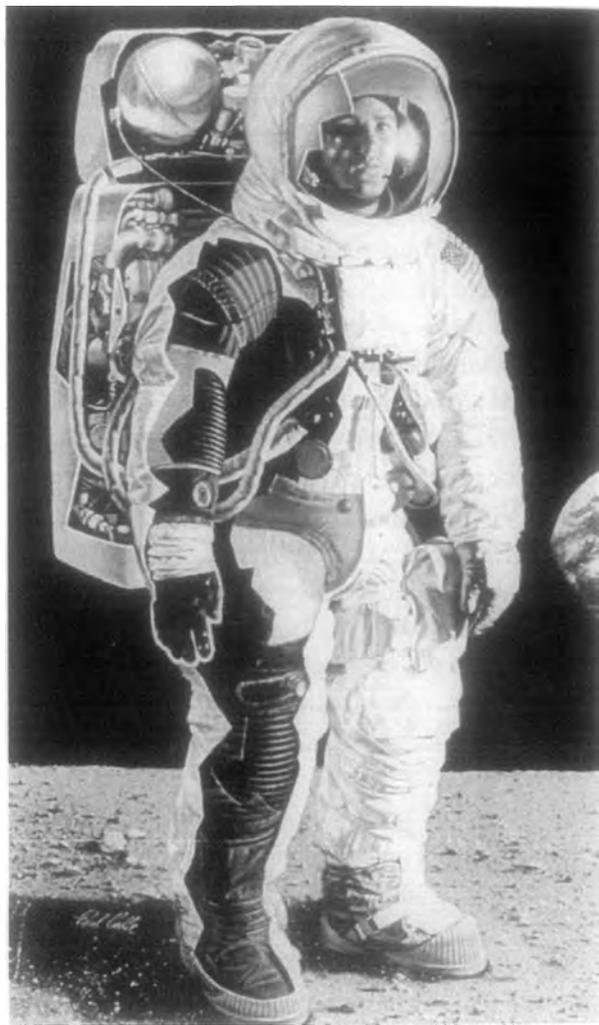


Figure 2. A7-LB spacesuit cutaway showing interior layers of the suit.

suits have the most complex structure. Each suit has an interior rubber bladder to maintain a constant pressure while the astronaut is in space. Layers of Mylar (a polyester film), aluminized Mylar (polyester film sandwiched with aluminum sheeting), Kapton (polyamide film manufactured by DuPont), Dacron (polyester fiber woven into a thin textile), Beta marquesitte (Teflon or polytetra fluoroethylene coated fiberglass woven into a cloth), and nylon (polyamide, made into fibers) were sewn and adhered together to protect the astronaut from extremes of temperature and exposure to high levels of radiation. Several layers of nylon and an outer layer of beta cloth (Teflon coated fiberglass) protect from meteorites and fire. Convoluters, lasagna shaped pieces of rubber located inside the shoulder, elbow, knee and ankle joints allowed the astronaut mobility and flexibility (fig. 3). The life support system, gloves, boots and helmets are attached to the exterior of the suit using anodized aluminum valves and bearings. Additional materials such as plasticized polyvinyl chloride (PVC) tubing, polycarbonate, brass, stainless steel, silicone rubber and neoprene are also found on the suits.

Deterioration to the spacesuit collection was noted as early as 1978 (Baker and McManus 1993; Kozloski et al. 1993). Studies by conservators and museum staff concluded that the suits should be placed in cold storage in order to slow down this deterioration. For the past two decades, a majority of the suits in the collection have been in refrigerated storage at 45% relative humidity (RH) and 5°C. These parameters were instituted as a “best guess” appropriate environment for the collections (Lange et al. 1995). Nonetheless, some of the

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Figure 3. Deteriorated rubber convolute from the knee of an Apollo spacesuit.

spacesuits stored in what were hoped to be ideal conditions have continued to deteriorate.

A majority of the suits placed into cold storage had some degree of deterioration. Many of the suits had been on and off display over a 20 year period, either at NASM or at other museums. Some of these suits suffered from display on inappropriate mannequins, in unsuitable lighting conditions, and from exposure to harsh temperatures and humidity extremes. These conditions prompted NASM to apply for funding to study further the deterioration and preservation of the spacesuit collection, and to establish parameters for optimum storage and display environments.

2. PHASES OF THE PROJECT

2.1 CONDITION ASSESSMENT OF THE COLLECTION

During the first phase of the SAT project, each spacesuit was thoroughly documented and exam-

ined for the first time since its acquisition in the 1970s. Five areas of deterioration were targeted for comparative analysis: the rubber bladder, the plasticized PVC tubing, the interior and exterior pressure zippers, the rubber convolutes, and the anodized aluminum wrist and neck rings. Each of these areas and the physical integrity of the suit as a whole were examined and rated using a criterion anchored rating system (Williams 2000). Each target area is examined and then rated objectively for condition.

2.1.a. RESEARCH AND ANALYSIS

Research was undertaken to classify material components and identify degradation products and the possible cause of this damage. Non-destructive analysis was performed on each suit in order to establish a condition baseline and permit monitoring of future changes. The analytical techniques performed included pH testing of actively degrading PVC tubing and neoprene zippers using ColorpHast indicator strips; measuring density of rubber components using a durometer (Pacific Transducer Corp, Instrument, Type A, Los Angeles, CA); and recording color on exterior textiles of each suit using a Minolta Chroma meter CR-200.

The interior 3-D morphology of a sampling of suits was recorded using Computed Tomography (CT) also known as a CAT scan (fig. 4). The Smithsonian Institution's National Museum of Natural History (NMNH), Washington, DC allowed researchers access to their equipment donated by the Siemens Corporation, Iselin, NJ. This technique has been very useful in evaluating

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the density and degradation of the rubber convolutes. It provided a unique opportunity to peer into the 20 layers of a spacesuit.

2.2 MATERIALS ADVISORY GROUP

An advisory group comprised of material experts in metals and polymers and industry experts was organized to assist and advise the project team regarding the deterioration and preservation of the spacesuit materials. Meetings were convened and two members who actually worked on the rubber components of the spacesuits during the 1970s participated as well. Research was completed on several of the target areas of deterioration during the two-year project.

Dr. Yvonne Shashoua, a conservator from the National Museum of Denmark, Lyngby, Denmark and Bill Ayrey, manager, Quality Engineering and Inspection of ILC, Inc., Frederica, DE performed analysis on segments of the plasticized PVC tubing

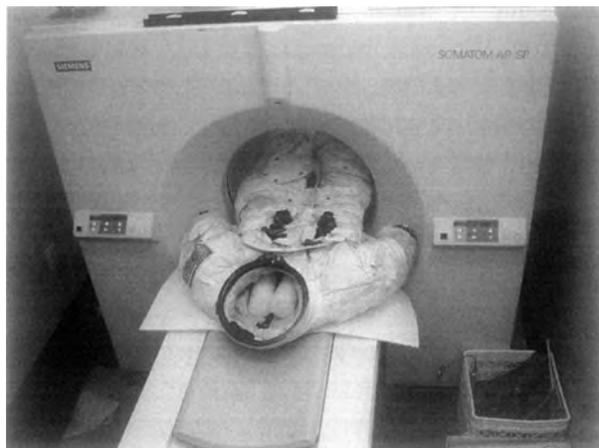


Figure 4. Alan Bean's Apollo 12 suit being CT-scanned at the Smithsonian Institution's National Museum of Natural History.

used in the Apollo liquid cooling garment and life support systems. Using reflectance Fourier transform-infrared spectroscopy (FT-IR), the material was identified as Tygon 443B, a polyvinyl chloride plastic with a di-octyl phthalate plasticizer. The samples were in a very degraded state and had lost most of their plasticizer, leaving behind discolored, brittle PVC. The plasticizer was migrating out of the tubing and staining adjacent suit material (Shashoua 2001).

A number of the anodized aluminum alloys used to create the wrist and neck bearings of spacesuits showed signs of advanced corrosion (fig. 5). Analysis at the Canadian Conservation Institute, Ottawa, Canada using scanning electron microscopy (SEM) with energy dispersive spectroscopy (EDS), and X-ray diffraction (XRD) identified corrosion products. The elements identified in all the samples included aluminum, oxygen, magnesium, copper and chlorides (Sirois et al. 2002). These findings were consistent with alloy 2024-T4 used to manufacture the wrist disconnects. The large number of chlorides present was a concern. Unlike training suits, the suits showing signs of corrosion were not tested in chlorinated swimming tanks or used for research purposes. After discussions with the manufacturers of the suits and several astronauts, it was concluded that the high levels of chlorides are likely the result of the astronaut's sweat.

Preservation of the rubber in Apollo era spacesuits has been the focus of past research. The rubber components of spacesuits are 70% latex and 30% neoprene, combined with nylon fabrics and webbing (Slavik 2000). The engineers who produced a

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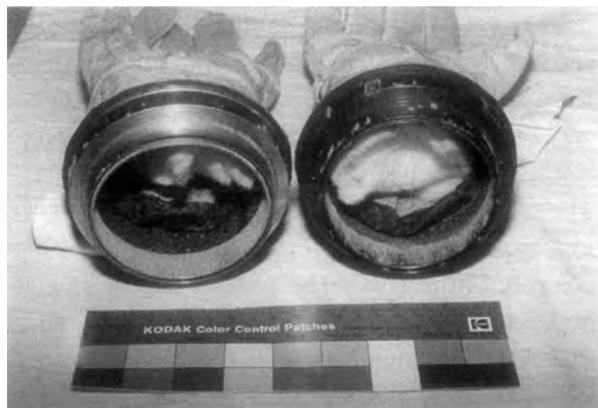


Figure 5. Corrosion found on the interior surfaces of the aluminum glove disconnects.

suit that could survive space were the first to be concerned with the aging properties of the natural rubber they used. The composition of the rubber compound remained the same throughout much of the program and the suits were evaluated and tested constantly to ensure they did not fail. In 1971, the antioxidant Agerite White (B.F. Goodrich, Akron, OH) was added to the rubber compound enabling astronauts to spend more time on the lunar surface and giving them the ability to live and work in a spacesuit for up to 115 hours (McBarron 2000).

Research involving the rubber components of the suits is being conducted to identify the materials, and to determine which factors may or may not accelerate their degradation. Rubber inherently degrades and it is highly susceptible to oxidation. What triggers this reaction and how long it takes is unknown (Baker 1995). The suits have been exposed to a variety of environments and conditions, from the time of their manufacture until their receipt by the museum. The survey undertaken as

part of this project provided no evidence that the addition of the antioxidant improved the long-term aging properties of the rubber. Initial findings suggest keeping the collection at about 35% RH and 16°C. Increased air circulation on open racking is also beneficial because the suits continually off-gas as they age (Young and Young 2001).

In addition to the PVC, aluminum, and rubber deterioration, several other areas of the suits are showing signs of degradation. The exterior nylon fabric of earlier suits and the beta cloth of later suits is very susceptible to damage caused by excessive light levels and exposure to ultraviolet (UV) radiation. Surface discoloration, physical breakdown and abrasion of fibers is also present. The exterior fabrics suffered general wear and tear during missions or training exercises resulting in abrasion, tears and exposed interior layers of the suit.

Microscopic examination revealed fungal damage on some of the layers such as the non-woven Dacron, the latex-neoprene, the beta marquisette, and the beta-cloth. High humidity levels seem to accelerate this process, encouraging the growth of bacteria and molds (Breuker et al. 2002). Tearing, crumbling, and disintegration of polymer materials is a result.

Other forms of chemical damage and general decay are evident such as missing exterior and interior components and physical stress caused by the insertion of inappropriate mannequins. General staining is apparent, which is either a result of use or contact with other materials that have deteriorated or caused a chemical breakdown in the fabric

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over time. The most common staining on Apollo lunar suits is discoloration of the exterior white fabric to a gray color from lunar dust.

2.3 LONG TERM STORAGE OF THE COLLECTIONS

An environmentally controlled Bally box, a modular environmentally controlled building (Bally Refrigerated Boxes, Morehead City, NC) was erected to store the spacesuit collection at the Smithsonian Institution's Paul E. Garber Preservation and Restoration Facility, Suitland, MD. This storage area, which will house approximately 100 spacesuits after their conservation, is a prototype for future suit storage. Storage racking and custom designed trays have been installed. The suit's materials, weight and size of the suits, accessibility to the collection, as well as the optimum environment for materials long-term are being considered.

3. CONCLUSION

Published guidelines and standards of practice for the conservation treatment, storage and display of spacesuits summarize information and research gathered during the Save America's Treasures spacesuit project. It is hoped that these guidelines will form a blueprint for further research. The information is being disseminated to organizations responsible for preservation of spacesuits and to museums that wish to borrow a spacesuit from NASM. These guidelines were produced in consultation with members of the NASM staff, industry experts, and conservation and preservation professionals.

NOTES

The photographs in figures 3-5 were taken by the author.

ACKNOWLEDGEMENTS

The author would like to thank everyone who donated his or her time to making this project a success. Special acknowledgement is owed to Amanda Young, curator of Spacesuits and Astronaut Equipment at NASM, for historical information on the spacesuits and her tireless efforts on behalf of this project. Ed McManus and Mary Baker should be recognized also for their conservation research performed on the spacesuits over the past decade.

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CONSERVATION THROUGH INVESTIGATION: UNCOVERING THE STORY OF A JAPANESE CEREMONIAL DOLL

LARA KAPLAN

ABSTRACT—This paper discusses the research and treatment of a 19th century Japanese *hina* or ceremonial doll from the collection of the University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, PA. It was necessary to determine the doll's art historical, stylistic and cultural context, as well as its construction techniques to decide on treatment options. To gain information on materials and techniques used in the doll's manufacture, analysis was carried out. Preliminary findings support much of the information found in art historical sources on *hina* dolls, and this doll was placed into its proper historical context with a higher degree of certainty. Treatment required an interdisciplinary approach, making use of materials and treatment techniques from objects, textile, paper and furniture conservation.

TITULO—CONSERVACIÓN A TRAVÉS DE LA INVESTIGACIÓN: DESCUBRIENDO LA HISTORIA DE UNA MUÑECA CEREMONIAL JAPONESA. **RESUMEN**—En esta ponencia se discutirá la investigación y análisis realizado, como proyecto estudiantil, de una muñeca ceremonial japonesa del siglo 19 de la colección del Museo de Arqueología y Antropología de la Universidad de Pennsylvania. La muñeca es una figura femenina sentada y vestida en estilo del período Heian, con un *kimono* de múltiples capas. Esta muñeca resultó ser un caso ideal para un proyecto estudiantil; su naturaleza compuesta ofrecía la oportunidad de experimentar tratamientos con diferentes tipos de materiales, combinando prácticas de conservación en textiles, objetos y papel. Más importante aún, era que esta muñeca tenía una historia que contar acerca de la cultura de

donde provenía. El valor de conservar esta muñeca estuvo en preservarla y compartir su historia. Para lograr este propósito, fue necesario comprender la manufactura, la historia y el contexto cultural de la muñeca.

Las muñecas ceremoniales japonesas, o muñecas *hina*, juegan un importante rol en la celebración del "Día de la niña japonesa" (*hina matsuri*). Durante esta celebración, que sucede al tercer día del tercer mes lunar, se ofrecen plegarias a la felicidad y futura prosperidad de las jóvenes. Como parte de la celebración, las muñecas se disponen en plataformas elevadas y se las ofrenda. Las dos muñecas principales en el escenario representan al emperador y la emperatriz. En escenas más elaboradas, pueden acompañar al par principal de muñecas, algunos oficiantes, músicos y otros personajes de la corte completado con mobiliario en miniatura y otros accesorios que pueden acompañar a la pareja.

La información que había acerca de esta muñeca *hina* en los archivos de la Universidad de Pennsylvania era muy escasa. Para revivir la historia de la muñeca fue necesario combinar varias perspectivas de investigación. La investigación por Internet y en biblioteca proveyó información introductoria sobre las muñecas *hina*, las visitas a museos que poseyeran muñecas *hina* en sus colecciones permitió hacer más estudios y comparaciones y, un completo estudio analítico de la muñeca dio luces sobre sus detalles constructivos. Esta ponencia tratará el proceso de investigación y el tratamiento de conservación que ayudó a descubrir y preservar la historia de este objeto.

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Figure 1. Front view of the University of Pennsylvania doll (29-264-1) before treatment.



Figure 2. Rear view of the University of Pennsylvania doll (29-164-1) before treatment.

1. INTRODUCTION

To conserve an object is to **help tell its story**. A Japanese *hina* or ceremonial doll (29-264-1) and its accompanying wooden platform from the collection of the University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia, PA (figs. 1, 2) offered an opportunity to explore the interdisciplinary nature of conservation. The doll was in poor condition and required treatment, but before treatment could be undertaken the doll's cultural context and materials and techniques used in its construction had to be researched and analyzed.

2. BACKGROUND

2.1 *HINA* DOLLS AND THEIR ROLE IN *HINA MATSURI*

Hina dolls are ceremonial dolls used in *Hina Matsuri*—the Doll Festival. This holiday also is known as Girl's Day and occurs on the third day of the third lunar month or March 3rd. It is a day for family and friends to bestow good wishes on young girls. As early as February, the dolls are displayed in the home on tiered platforms in front of painted screens. On the day of the festival, girls act as hostesses giving the dolls ritual offerings of sake and tiny diamond shaped rice cakes. Soon after the celebration, the dolls are carefully wrapped and put away. Leaving the dolls out for too long after the holiday is considered unlucky as it is believed to risk delaying a girl's marriage.

There are always two main *hina* dolls in the display, or *hina dan*—an imperial couple in Heian

period (784-1185) courtly dress known together as *darai-bina*. Who this couple represents is a matter of some debate. Some sources report that to most modern Japanese, they represent an idealized emperor and empress (Moore 2002); others claim they embody a more abstract sense of imperial heritage (Pate 1998). That the *darai-bina* are imperial, however, is not disputed.

2.2 HISTORY

Darai-bina evolved from a long history of doll use in Japan. Since early times, dolls have played many roles in Japanese culture. Though some dolls were used as playthings or for decoration, others functioned as powerful ritual objects. These dolls were believed to have the power to absorb the negative energies thought to cause disease and misfortune. Other forms of ritual dolls functioned as talismans, particularly for the protection of young children.

The Doll Festival itself also has a rich history stemming from Japan's early agrarian roots. March 3rd, the day of the festival, has long been sacred in the Japanese calendar. It was originally a harvest holiday, where purification rituals involving dolls were carried out as part of fertility rites. Though it is not clear exactly when the practice of displaying *hina* dolls began, by the beginning of the Edo period (1603-1868) the custom of exchanging sets of dolls as valued gifts for young girls was well established, and the annual doll display was common practice in court and samurai families.

Hina doll forms have evolved over time. The earliest forms were the standing *hina* (*tachi-bina*).



Figure 3. Three-quarter view of the University of Pennsylvania doll (29-264-1) before treatment.

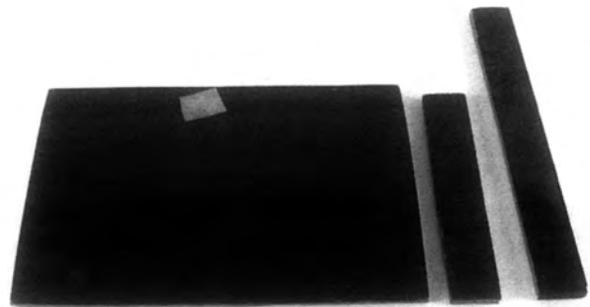


Figure 4. Recto of detached top and side pieces of platform before treatment.

Hina dolls in a seated pose (*suwari-bina*) are a later form thought to have originated no earlier than the 15th century (Gribbin 1984). One of the later styles of the seated *hina*, known as *kokin-bina*, is thought to have been manufactured first during the Meiwa era (1764-1772) by the Edo doll maker Hara Shûgetsu (Pate 1998). To this day, the *kokin-bina* style is considered to be the classic form for *hina* dolls.

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Kokin-bina (figs. 3, 4) are characterized by their round solemn faces with naturalistically rendered features, curved arms and elaborate costumes. The costumes worn by *kokin-bina* empress dolls are based on the *jūni-hito-e*, a “12 layer” formal kimono ensemble. The costume consists of a pair of wide-leg trousers (*hakama*), multiple layers of wide-sleeved robes (*ōsode*), an outer jacket (*karaginu*) often brocaded, and an apron known as the *mo* which flows down the back. In addition to the kimono ensemble, the dolls typically hold fans and wear ornate metal Chinese-style phoenix crowns.

2.3 CONSTRUCTION TECHNIQUES

Increased demand for the popular *kokin-bina* caused doll makers to develop new manufacturing techniques. The heads of *kokin-bina* originally were carved out of wood and covered with a substance called *gofun*, a mixture of oyster shell and starch paste polished to give the dolls’ faces a luminous porcelain-like appearance. Features such as carved eyes, eyebrows and mouths were enhanced with paint. In later *kokin-bina*, particularly those from the Meiji era (1868-1912), heads were molded out of a wood composite paste called *tōso* rather than being carved in wood (Pate 1998). With the advent of *tōso* came the use of glass inset eyes which replaced carved painted eyes.

Other aspects of *kokin-bina* manufacture followed traditional methods. There is a contrast in quality and finishing of inner and outer materials in the manufacture of the bodies of *kokin-bina*. The cores of the bodies are made of bound rice straw, wood shavings or other low-grade material, while the

doll’s *gofun*-covered faces and rich, silk clothing are highly finished. The dolls are regal and lofty, and at the same time close to the earth from which they came.

Manufacturing techniques also were borrowed from other crafts. The manner in which clothes were adhered appears in some cases to be similar to those used in scroll mounting (Uyeda 2002). This can be seen particularly on the sleeves of the *kokin-bina*, where several layers of fabric are overlapped to mimic the layered robes characteristic of imperial formal attire.

3. OBJECT DESCRIPTION

3.1 GENERAL INFORMATION

The doll from the Museum of Archaeology and Anthropology (figs. 1, 2, 3) is a seated female figure accompanied by a low wooden three-sided platform (fig. 4). A stylistic comparison with examples from other collections shows this doll to be an empress figure of the *kokin-bina* style, probably from the late Edo or early Meiji period. The museum’s curatorial records provide no evidence for this date, though an inscription on a label on the verso of the platform reads, “Bought in Chinese Quarter/in San Francisco/1868,” giving a possible indication of a late date for the doll.

3.2 HEAD, FACE AND HAIR

The head is removable (fig. 5) and appears to be made from the modeling paste *tōso*, rather than being carved from wood. The head is coated with *gofun*. A dowel adhered to the neck secures the



Figure 5. Head detached.

head to the torso. Facial features have been delicately modeled and are enhanced with paint. The eyes appear to be glass, which corresponds to historical information about the use of inset glass eyes with *tōso*.

At first glance, the doll's dark-brown hair closely resembles human hair. Upon closer inspection it is apparent that each "hair" consists of several strands of silk twisted together. The hair is bound



Figure 6. Detail of proper right sleeve showing gold-colored paper strips.



Figure 7. Detail of tassel and couched embroidery.

into a long ponytail that falls to the doll's waist. Originally there may have been a hair extension that further flowed down the doll's back, however this is now missing.

3.3 CLOTHING AND BODY

The costume consists of layers of fabric and paper that have been pasted to the doll's body. Various weaves are seen in the fabrics including plain, twill and compound. The compound weaves have floral patterns and from a distance are similar in appearance to brocade. Fabric colors include orange, dark blue, dark green, light green, gold, brown and purple.

All the fabrics are silk, although some of them include paper strips that are covered with a metallic-like material. Brownish-gold strips have been incorporated into the brocade-like fabrics as a weft material (fig. 6). Pinkish-silver strips have been wrapped around threads used in additional decorative elements such as tassels hanging from the doll's collar and couched embroidery on an orange cuff at the end of the proper left sleeve (fig. 7).

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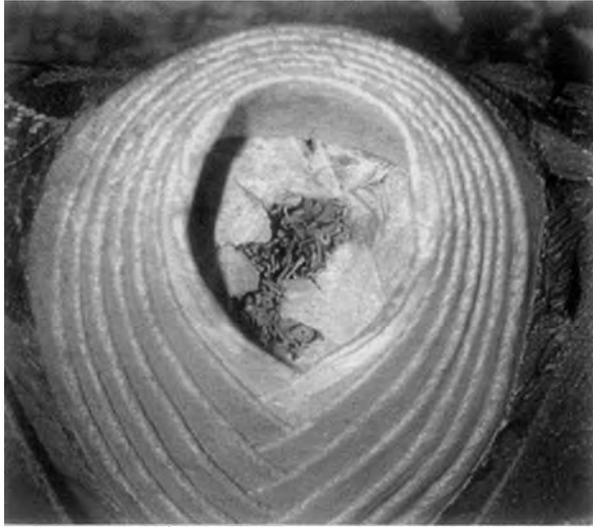


Figure 8. Interior of neck showing top of reed bundle.

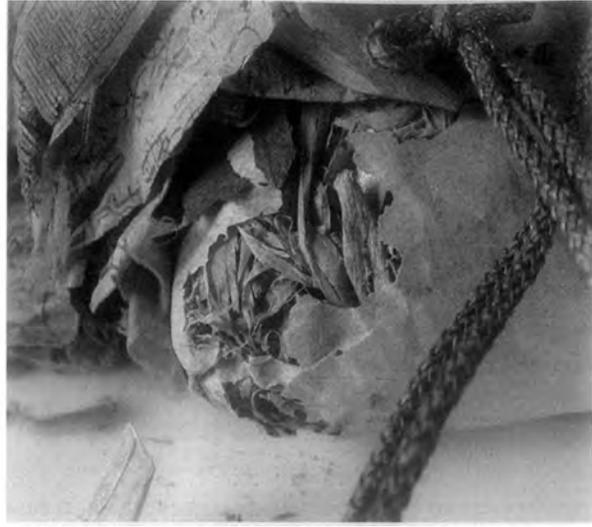


Figure 10. Areas of loss on knee form before treatment.

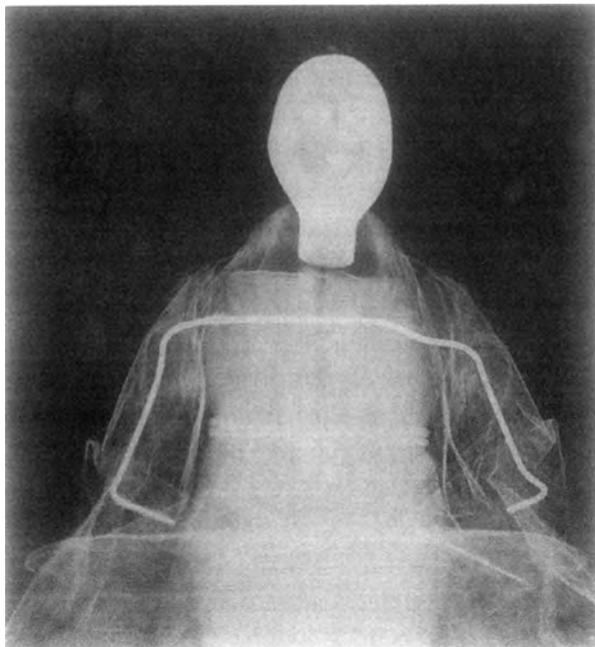


Figure 9. X-ray.

Paper elements are used extensively in the doll's construction. Many of the fabrics are lined with paper, some of which are printed with Japanese characters. Paper also covers the front of the form representing the doll's kneeling legs. Under the sleeves, a blue paper decorated with painted gold floral designs covers the sides of the knee form.

Several materials were used to form the doll's body. The torso is constructed of a bound bundle of reed-like elements. The top of the reed bundle can be seen in the interior of the neck when the head is removed from the body (fig. 8). The reed bundle itself and the wire armature forming the shoulders and arms can be seen in a frontal X-ray taken of the doll (fig. 9). The paper-covered knee form and the sleeves are padded with a straw-like stuffing material. This can be seen in areas of loss (fig. 10). The doll's arms are made of wood and terminate in tapered ends. No hands are present.

3.4 PLATFORM

The platform is wood, possibly cedar. On the visible surfaces of the platform, a coating of a shiny, black material resembling *urushi* has been applied. *Urushi* is a hard varnish comprised mostly of the resinous exudate of the tree *Rhus verniciflua*, native to Japan and China. The presentation surface has been more finely finished than the rest of the platform.

4. TECHNICAL ANALYSIS

4.1 OBJECTIVES

The aim of analysis was to identify materials used in the doll's manufacture. Determining the presence of materials that were known only to have been used after a certain date would be useful in placing the doll in its proper historical context.

Various parts of the doll were examined including the face and eyes, the torso bundle and stuffing material, the textile and paper elements forming the costume and the platform. Analytical techniques used included energy dispersive X-ray fluorescence (XRF) spectroscopy, Fourier transform-infrared spectroscopy (FT-IR), X-radiography, microchemical spot testing and paint cross-sectional analysis.

4.2 EXPERIMENTAL PROCEDURES

XRF was used to identify inorganic pigments in the *gofun* coating, to learn more about the materials making up the eyes, and to determine if any metals were present in the gold and silver-colored

paper strips in the textiles. The equipment used was a KeveX 0750. Analysis was run at 45 kV and 0.4 milliamps for 200 seconds over a 0-40 keV spectrum, with carbon as a secondary target. Data were processed with Toolbox software.

FT-IR was used to analyze the colorant and binder of the *gofun* coating on the face; the blue, green and purple fibers to determine the fiber type and dyes present; and the platform to help establish whether *urushi* or imitation lacquer was used. The FT-IR unit was a Nicolet Magna 560 bench with a Nic-Plan IR microscope equipped with a MCT (mercury cadmium telluride) detector cooled with liquid nitrogen. The aperture used was 1.5 mm, 120 scans were taken at a resolution of 4 wave numbers with a collection range of 4000 to 650 wave numbers.

Microchemical spot testing with iodine (I₂) in potassium iodide (KI) was used to test for the presence of starch in samples of *gofun* to determine if starch paste was used as a binder. Paint cross-sections were used to examine the coating stratigraphy on the platform.

Area Analyzed	Major Elements Detected	Minor Elements Detected
Cheek	Ca	Fe, Sr
Proper Left Eye	Pb	Ca
Proper Right Eye	Pb	Ca

Table 1. XRF results for face and features.

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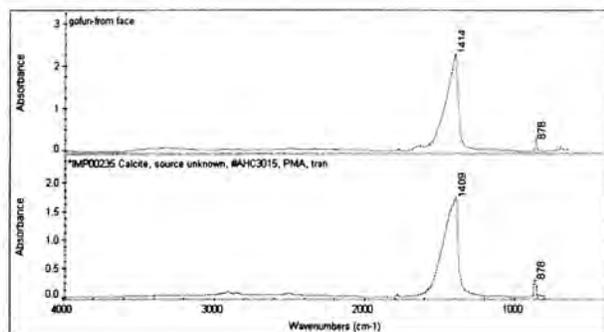


Figure 11. FT-IR Spectra of *gofun* and CaCO_3 reference.

X-radiography was used to provide information about the doll's inner structure, particularly in the torso area and the head. A frontal X-ray was taken of the doll with AA film at 20 kV and 2.5 mA. The tube distance from the film was 223.6 cm (88"), and the exposure time was 2.00 minutes.

4.3 RESULTS AND CONCLUSIONS

XRF showed the presence of calcium and small amounts of iron and strontium in the *gofun* coating (table 1). A sample of *gofun* analyzed using FT-IR also showed the presence of calcium carbonate. While these data together do not specifically confirm the presence of oyster shell (the colorant in *gofun*), at least they rule out the possibility that another white pigment such as lead, zinc or titanium white was used (fig. 11).

To determine the identity of the binder in the *gofun*, peaks corresponding to calcium carbonate were subtracted out of the FT-IR spectrum. The resulting spectrum was found to match the reference spectrum for hide glue, suggesting that a proteinaceous binder was used. This was unexpected, as most art historical sources indicated that the

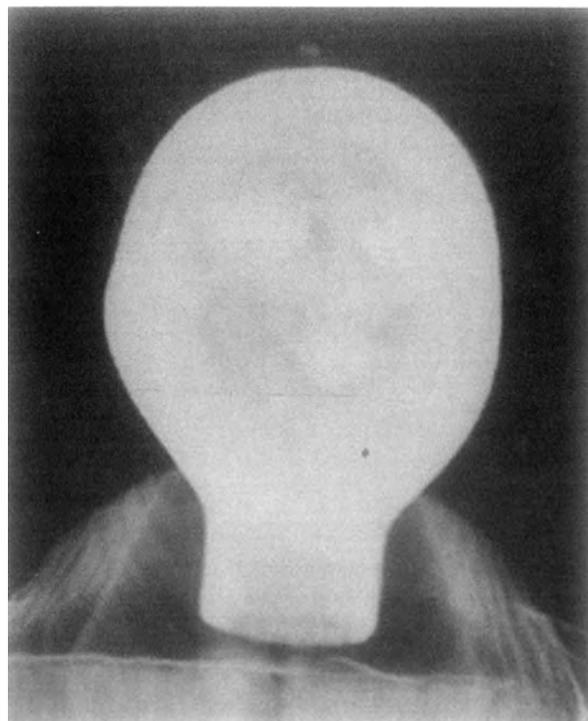


Figure 12. X-ray detail eyes.

binder used in *gofun* is starch paste. The absence of starch was corroborated by negative results from microchemical spot testing.

The composition of the eyes was not determined conclusively. Data suggest that the eyes might be lead glass. Because the eyes are deeply inset, the optimal tube sample distance could not be achieved. Nevertheless, XRF showed the eyes to contain lead (table 1), and on the X-ray (fig. 12), the eyes appear dense and opaque, suggesting the presence of a dense element such as lead. It was decided that taking samples from the eyes would be inappropriate, limiting the acquisition of further data.

Area Analyzed	Metals Detected
Gold-Colored Paper	Fe, Cu, Sn
White Fabric Surrounding Gold-Colored Paper	Fe, Cu, Sn
Silver-Colored Paper (couched embroidery)	Ag, Fe, Cu, Sn
Orange Fabric Surrounding Silver-Colored Paper	Ag, Fe, Cu
Silver-Colored Paper (tassel)	Ag, Fe, Cu, Sn

Table 2. XRF Results for paper strips and surrounding fabrics.

Indigo and safflower commonly are mentioned in the literature for dyeing the clothes of *hina* dolls (Gribbin 1984). FT-IR analysis of the blue fibers detected the presence of indigo. However in the purple and green samples any indigo that may have been present was masked by the presence of starch paste (which appears in the same area of the spectrum), and thus was not apparent. Safflower was not detected, nor were any synthetic dyes found.

The study shed light on the nature of the metallic-looking paper strips woven into the fabric. In the X-ray, the paper strips were not especially visible, suggesting little or no metal present. This observation was confirmed by XRF analysis. No metals were detected in the paper strips that were not also present in the surrounding fabric (table 2). In all cases, only small amounts of metals were detected. Similar amounts of iron, copper and tin were present both on the gold-colored paper strips on the proper left sleeve and on the white fabric into which they were woven. Similarly, the silver-colored paper strips from both the tassel and the couched embroidery on the proper left sleeve were

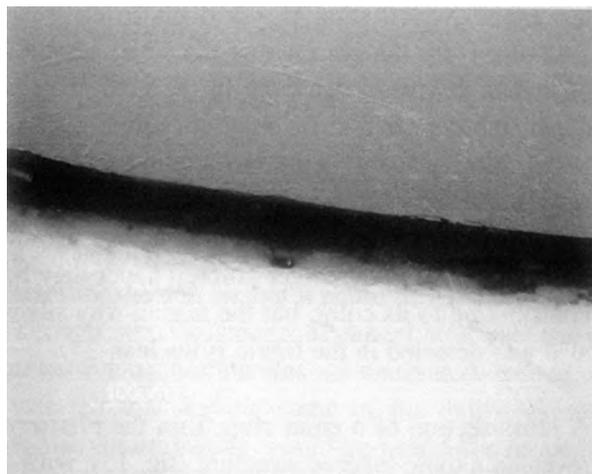


Figure 13. Sample from platform top seen under visible light.

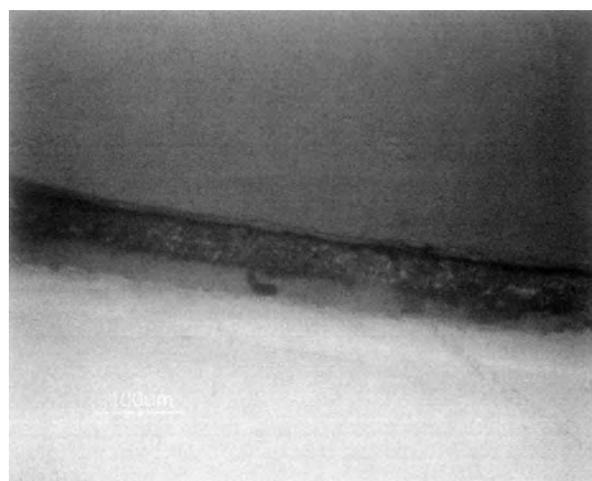


Figure 14. Sample from platform top seen under UV light.

found to contain small amounts of silver, iron, copper and tin; the fabric surrounding the couched embroidery had a similar spectrum, though a slightly smaller amount of silver was detected.

XRF data show that the paper strips are not covered with gold and silver metal leaf, but rather a

CONSERVATION THROUGH INVESTIGATION: UNCOVERING THE STORY OF A JAPANESE CEREMONIAL DOLL

less expensive imitation. It is difficult to determine the reasons for the presence of the small amounts of metals that were detected. In the gold-colored paper, the copper and tin may constitute a powdered coloring agent; in the surrounding white fabric, the iron may be due to dirt or some other contaminant and the tin due to tin-weighting of the silk. The silver in the silver-colored paper may be contributing to its color, but the reason why silver also was detected in the fabric is unclear.

A cross-section of a paint chip from the platform revealed a three-layered structure (fig. 13), with a ground layer, a heavily pigmented black layer, and a top varnish layer that fluoresced bright orange under UV light (fig. 14). Since a bright orange auto-fluorescence is typical of shellac and no *urushi* was detected, it seems likely that the platform is not genuine *urushi* but rather a Western imitation.'

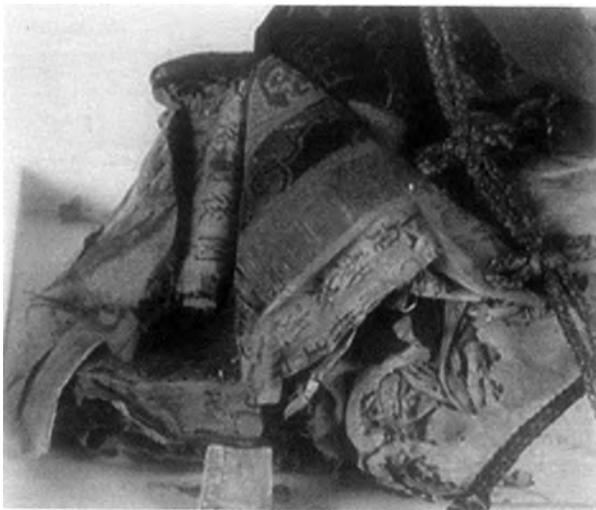


Figure 15. Proper right sleeve before treatment.



Figure 16. Fabric strip before treatment.

FT-IR showed a sample of the lacquer to have characteristics of both *urushi* and shellac. It may be that the platform originally was coated with *urushi* (which may not have been visible in the cross section) and was brightened at some later point with a layer of shellac.

5. CONDITION

Before treatment, the doll and platform were in poor condition. The doll could not be handled without causing further loss and damage. It was dirty and grimy, and had suffered many losses to its paper and textile elements. The proper left sleeve, though largely intact, was crumpled and damaged. The cuff of the proper right sleeve mostly was lost, so that padding material could fall out of the sleeve's open end. In addition, a strip of fabric-lined paper that was meant to lie horizontally

over the main body of the proper right sleeve was torn and folded over (fig. 15).

Though the textiles were fragile, many of the dyes remained vivid. The orange dyes, however, had faded significantly and discolored where exposed to light. This especially was visible on a piece of orange silk crepe lined with paper that had become detached from the doll (fig. 16). It was folded in half and was faded and discolored on top but showed a rich orange color on the bottom.

The platform was disassembled and one of the side pieces was missing. The platform top had warped as well. Despite this damage, the wood and the black coating covering the platform were in good condition overall.



Figure 17. Doll and platform after treatment.

6. TREATMENT

6.1 TREATMENT GOALS

Before treatment could begin, several considerations had to be addressed. Since the doll was to be used largely for research, the primary goal was to stabilize the doll so that it could be handled safely. Though some cosmetic treatment was necessary, extensive restoration was not warranted. Indeed, it was felt that leaving some of the doll's layered sub-structure visible would be useful for research purposes. Of equal importance was determining a respectful way to approach an object that may for some have spiritual significance.

6.2 CLEANING AND CONSOLIDATION

The treatment of this *hina* doll required the use of strategies from objects, textile, paper and furniture conservation. Treatment began with an overall cleaning of the doll and the platform using a soft brush and a Nilfisk HEPA filter vacuum with variable speed control. Low suction was used, and the vacuum's nozzle was covered with nylon net to prevent loss of any pieces that might become detached during cleaning. Vacuuming alone significantly improved the doll's appearance; the colors appeared brighter and the designs in the textiles were more apparent. Cleaning the doll's face also improved the doll's appearance. After testing various solvents, it was found that gentle rolling with a swab barely dampened with ethanol cleaned the face without damaging the *gofun* coating.

Lifting paper strips and silk threads were consolidated and tacked down with brush applied methyl

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cellulose (3 g in 72 ml water/100 ml ethanol; unless otherwise noted, this concentration was used throughout the treatment). Fragile and frayed areas of silk were consolidated and protected with dyed nylon net overlays. The nylon net first was coated with a 2% solution of 8000 cps methyl cellulose in deionized water and allowed to dry. It then was cut to size, put in place and reactivated with mist from a nebulizer. Losses to paper elements were compensated with Japanese tissue fills.

6.3 PLATFORM

The last step was the treatment of the platform. Since the coating was in good condition and the wood still was relatively flexible, it was decided to humidify the platform and flatten it under weights. After applying a barrier coat of cyclododecane (a wax that sublimates directly from a solid to a gas) to the paper label, water was sprayed directly onto the verso of the platform top with a dahlia sprayer. Damp blotters then were placed on the platform and covered with plastic sheeting. Once sufficiently humidified, the platform top readily flattened under weights. Blotters were changed so that the platform top dried slowly over several days. In the meantime, a replacement for the missing side piece was fabricated, and when the top piece was dry the platform was reassembled with hide glue and the treated doll placed on top (fig. 17).

7. CONCLUSION

Uncovering the story of this Japanese *hina* doll necessitated input from disparate sources. Each step of the process required a search for trends and patterns. Due to its interdisciplinary nature, the

treatment of this *hina* doll was a particularly illustrative example of this process.

ACKNOWLEDGEMENTS

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Museum of Fine Arts, 465 Huntington Avenue,
Boston, MA 02115.

SOURCES OF MATERIALS

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Tel: (800) 327-8448

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Ayex-P wheat starch paste
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FOUR SPANISH POLYCHROME PROCESSIONAL SCULPTURES FROM THE EARLY 18TH CENTURY AND A MASTERPIECE IN FOCUS

MAUREEN RUSSELL

ABSTRACT—The paper discusses the history and contemporary presentation of processional sculpture carried during *Semana Santa* or Holy Week which precedes Easter Sunday in Seville, Spain. The conservation of four Spanish polychrome sculptures in the collection of the Los Angeles County Museum of Art (LACMA), Los Angeles, CA is presented, with special focus on the technical investigation of *The Pietà* (circa 1725). Although the nearly life-size sculpture appears to be carved from wood, it is actually one of the few surviving images fabricated almost entirely of finely woven linen made rigid with calcium sulfate with only the Virgin's head and hands constructed of cast plaster. X-ray radiographs reveal virtually no interior armature. The unique linen construction is significant because it renders the sculpture more lightweight and therefore ideally suited for carrying in religious processions. The conservation of a classic *Virgin Dolorosa* or Sorrowing Virgin, including the reconstruction of a missing glass eye using wax, powdered pigments and Gamblin Conservation Colors is also detailed.

TITULO—PREPARÁNDOSE PARA LA PUESTA EN VALOR DE UNA OBRA MAESTRA: EL TRATAMIENTO DE CONSERVACIÓN E INVESTIGACIÓN TÉCNICA DE CUATRO ESCULTURAS DE PROCESIÓN ESPAÑOLAS DE PRINCIPIOS DEL SIGLO XVIII. **RESUMEN**—El Los Angeles County Museum of Art instaló una exhibición titulada "Tendencias, una nueva presentación de la colección de arte europeo del LACMA", con el objetivo de dar a conocer las nuevas adquisiciones del Centro para el Arte Europeo del museo. De particular importancia son cuatro curiosas esculturas policromadas

españolas que se exponen por primera vez. Ellas datan de principios del siglo XVIII y fueron originalmente realizadas para ser usadas en las procesiones religiosas de Semana Santa, la semana que precede el Domingo de Pascuas. El Departamento de Conservación aprovechó la oportunidad de su exhibición para conservar y estudiar con detalle estas esculturas.

La pieza central de la exhibición es la "Piedad", una imagen icónica de la Virgen María sosteniendo el cuerpo de Cristo. Esta obra de arte de tamaño casi natural es la única escultura de su tipo conocida en algún museo estadounidense. Es también una de las pocas esculturas hechas con cola o goma saturada y lino moldeado que sobreviven a la fecha. La liviandad de los materiales usados hacen que estos iconos sean ideales para ser trasladados en procesiones religiosas. Esta escultura es particularmente notable por su equilibrada composición y su convincente expresión de dolor o patetismo. La cabeza y las manos de la Virgen están esculpidas en yeso, sus ojos se hicieron con vidrio para alcanzar mayor realismo. Vestida con una lujosa cascada de paños, su manta dorada fue labrada con variados diseños realizados en la técnica de "estofado" (el sustrato de lino moldeado es primero dorado, se pinta con colores brillantes y luego se graban en él diseños que imitan una tela brocada tejida con hilos de oro).

En la actualidad, se está llevando a cabo un examen técnico para dilucidar el método y materiales de manufactura. Las radiografías de rayos X realizadas en el Getty Museum revelan un centro hueco con una armadura limitada. Otros métodos de análisis incluirán espectroscopia infrarroja,

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microscopía de luz polarizada y fluorescencia de rayos X.

La presentación de la "Piedad" es realizada con otras esculturas relacionadas de la colección permanente del LACMA. Un "Busto de Mujer Doliente", del siglo XVIII, hecho de madera policromada con ojos de vidrio, era originalmente una "imagen de vestir", que corresponde a un tipo de maniquí en el cual sólo su cabeza y brazos se trataban, como si fueran esculturas completamente terminadas.

También se conserva y está en exhibición una reciente adquisición de la colección, un "Cuerpo de Cristo Moribundo", que corresponde a un pequeño crucifijo hecho de fibra macerada y yeso, como la "Piedad" española. Esta escultura es particularmente interesante porque su corona de espinas está hecha con espinas de pescado verdaderas y coral incrustado.

La cuarta escultura corresponde a un "Busto de una Virgen Doliente", de alrededor de 1700, hecho de madera dorada policromada y que fue prestada a nuestro museo por la Huntington Library, Art Collections and Botanical Gardens de San Marino, California. Este busto de madera tallado fue descubierto recientemente en el subterráneo del Huntington Museum. Un ojo de vidrio se perdió parcialmente y la pieza estaba cubierta por la acumulación de décadas de suciedad y mugre. El tratamiento de conservación y el examen técnico aplicado a esta escultura reveló nueva información, como por ejemplo, que un manto de diferente color existió bajo el actual y que delicadas capas

de dorado y grabado del tipo "estofad" existían bajo antiguas restauraciones del yeso.

La exhibición "Tendencias" incorpora una variedad de disciplinas y sistemas mediáticos, en una instalación contextual para fomentar el conocimiento general del visitante acerca del arte y la vida europeo, todo presentado en galerías que sugieren el medio ambiente propio de los siglos XVII y XVIII europeo. Está en los objetivos futuros de LACMA presentar sus colecciones de manera que se comprometan todos sus departamentos, curadores, conservadores, estudiantes y el público, para apreciar sus obras con nuevos enfoques que representen o ejemplifiquen la fusión de los talentos y recursos del museo.

1. INTRODUCTION

Following the 1994 exhibition *Spanish Polychrome Sculptures, 1500-1800 in United States Collections*, the Los Angeles County Museum of Art (LACMA), Los Angeles, CA has pursued actively the acquisition of Spanish polychrome sculptures to enhance its collection of European art. The recent acquisition of four Spanish polychrome processional sculptures all requiring conservation provided the author with the impetus to travel to Spain to witness the ritual use of these devotional objects (fig. 1). This paper focuses on the history of Spanish polychrome processional sculpture, its contemporary context and the examination and conservation of LACMA's latest arrivals.

The four sculptures acquired by LACMA date to the last three decades of the Golden Age of Spain,

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Figure 1. Sevillian processional *pasos* or float depicting the Crucifixion.

1700 to 1730. They are processional sculptures; devotional art made to be carried during *Santa Semana* or Holy Week, the week which precedes Easter Sunday. All incorporate the visceral realism that was popular at the time and which is particular to devotional sculpture in Spain. Realistic polychromy was eschewed in other parts of Europe where white marble and bronze were the materials of choice. The Spanish sculptures emphasize an exaggerated sense of realism with glass eyes and tears, ivory or bone teeth and shockingly convincing wounds and blood (Stratton 1993). They were conceived during the turbulent years of the Spanish Inquisition and were meant not only to inspire devotion but also to spur the devoted to perform acts of penance and self-mortification.

The innocent viewer who expects to see a mere statue instead comes away shocked, having viewed a dressed corpse or a tormented image of a mother whose tortured and bleeding son has just died on a crucifix. They are images that are meant to engage and provoke the viewer and number among the most illusionistic sculptures ever made (figs. 2, 3).

2. HISTORY OF SPANISH PROCESSIONAL SCULPTURE

The historical context of processional sculpture intertwines legend with truth. In 1248, King Ferdinand liberated the southern area of Spain from the Moors and reorganized Seville in typical medieval fashion, dividing up the streets and areas according to nationality and profession. When these areas later became official parishes, they maintained a parallel professional orientation, such as the merchants' guild of the parish of El Salvador, the carpenters' guild of San Andrés, the



Figure 2. Gregorio Fernández, *Reclining Christ* (circa 1625-1630). Held in trust by Museo del Prado. No accession number.

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Figure 3. Gregorio Fernández, *Sexta Augustia* (detail). Valladolid, Confradía de Las Angustias.

cloth and canvas makers' guild of the Magdalena. Although secular, the trade guilds had both an economic and a spiritual character. They maintained trade workshops and hospitals that ministered to both the physical and spiritual needs of their members. They acted as burial societies and maintained small chapels where their patron saints were venerated. The guilds were all powerful in the lives of their members and in the flow of Seville's medieval economy.

The power of the guilds did not go unnoticed by the Crown who held exclusive jurisdiction over civil associations. In 1528, they were outlawed when Charles I condemned the activities of the guilds, accusing them of "sins, monopolies, price fixing, and very great scandal" and revoked the privileges of "all the confraternities except the [wholly] spiritual ones" (Webster 1998, 20). In a bid to stay in existence, the banned trade unions became confraternal brotherhoods sponsored by the guilds and then sought to align themselves with

an even greater authority than the Crown, the Catholic Church.

In 1615 the Sevillian penitential confraternity of *la Pasión* commissioned the renowned sculptor Juan Martínez Montañés to create a sculpture of Christ carrying a cross for their group to carry and present to the Church during Holy Week. According to legend, when the great artist saw the sculpture borne in procession for the first time, he followed it through the streets crying out in amazement that his sculpture had come alive and how could he have given life to such a devout and expressive image (Webster 1998). The scene acquired mythic proportions and was recreated by the 19th century Sevillian painter Joaquín Turina y Areal (figs. 4, 5). Montañés gained the reputation as the greatest sculptor of his time with the sobriquet "God of Wood". Today some 400 years later, the same confraternity still carries the sculpture of *Jesús de la Pasión* in ritual procession on the Thursday before Easter in Seville (Webster 1998).

3. CONTEMPORARY PROCESSIONS IN SEVILLE

The author visited Spain during *Santa Semana* in Spring 2002 to photograph the processions for this research and had the opportunity to experience the religious and aesthetic context of artwork similar to those treated and researched over the last few years. In a contemporary context, the processions may appear very strange. A Spanish guidebook cautions:

Be so kind as to come with a benevolent disposition, prepare yourself to try to understand that which at first sight may be difficult, if not

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Figure 4. Joaquín Turina y Areal, *Martínez Montañés at the exit of the confraternity of La Pasión* (circa 1890). Seville, Confraternity of La Pasión, Church of El Salvador.

impossible to understand. Because all attempts at understanding will be of no avail if prejudices and prior judgments are not put aside, or if inadequate information is allowed to influence your perception of Holy Week in Seville (Molina 1997, 3).

Santa Semana is not a spontaneous event. It is a legacy repeated every Spring, in much the same way as it was in medieval times. All year, confraternal members work with a parish priest in preparation for Holy Week. They perform acts of charity and penance, daily chores and acts of devotion to their patron saint or the Virgin Mary, as well as Lenten rituals required by the Catholic Church. They draw on the skills of artisans whose craft has not changed over the centuries to prepare the floats, costumes, and members' uniforms for the processions. The sculptor carves the religious images and decorative wood elements that adorn



Figure 5. Juan Martínez Montañés, *Jesus de la Pasión* (circa 1615). Seville, Confraternity of La Pasión, Church of El Salvador.

the float and the silver and gold worker fabricates the ornamental metal trim, sconces and elaborate candelabra. The gilder applies thin sheets of gold and silver to the delicate metalwork. The embroiderer painstakingly stitches the canopy, textiles and costumes with intricate, detailed needlework (Molina 1997). The artisans labor together throughout the year with the Brotherhood in preparation for *Santa Semana* and for only one week we see their efforts in procession on the narrow streets of Seville.

The procession begins and ends in the guild's local parish or neighborhood and winds through the crowded streets of Seville to the cathedral. Routes were established centuries ago when guilds were territorial and street battles erupted whenever rival groups failed to give way. Members wear the same dress and insignia their ancestors wore centuries before; their capes, mantles, and hoods make them

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Figure 6. La Confradía del Cacharro in procession.

anonymous. The color of the tunic represents the liturgical color of the Brotherhood's patron saint or is related to religious, monastic or military orders (Molina 1997). The flowers carried not only increase the realism of the scene but the colors convey a specific visual association represented in the processional tableaux. Red represents the passion or blood of Christ, white is associated with purity, and purple, the regal color of Christ's divinity.

A written program notes that the confraternity of *El Cachorro* with 1500 members (fig. 6) was formed in 1689 and the sculpture they carry was created in 1682. Each confraternity carries two floats or *pasos*. One represents any scene from the life of Christ, usually associated with the Passion (fig. 7) or the moments leading up to and including Christ's crucifixion and death. The other float has become an art form in itself and depicts the Virgin Mother portrayed as a Sorrowing Virgin (*Virgin*

Dolorosa) at the moment her son died on the cross. Traditionally, the sculptures have glass tears and sometimes, swords signifying the seven sorrows which pierce the Virgin's heart (Webster 1998) (figs. 8, 9).

The confraternal participants are known as Nazarenos; groups of penitents in the membership walk the route barefoot and carry a cross. All walk slowly in single file. Contradictory emotions are at play as the processions are celebratory and joyous yet austere and solemn. It is a family event as well as a period for individual reflection and penance. Hooded fathers walk beside their small children. Children carry baskets filled with candies that they pass out along the way. Originally, the confraternities and the processions were exclusively male but today young girls and women participate.

Young men of the confraternity take on the arduous role of *costaleros* or float bearers which is considered another form of penance. To lift and



Figure 7. A processional *pasos* or float with multiple figures depicting the Passion of Christ.



Figure 8. *Virgin of the Esperanza Macarena* (detail: head with glass eyes and tears). Seville, Confradía de La Macarena.

carry each float requires between 30 and 40 *costaleros*. Deputies are present in each group of Nazarenes and penitents to maintain order. No words are spoken. A wooden clapper is used to signal to the float bearers when to lift and when to move on. An eerie music or *saeta* accompanies each tableau. It combines a flamenco rhythm and a funeral dirge. It is a prayer, a song, popular liturgy and melds the music with the image before the viewer. *Santa Semana* lasts just one week but weaves a lasting spell that combines tradition, drama and artistry together, and allows the viewer a glimpse back to the medieval age that created it.

4. LOS ANGELES COUNTY MUSEUM OF ART'S FOUR SCULPTURES

4.1 THE PIETÀ

In 2000, LACMA acquired a life-size sculpted *Pietà*, circa 1725 (fig. 10). The sculpture repre-



Figure 9 *Our Lady of Rocío*. An elaborately dressed *imagen de vestir*. Seville, Confradía Beso de Judas.

sents an iconic image of the Virgin Mary holding the dead body of Christ after his crucifixion. The nearly life-size work of art most likely originated in Seville or Cordoba and it is the only known sculpture of its kind in an American museum.



Figure 10. *Pietà* (circa 1725). Los Angeles County Museum of Art. M.2000.12.

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Figure 11. *Pietà* (X-ray radiograph showing proper right side of Virgin's torso).

Although upon initial viewing the sculpture appears to be carved from wood, it is actually one of the few surviving images fabricated almost entirely of linen made rigid with calcium sulfate or plaster. The unique linen construction is significant because it renders the sculpture more lightweight and therefore, ideally suited for religious processions.

X-ray radiographs taken at the J. Paul Getty Museum, Los Angeles, CA reveal virtually no interior armature except for two wire extensions that coil around the arms and attach to a narrow strip of wood set diagonally in the upper torso of the figure (fig. 11). The Virgin's head and arms are made of plaster. A metal dowel runs into the head down into a wooden collar, another dowel with contemporary machining probably was added later and supported a halo.

A coring executed under magnification helped clarify the layering sequence. The coring site was located on the proper left side of the Virgin's mantle, directly behind Christ's elbow through the relief *estofado*, the traditional technique of polychromy in Spain. It shows first, a paint layer, a layer of gilding, a red layer that is probably bole, a thick compressed white ground, and an underlying layer of gauzy fabric. A cross-section taken from the same location shows that the top layer is a glue layer that serves as a varnish. The second layer is a green pigment and is suspected to be an artificial copper carbonate or artificial malachite based on Fourier transform infrared (FT-IR) and Raman spectroscopy. The third layer is a thin gold layer followed by a red-iron oxide layer, next is the gypsum or calcium sulfate layer which covers the fabric layer. Structurally the bast fibers form a thread which is woven and the warp and weft can be discerned.



Figure 12. *Pietà* (detail showing the Virgin with draped mantle and cloak). The fabric was saturated in plaster to stiffen the drapery folds in the *tela encolada* technique and then was polychromed in *estofado*, the traditional technique of polychromy in Spain.

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The Virgin's cloak was formed from freely draped, finely woven linen that was soaked in plaster in order to stiffen the drapery folds (fig. 12). This technique is called *tela encolada* in Spanish. The stiffened fabric then was polychromed in *estofado*. In this process the surface was covered in gold leaf and then coated with paint. The painted layer was subsequently incised with patterns to reveal the gold underneath, often to simulate the weave of a brocade. Interestingly, according to LACMA curators and conservators, the Virgin is wearing an actual sewn dress; not a draped cloth made to resemble a dress. The figure of Christ is made of finely woven linen, probably formed by pressing it into a mold and then coating it in plaster.

4.2 THE EXPIRING CHRIST

The *Expiring Christ* (fig. 13) is an accessory sculpture that was mounted on a crucifix and carried in the arms of another sculpture as is illustrated here in figure 14. It dates to between 1690 and 1700 and is made of macerated bast fiber made rigid with



Figure 13. *Expiring Christ* (circa 1700) (detail). Los Angeles County Museum of Art. TR.130.10.2.



Figure 14. Pedro de Mena, *The Repentant Mary Magdalene* (circa 1664). Held in trust by Museo del Prado. The sculpture carries a crucifix similar to LACMA's *Expiring Christ*.

gesso. It is extremely lightweight and is only 20.3 cm (8"). The head is made of terra cotta. Under magnification, the crown of thorns appears to be made of dyed hemp fiber intertwined with the spines of a marine animal, probably a sea urchin used to represent the thorns. Small fragments of coral are also embedded in the crown.

4.3 BUST OF A FEMALE SAINT

The *Bust of a Female Saint* (fig. 15) is a carved wooden bust known as an *imagen de vestir* literally, a sculpture made to be dressed. This type of sculpture was fabricated from a simple armature with attached carved head and hands. Only the exposed parts of the body needed to be beautifully finished as the bust. The sculpture was dressed in elaborate garments that covered the armature. Confraternal records show that an *imagen de vestir* often had many garments that were donated by wealthy patrons and could be changed to the commemorative colors worn on a specific feast or holy day.

FOUR SPANISH POLYCHROME PROCESSIONAL SCULPTURES FROM THE EARLY 18TH CENTURY AND A MASTERPIECE IN FOCUS

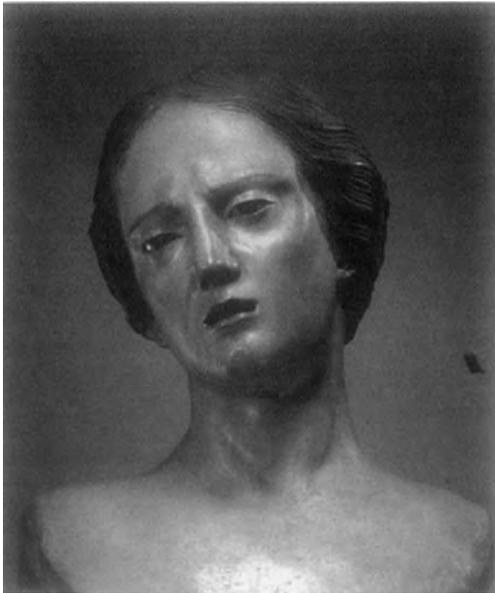


Figure 15. *Bust of a Female Saint* (circa 1725). Los Angeles County Museum of Art. AC.1995.174.1.



Figure 16. *Bust of a Sorrowing Virgin* (circa 1725). The Huntington Library, Art Collections, and Botanical Gardens. L.2000.7.

4.4 BUST OF A SORROWING VIRGIN

The *Bust of a Sorrowing Virgin* is a classic Spanish processional *Virgin Dolorosa* (fig. 16). The carved wooden bust fabricated circa 1725 was found under an old tarp in the basement of the Huntington Library, Art Collections, and Botanical Gardens in San Marino, CA. Since the Huntington's mandate precludes the exhibition of anything but British and French art, the sculpture was offered to LACMA on long-term loan. Processional sculptures are quite rare. Their fragile construction and their frequent, repeated use in processions mean they seldom survive.

Treatment of the bust was challenging. Years of accumulated dirt and grime obscured the fine carving and incised *estofado* as well as the overall condition of the sculpture. In addition, the proper right



Figure 17. *Bust of a Sorrowing Virgin* (old pine tar resin fills and new fills with CSS PVA filler, during treatment).

glass eye was partially missing. Poultices and solvents could not be controlled precisely to ensure the original surface would not be damaged during removal of the surface dirt. Mechanical cleaning under the microscope allowed the dirt layer to be removed without disturbing the underlying surface. Cleaning revealed historic pine tar resin fills under the dirt layer. The old fills were quite adequate, and as their removal likely would have led to additional damage, they were left in place. Any overfills were trimmed back to improve their aesthetic appearance. CSS PVA fill material (a water-based emulsion with calcium carbonate, water and Polyvinyl Acetate Polymer) was used to fill pinholes and make final adjustments to the old fills (fig. 17). After cleaning the sculpture, tracks of crizzled paint on the cheeks became visible. These tracks traced where the tears were depicted originally lending further evidence to the bust being a classic *Virgin Dolorosa*.

The prominent loss to the proper right glass eye required a flexible material to fill the gap that was also translucent and easy to apply. Since there is no

access to the back of the sculpture, an epoxy resin could not be used. It could not be isolated with a dam or support and would, consequently, wick into the surrounding wood causing irreversible damage. Also, with no access to the glass eye from behind, a cured epoxy fill could not be trimmed from the sides or verso.

Although it is a fragile alternative, wax was selected for the repair because it met the necessary requirements. Multiwax W-445, a soft microcrystalline wax with a melting point between 76 and 82°C, was melted in a crimped aluminum dish and mixed with powdered pigments. The colored wax was slightly gritty and matte but was easily applied to the missing section and bridged the loss without covering any original remaining glass. Gamblin Conservation (Portland, OR) colors were used to improve the color of the pupil and inpaint the iris. The pigments covered sufficiently for a good color match. However, the color was still matte and gritty and lacked the necessary glassy appearance of the rest of the eye. In order to achieve the appropriate glassy look, the Gamblin Galdehyde resin



Figure 18. *Bust of a Sorrowing Virgin* (proper right glass eye with missing section, before treatment).

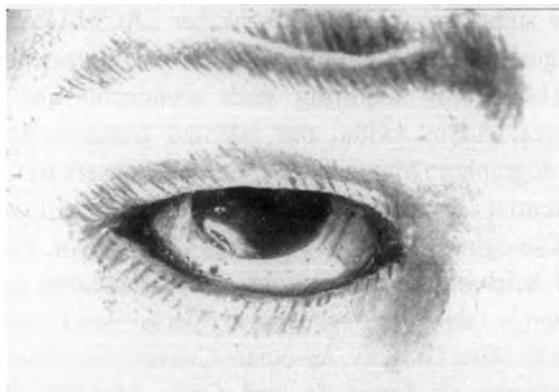


Figure 19. *Bust of a Sorrowing Virgin* (proper right glass eye with wax fill, after treatment).

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solution was wicked onto the wax fill. Whenever the resin pooled or pulled away during the seven-hour cure time, a little more was applied on a brush tip until the resin leveled and eventually cured with an even glassy surface (figs. 18, 19). The same resin was used to bead in the tears following the original remaining tracks. Because the wax fill is somewhat soft if touched and will attract dust, the sculpture will be exhibited under a vitrine with a stable and relatively low gallery temperature.

5. CONCLUSION

Thank you for sharing this *Santa Semana* journey. As anyone who has witnessed the event will tell you, it is an enlightening way to observe sculpture away from the static confines of a museum gallery. The ritual context, combined with the movement of the procession, profoundly transforms and effects the devotional sculpture, elevating it beyond the status of a carved wooden object to the function for which it was created.

ACKNOWLEDGMENTS

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their editing skills and most of all their patience and friendship. I would like to dedicate this paper to my father, Col. Gerald F. Russell, who shared my trip to Spain and enthusiastic discovery of the art of Spanish processional sculpture.

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Diario El País. S.L. Comunicación y Turismo S.L.
(Brochure)

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SOURCES OF MATERIALS

CSS PVA filler (water-based emulsion with calcium carbonate, water, and Polyvinyl Acetate Polymer), Multiwax w-445 a microcrystalline wax
Conservation Support Systems
924 West Pedregosa Street
Santa Barbara, CA 93101
Tel: (800) 482-6299

Gamblin Conservation Colors and Galdehyde Resin Solution
P.O. Box 625
Portland, OR 97207
Tel: (503) 235-1945

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YET ANOTHER PADDED HANGER

JANE L. MERRITT AND CAROL B. REED

ABSTRACT—Garments in good condition commonly are stored by hanging them from padded hangers. The padded hanger provides support when its size and padding conforms to the style and shape of the garment. A hanger mis-sized for the shoulder area of a garment can cause damage.

Many options exist for constructing padded hangers. Typically, they involve the use of a purchased polystyrene or wooden hanger and added padding and covers. Cotton or polyester batting or polyethylene foam cushions the hangers. There are disadvantages to using purchased hangers. Wood and polystyrene hangers produce acidic fumes and must be sealed before use. The hanger's metal hook can rust; often the shaft is not long enough to allow for any customized padding in the neck or collar area.

Re-housing the textile collection at Gettysburg National Military Park, Gettysburg, PA afforded the authors the opportunity to develop and test a new type of padded hanger that can be custom-fit to any garment shape. This paper, based on a poster, describes the materials and process of fabricating a hanger which takes little time to make and is cost effective.

TITULO—SIN EMBARGO (O CON TODO), OTRO TIPO DE COLGADOR ACOLCHADO. **RESUMEN**—Los trajes que se encuentran en buenas condiciones se guardan comúnmente suspendidos de colgadores acolchados. Este tipo de colgador es un buen soporte sólo si el tamaño y el acolchado del colgador se adapta al estilo y forma del traje. Un colgador demasiado corto o largo en

relación al área de los hombros del traje, causará daños tales como estrés o rajaduras.

Existe variadas opciones para fabricar colgadores acolchados. Típicamente, se utilizan colgadores comprados de madera de poliestireno, como base al cual se le agrega el acolchado y cobertura. Se ha sugerido usar rollos estables de poliéster o algodón y espuma de polietileno para acolchar los colgadores y muselina de algodón o medias de algodón para cubrirlos por el exterior.

Son varias las desventajas de usar colgadores comprados. Los colgadores de madera y poliestireno desprenden vapores ácidos y deben ser sellados antes de usarse. El gancho de metal del colgador puede oxidarse, y, generalmente, su eje no es lo suficientemente largo para el acolchado que el conservador necesite para el área del cuello.

La relocalización de la colección textil del Gettysburg National Military Park, le ha dado la oportunidad a los autores para desarrollar y testear un nuevo tipo de colgador acolchado que puede acomodarse a cualquier forma de traje, que usa materiales estables, toma muy poco tiempo en hacerse y es de bajo costo.

El colgador se fabrica con un tubo de Ethafoam de 2 pulgadas de diámetro, disponible en el mercado. El Ethafoam puede ser cortado y moldearse de cualquier manera para formar el área de los hombros del traje. Se corta una varilla delgada de acero inoxidable del largo deseado y un extremo se curva para formar el gancho del colgador. Este se inserta en la mitad del tubo. Finalmente, se cubre el colgador ya sea con algodón o con una media de poli-

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ester. Se realiza un ojal en cada extremo del Ethafoam y se mete la media dentro de él. No se requiere costuras. Los colgadores pueden ser hechos muy rápidamente y sin mayor costo.

1. INTRODUCTION

Garments in good condition often are stored by hanging them from padded hangers. The padded hanger provides support only if the size and padding of the hanger conforms to the style and shape of the garment. A hanger that is too short or too long for the shoulder area of the garment will cause damage such as stress or tears.

Most instructions for padded hangers are based on a purchased hanger made from wood or polystyrene. These must be sealed before use. In addition, the neck of the hanger may not be long enough to pad out a collar or the collar may stand up higher than the hanger neck and touch the pole of the storage cabinet.

These instructions use a commercially available 5 or 7.5 cm (2 or 3") diameter solid Ethafoam tube and thin stainless steel rod to create a custom hanger (fig. 1). The Ethafoam tube can be carved to conform to the shape of the neck and shoulder area or augmented with padding to provide support for a hanging garment. The thin stainless steel rod is cut to the desired length specifically to accommodate the height of the collar or other neck detail and one end is rounded to form the hook for the hanger. It is inserted through the middle of the tube. A final layer of either cotton or polyester stockinette covers the hanger. A slit in each end of the Ethafoam tube allows the stockinette to be

tucked into the slit. Hangers can be made quickly, as no sewing is required, and without much cost.

2. MATERIALS

Stainless steel rod (302/304 soft temper), 0.125 cm (1/8") diameter

Stainless steel washers

5 or 7.5 cm (2 or 3") diameter solid Ethafoam tube

7.5 cm (3") diameter white or natural cotton or polyester stockinette

Straight pins

Measuring tape

Pliers

Knife (to cut and carve Ethafoam)

Spatula or bone folder

Sandpaper

Cotton twill tape

Polyester batting

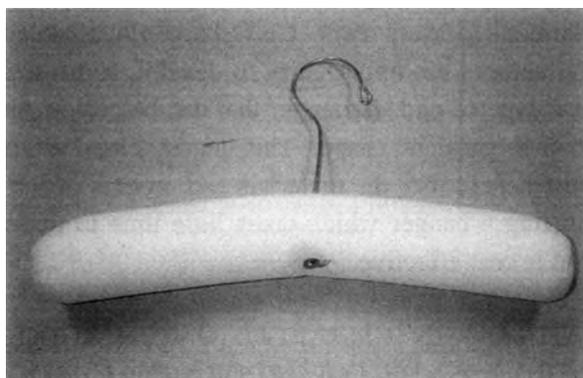


Figure 1. An example of a finished hanger.

3. CONSTRUCTION METHOD

1. Place the garment flat on a clean surface and measure the interior depth of the garment at the shoulders from front to back. Select the

diameter of Ethafoam tube most suitable to this size, never forgetting to consider the cut of the garment which is to be stored. It is also possible to use the larger diameter tube and carve it down to a smaller size. Measure the length of the shoulders inside the garment and use a sharp knife to cut the Ethafoam tube to that length.

2. Round each cut end of the Ethafoam tube, especially the top side (fig. 2). It is important to analyze the construction of the garment and visualize the final shape of the hanger so that garment details such as the collar are supported. Support can be achieved by carving the Ethafoam tube to build up necklines or by the addition of padding. Polyester batting can be stuffed into short lengths of the stockinette. The ends can be tied with twill tape to create small pads (fig. 3). These pads can be used to shape and support neck and shoulder areas (fig. 4).
3. Grasp each end of the Ethafoam tube and bend slightly for several minutes until the Ethafoam remains gently curved imitating the natural slope of the shoulders. A small triangle of Ethafoam can be removed from the bottom center to aid in the bending (see fig. 8).

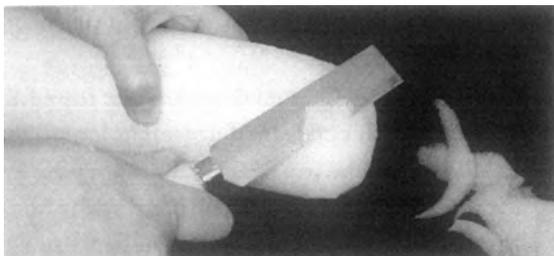


Figure 2. Round ends of Ethafoam tube.

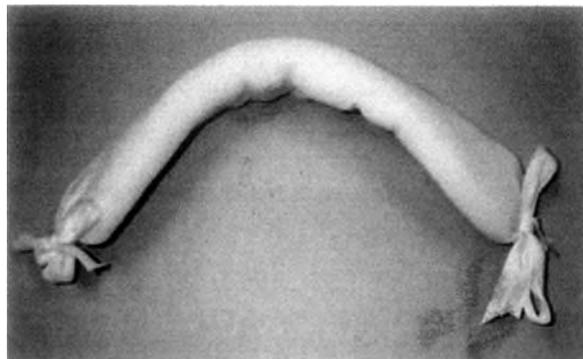


Figure 3. Supplementary neck support for garment made from polyester batting in stockinette and tied at ends.

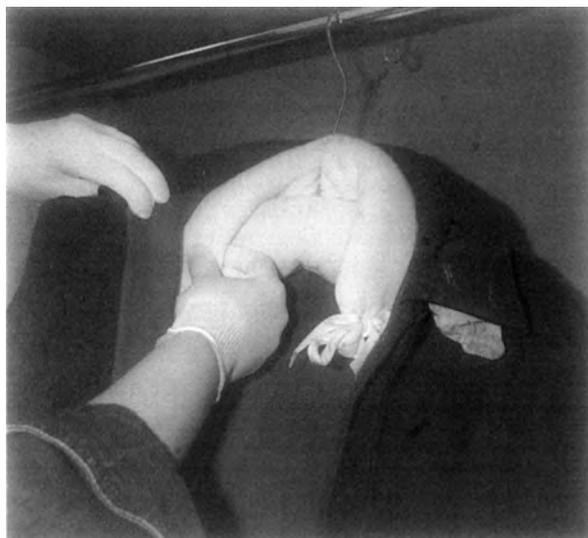


Figure 4. Insertion of a supplementary support set over hanger will provide customized support to neck of coat.

4. Cut a piece of polyester or cotton stockinette approximately 5 cm (2") longer than the length of the Ethafoam tube. Polyester stockinette has slightly less grab than cotton stockinette and therefore garments slide onto the hanger more easily. Stretch the stockinette over the tube. Cut a horizontal slit into each end of the Ethafoam tube and push the cut

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ends of the stockinette into the slit with a spatula or bone folder (fig. 5). Make sure that the stockinette is smooth and that it completely covers the Ethafoam.

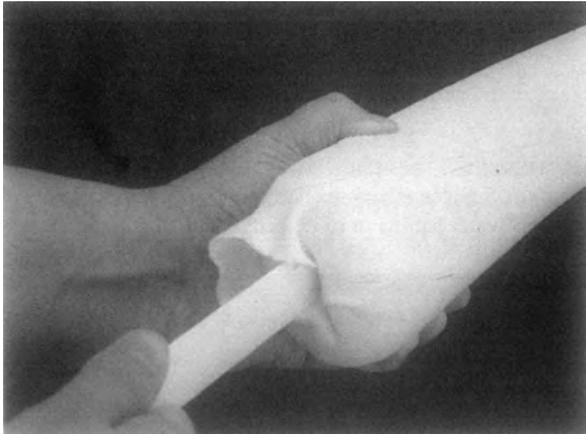


Figure 5. A bone folder is used to push the stockinette into the slits made in the ends of the Ethafoam.

5. To create the metal neck of the hanger, a piece of stainless steel rod is cut to whatever length is required to accommodate the height of a collar or other garment detail. Customizing the length of the rod ensures that the neck of a garment will not be too close to the hanging pole of the cabinet or closet and be crushed.
6. Cut a length of the stainless steel rod usually between 35 and 43 cm (14 and 17") long, depending on garment construction. Smooth the ends of the rod with sandpaper. Bend back a small U at one end of the rod, which will be used to secure the rod into the bottom of the hanger.
7. Locate the mid-point under the curve of the Ethafoam tube; or what is to be the bottom of

the hanger. Use several pins to pull apart the stockinette and create a tiny hole between the threads. In straight alignment starting from the bottom, push the rod through the stockinette, the Ethafoam tube, and out the upper side. When done carefully, the rod will go through the layers without cutting or tearing the stockinette. The U-bend in the rod will prevent the rod from going completely through the tube.

8. To prevent slippage of the rod, slide a stainless steel washer onto the bottom of the rod where the small U-bend is located and insert the U-bend into the Ethafoam tube (fig. 6).

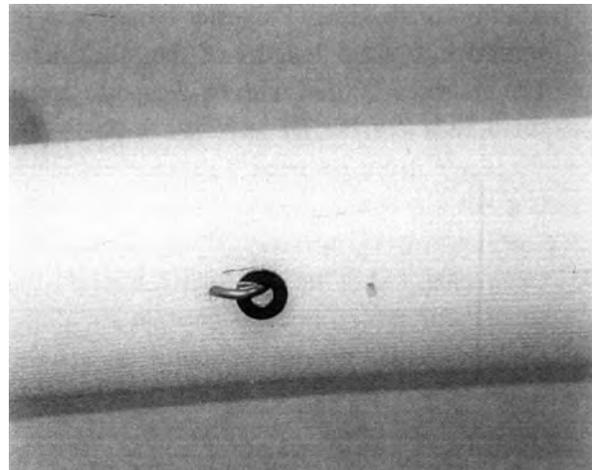


Figure 6. The bottom of hanger showing the U-bend inserted into the Ethafoam with washer to prevent slippage.

9. Finish creating the metal neck at the top of the hanger, which consists of a straight length that extends from the top of the Ethafoam tube and then bends into a curve that fits over the hanging pole in storage. Approximately 5 cm (2") of the rod needs to be straight as it extends

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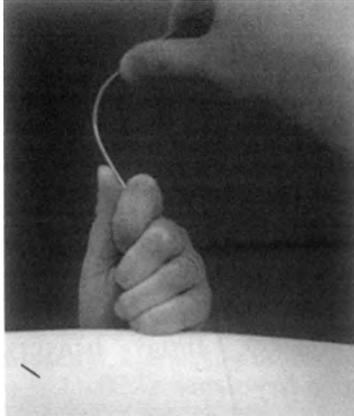


Figure 7. Bend rod to form curve for the hanger neck.

from the Ethafoam tube before beginning the bend. If the garment has a stand up collar this length may need to be longer. Make a bend that roughly imitates that of a commercial hanger (fig. 7).

10. Sand the tip of the rod so it is not sharp and bend it up and back towards itself so there are no pointed edges (fig. 8). Make sure that the curve of the hook will fit between the hanging pole and the top of the cabinet or closet.

SOURCES OF MATERIALS

Stainless steel washers and rod:
McMaster-Carr
P.O. Box 440
New Brunswick, NJ 08903-0440
Tel: (732) 329-3200
www.mcmaster.com

Ethafoam™ tubes:
Preservation Products, a division of Gladon

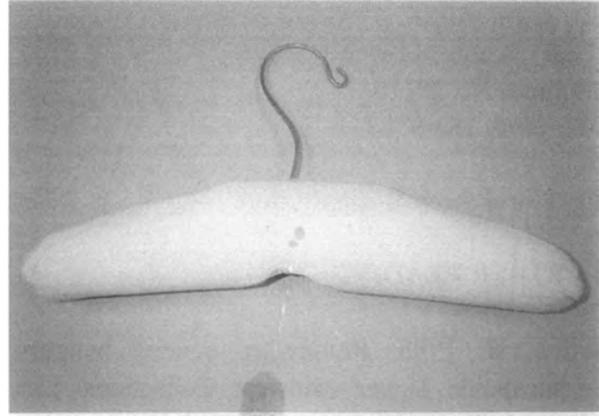


Figure 8. Finished hanger has sloped shoulders, a V cut out at center bottom and a slightly elongated rod neck.

Company Inc.
178 West Boden Street
Milwaukee, WI 53207
Tel: (800) 448-6070
Fax: (800) 322-6525
www.gladon.com/preservation_products

Advanced Packaging Inc.
Seton Business Park
4818 Seton Drive
Baltimore, MD 21215
Tel: (410) 358-9444

Polyester batting and twill tape:
Local sewing or quilt store

Stockinette:
Benchmark
P.O. Box 214
Rosemont, NJ 08556
Tel: (609) 397-1131
www.benchmarkcatalog.com

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Rx Textiles
3107 Chambers Drive
Monroe, NC 28110
Tel: (704) 283-9787

Or a local medical supply store

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