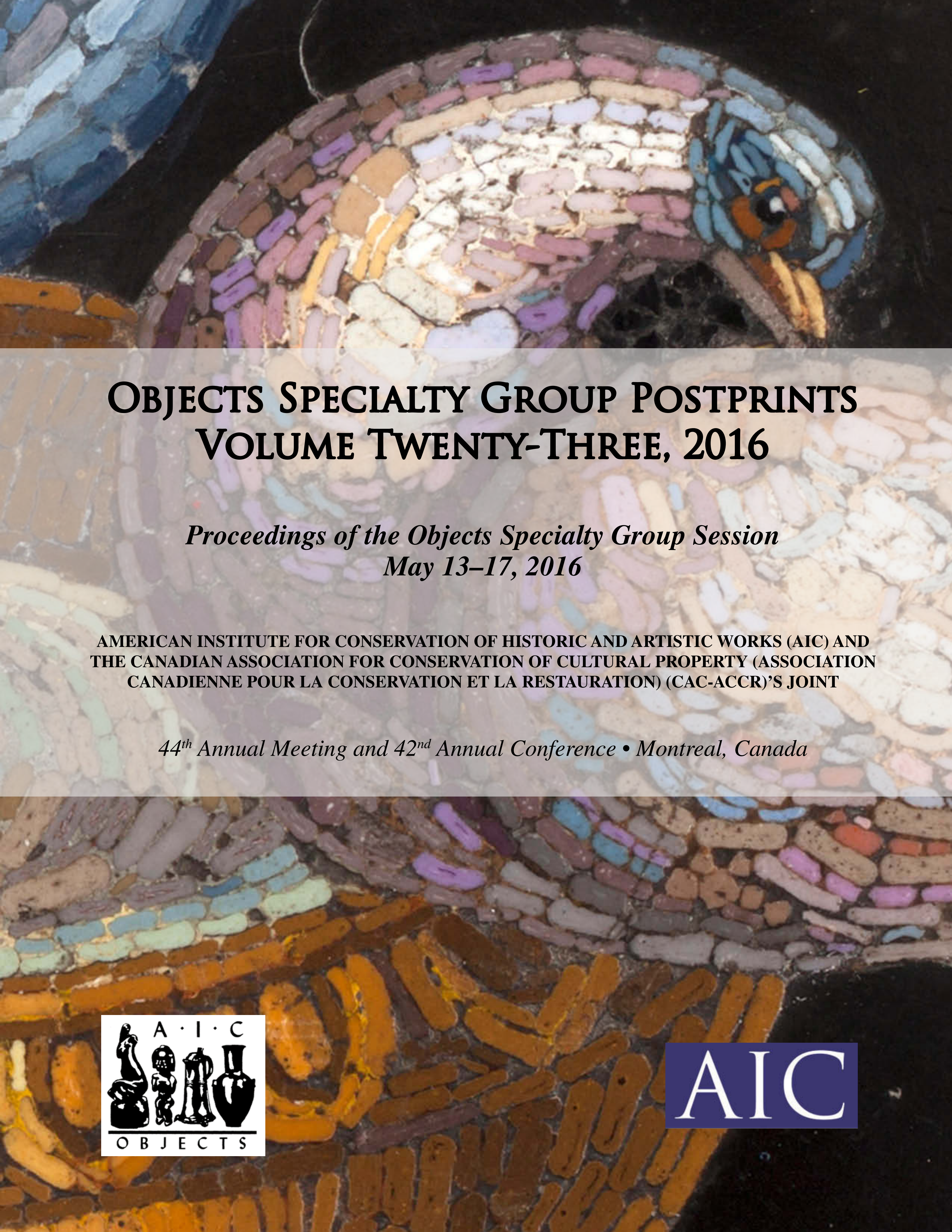

Objects Specialty Group Postprints Volume Twenty-Three, 2016

Proceedings of the Objects Specialty Group Session
May 13–17, 2016

AMERICAN INSTITUTE FOR CONSERVATION OF HISTORIC AND ARTISTIC WORKS (AIC) AND THE CANADIAN ASSOCIATION FOR CONSERVATION OF CULTURAL PROPERTY (ASSOCIATION CANADIENNE POUR LA CONSERVATION ET LA RESTAURATION) (CAC-ACCR)'S JOINT

44th Annual Meeting and 42nd Annual Conference • Montreal, Canada

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OBJECTS

AIC

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Edited by Emily Hamilton and Kari Dodson
with Laura Lipcsei, Christine Storti, and Leslie Friedman, Program Chairs

A · I · C

OBJECTS

Proceedings of the Objects, Objects + Architecture,
and Objects + Wooden Artifacts Specialty Group Sessions
May 13–17, 2016
44th Annual Meeting
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This publication, entitled *Objects Specialty Group Postprints, Volume Twenty-Three, 2016,* is produced by the Objects Specialty Group of the American Institute for Conservation of Historic & Artistic Works.

Cover photograph by Elizabeth La Duc. Side view of a micromosaic tabletop. Unknown maker, Marble and micromosaic tabletop, 1870–1890, 56.3 cm (D) × 1.7 cm (H), Historic New England, 1933.1254. Gift of Mrs. George P. (Susan Emily Jewell) Sanger. (Courtesy of Historic New England)

The articles presented in *Objects Specialty Group Postprints, Volume Twenty-Three, 2016* have been edited for clarity and content. Articles were reviewed by the OSG editors and at least one content area specialist, and the authors revised their work based on these anonymous reviews. Responsibility for the methods and materials described herein, however, rests solely with the authors, whose articles should not be considered official statements of the OSG or the AIC.

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Program Chair's Foreword

I am pleased to present the Postprints of the Object Specialty Group (OSG) program at the AIC 44th Annual Meeting and CAC-ACCR 42nd Annual Conference: *Emergency! Preparing for Disasters and Confronting the Unexpected in Conservation*. This was a joint conference held in Montreal, Canada, from May 29 to June 3, 2016. The authors have embodied the highest caliber work, both in their conference presentations and in Postprint submissions. My fellow OSG officers, Group Chair Sarah Barack and Assistant Program Chair Tony Sigel, as well as Carol Dignard, our CAC-ACCR colleague, assisted in the challenging selection of papers for the OSG program. Chairs Christine Shaette of the Wooden Artifacts Group (WAG) and Leslie Friedman of the Architectural Specialty Group (ASG) provided critical help in bringing the specialty groups together for two joint sessions this year.

The theme of the 2016 meeting focused on preparing for disasters and confronting the unexpected in conservation. Efforts were made to adhere to this conference theme in the selection of papers for the OSG and joint programs. Other submissions, however, were evaluated on their own merit, relevance to the OSG membership, and to the field in general. The great range and diversity of our profession was thus captured in the resulting papers.

In this volume, you will find papers that focus on objects' condition, methods of manufacture, inherent vice, treatments and tips, current scientific research and analysis, and materials identification. Objects featured range in size and complexity from the monumental to the miniscule, from the Decorative and Fine Arts to Archaeological and First Nations collections, and from the local to the remote or areas of conflict.

This year's OSG session had an ambitious program that featured more papers than usual because of a "lightning round session" that allowed four 15-minute papers instead of two 30-minute presentations. Papers in the OSG session were chosen to appeal to as many people as possible, with the hope of offering something for everyone. The session opened with a focus on techniques of manufacture, followed with a series of presentations focusing on treatment and scientific research.

In the second session, OSG teamed up with ASG to create a joint session on site-based works. The third session was a joint program with WAG, featuring papers on a variety of objects from the monumental to the miniature. This session concluded with two papers presenting the latest research on Southeast Asian and Far East Asian lacquers. A tips session was included in the program again this year due to its popularity among members for its topical relevance and ability to provide quick tips and tricks to assist the conservator in everyday practice.

In closing, I would like to express my sincere gratitude to Emily Hamilton and Kari Dodson, OSG Postprint Editors, for their tireless efforts in overseeing all aspects of the creation of this volume and without whom the Postprints would simply not be possible. Thank you to our peer reviewers as well—the anonymous and unsung heroes who toil behind the scenes.

Laura Lipcsei, OSG Program Chair

A METHODOLOGY FOR DOCUMENTING PRESERVATION ISSUES AFFECTING CULTURAL HERITAGE IN SYRIA AND IRAQ

LEEANN BARNES GORDON, BIJAN ROUHANI, SUSAN PENACHO, AND ALLISON CUNEO

Armed conflict in Syria and Iraq has resulted in a humanitarian crisis that includes the destruction of cultural heritage. The Cultural Heritage Initiatives project is a cooperative agreement between the United States Department of State and the American Schools of Oriental Research to implement cultural property protection in the region. This article discusses the development of the project's methodology for documenting preservation issues affecting cultural heritage. The methodology was created to better understand the types and patterns of threats and damage, which in turn inform future safeguarding and post-war conservation efforts. The condition assessment process is closely linked to other activities of the project, including the development of a digital inventory and map of heritage sites and the archiving of information about cultural heritage from major news outlets, online media, satellite imagery, and in-country sources. The methodology was initially designed to record the physical condition of a property as well as threats and/or disturbances. A Condition Issues section was developed in order to track the effects of damage and the components of a property that may be affected. Later additions include a section designed to rate the priority for future on-the-ground assessments. Testing, revision, and improvement of the methodology are discussed, and initial results of assessments of the properties within the United Nations Educational, Scientific and Cultural Organization World Heritage Site of Ancient Aleppo are presented.

KEYWORDS: Condition assessment, Documentation, Emergency response, Cultural heritage, Heritage inventory, Satellite imagery, Remote sensing, Armed conflict, Post-conflict, Cultural property protection, Syria, Iraq, World Heritage, Aleppo

1. INTRODUCTION

The armed conflict in Syria began in 2011 when protests against the Syrian government broke out in various cities, inspired by popular uprisings in the region. Military crackdowns on protesters led to widespread insurgency. By 2013, the Syrian Army was engaged in a full-scale civil war against local rebel militias throughout the country. Meanwhile, the emergence of jihadist groups signaled an increase in foreign, extremist influence among the armed opposition. In the spring of 2014, the situation escalated with the takeover of Mosul, Iraq, by the Salafi-jihadist group ISIL, followed soon by the declaration of Raqqa, Syria, as the capital of its new Islamic caliphate. Despite cease-fire attempts, fighting has continued to the present time with even greater international involvement.[1]

These five years of war have caused a humanitarian crisis with hundreds of thousands of casualties and more than 11 million people forced from their homes (United Nations 2015; 3RP: Regional Refugee and Resilience Plan 2016). Additionally, collateral damage to historic monuments and cultural repositories has been extensive: archaeological sites have become militarized for their strategic locations, celebrated landmarks have been demolished in crossfire between groups, and historic neighborhoods have been obliterated by indiscriminate bombing (fig. 1) (American Schools of Oriental Research Cultural Heritage Initiatives 2016). This conflict has also been marked by systematic, deliberate destruction of heritage sites throughout Syria and Iraq, perpetrated largely by militant Salafist groups such as ISIL (Danti 2015; Harmanşah 2015).

By 2013, following the first few years of the war in Syria, UNESCO placed all six of the country's World Heritage Sites on their List of World Heritage in Danger due to severe and sustained damage and threats (United Nations Educational Scientific and Cultural Organization—World Heritage Centre 2016). Soon after, international responses to the cultural heritage crisis increased rapidly, including the formation of the Cultural Heritage Initiatives (CHI) project in August 2014. CHI is a

Fig. 1. Satellite image showing demolished historic structures, rubble, and craters caused by bombings near the Aleppo Citadel, December 15, 2014 (Courtesy of DigitalGlobe)

cooperative agreement between the United States Department of State (DoS) and the American Schools of Oriental Research (ASOR) to monitor and report on the crisis, promote global awareness, and develop preservation projects to implement now and in the post-conflict period. The project includes a multidisciplinary team of specialists in archaeology, remote sensing, conservation, risk preparedness, and cultural heritage management, which works collaboratively with international scholars, cultural agencies, NGOs, and in-country specialists. This article focuses on CHI's methodology for documenting preservation issues affecting cultural heritage in Syria and Iraq.

2. ASOR'S CULTURAL HERITAGE INITIATIVES: OVERVIEW OF ACTIVITIES

The CHI project was initially conceived and primarily funded by the DoS, which designed a highly structured and rigorous reporting program from which CHI's primary activities derive. First, CHI is developing a comprehensive digital map and inventory of archaeological sites, built heritage, museums and collections, and libraries and archives in Syria and ISIL-occupied areas of Iraq. As of May 2016, CHI's inventory contained more than 6,500 cultural properties in Syria and 5,900 in Iraq, and was compiled through collaboration with numerous other groups and institutions (fig. 2). It continues to

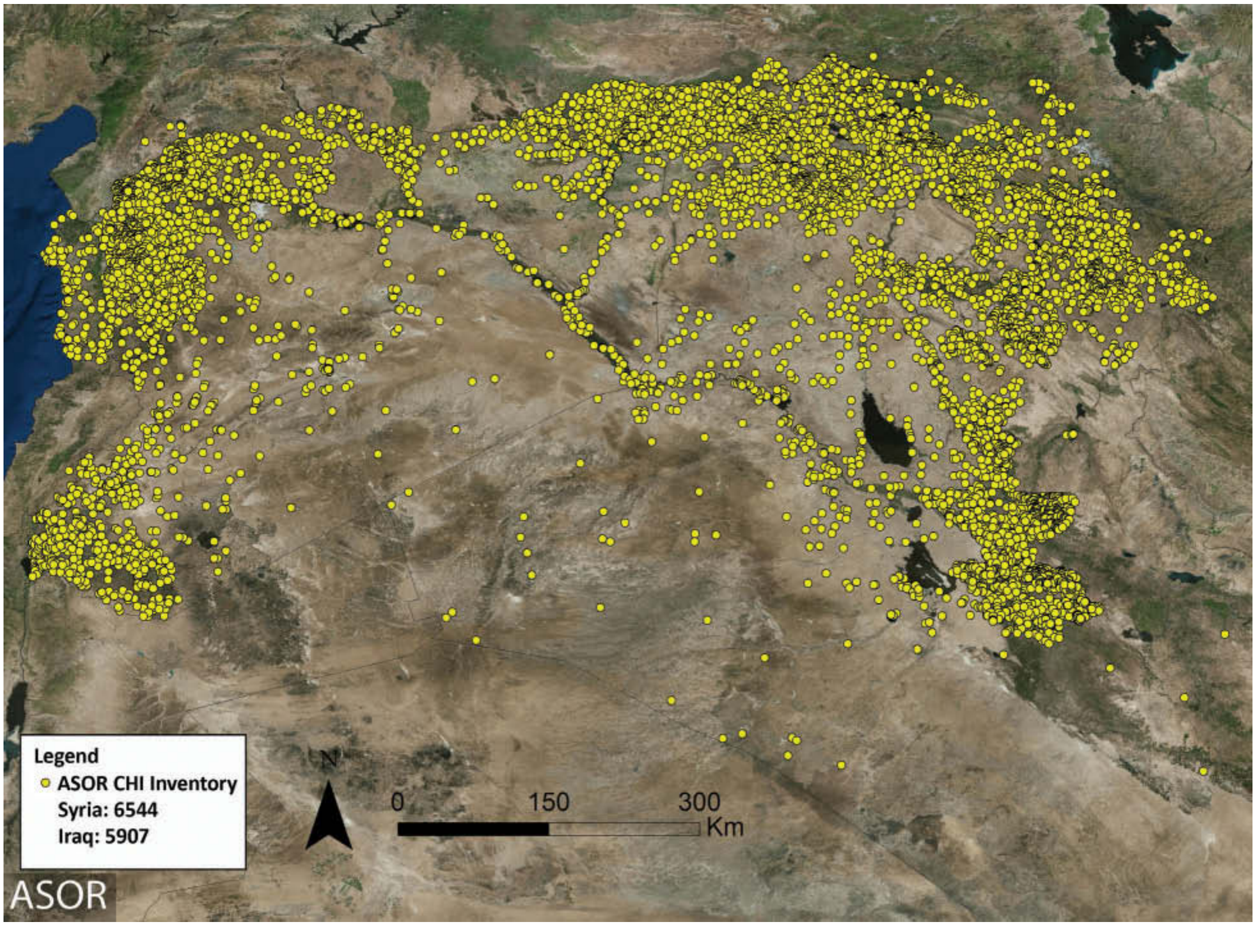

Fig. 2. Distribution of cultural heritage entities in the CHI Inventory, May 2016 (Courtesy of ASOR CHI)

grow as more heritage sites are affected by the conflict. The inventory is stored and analyzed on various platforms including ArcGIS, FileMaker Pro, and Arches (to be discussed in further detail in section 3.1).

Next, CHI assesses and maintains an awareness of the impact of the conflict on cultural heritage. On a daily basis, team members follow online news outlets and social media to gather data about the status of sites and collections in the region. CHI also receives information from in-country sources. The team collects photographs, videos, and written documentation related to damage or condition, as well as information about illegal excavations, theft, trafficking, and sales of antiquities. All of this information is archived in a custom FileMaker Pro database (fig. 3). Each piece of media is tagged with the related site inventory number so that all the media connected with each site in the inventory can be tracked and viewed.

Remote sensing analysis provides another important form of baseline data. CHI's geospatial specialists analyze high-resolution satellite imagery to monitor changes at heritage sites over time, and their analysis is often used to verify open-source and in-country damage reports. Satellite imagery is particularly useful for documenting illegal excavations over time, as illustrated at the site of Dura Europos in figure 4, but also for tracking military-related damage, such as the spring 2016 construction of a Russian military base on the ancient site of Palmyra (fig. 5). As of May 2016, CHI carried out satellite imagery-based assessments for more than 5,700 sites within its inventory. Some sites have been assessed multiple times based on newer satellite imagery, bringing the total number of assessments to over 7,800.

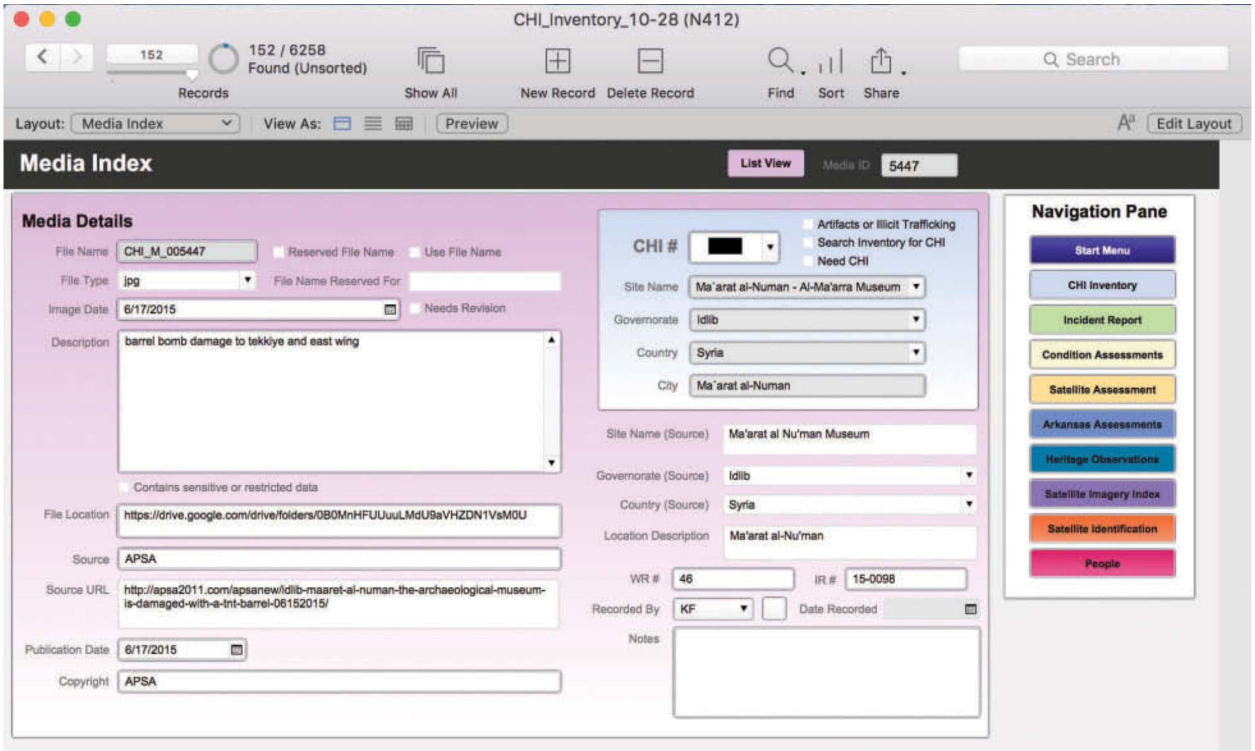

Fig. 3. CHI's Media Index in its FileMaker Pro project database (Courtesy of ASOR CHI)

CHI constantly monitors all newly available satellite images to check for new and additional damage to sites within the inventory.[2]

All of these observations from news media, local contacts, and satellite imagery are collated into biweekly reports, which are available on the CHI website (http://www.asor-syrianheritage.org/weekly-reports/). Approximately 800 incidents have been documented in the project's reporting series since the beginning of the project. CHI also produces additional in-depth Special Reports, including multiple reports on Palmyra and its monuments, which go into greater detail and analysis. CHI's remote condition assessments, the focus of this article, utilize all of the data collected through these monitoring and reporting activities to produce standardized documentation of the major preservation issues facing cultural properties. These data can be analyzed by many factors, such as geographical location, type of heritage, type of threat, or extent of damage, which helps satisfy DoS reporting requirements including planning for safeguarding measures and future documentation on the ground.

In addition to monitoring and documentation, CHI provides support to in-country groups that are working to safeguard heritage during the conflict. This has included the preparation and distribution of basic photo-documentation guides in Arabic for sites and artifacts. Additional support has included technical advice and funding for documentation supplies, emergency responses, and risk preparedness activities. With this assistance, the Bosra Al Sham Antiquities Department in Bosra, Daraa Governorate, Syria, has been able to inventory and re-house collections at the Bosra Museum, as well as to clean and organize storage facilities. The group has documented damage to structures within the World Heritage Site of Bosra, has cleaned and removed debris including unexploded ordnance, and has made temporary repairs to damaged structures. Another example includes the Ma'arra Museum in Maarat al-Numan, Idlib Governorate, a collection of important mosaics housed in a historic 16th-century Khan. Following a barrel bombing of the facility last summer (fig. 2), CHI assisted local groups with emergency response activities such as clearing debris, relocating objects, and carrying out temporary protection measures.

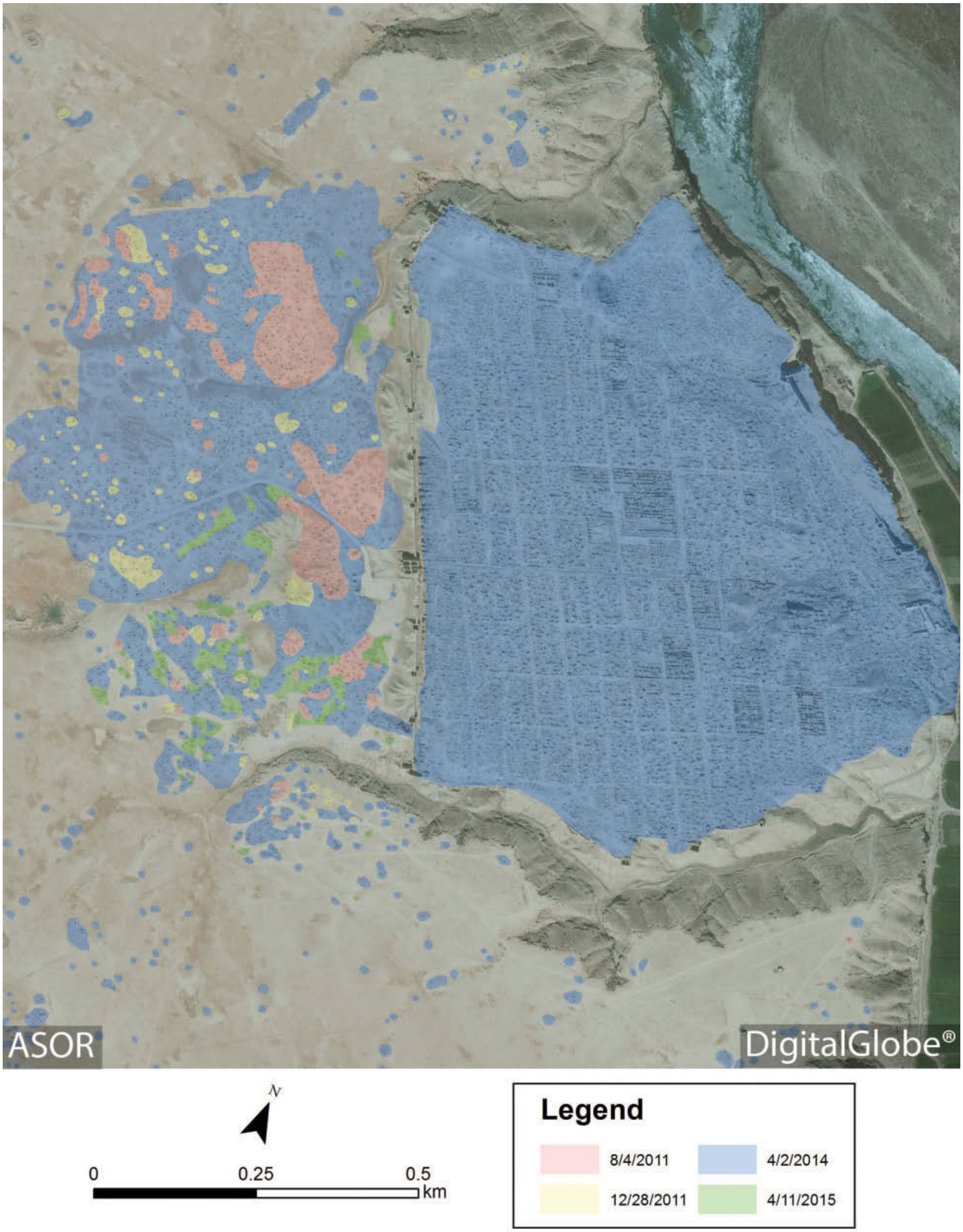

Fig. 4. Expansion of looted areas over time at Dura Europos (Courtesy of DigitalGlobe/ASOR CHI)

Fig. 5a. Palmyra World Heritage Site, March 30, 2016; 5b. Newly constructed Russian military base at Palmyra, April, 22, 2016 (Courtesy of DigitalGlobe/ASOR CHI)

Finally, CHI produces periodic reports that analyze all of the data collected through these activities to better understand the full impact of the conflict on cultural heritage in the region. Using this information, proposals have been developed for future in-country documentation of damage and assessment of preservation needs. CHI also maintains proposals for large-scale heritage projects that could be undertaken in the post-conflict period, as an important part of recovery and revitalization. The project also monitors the long-term needs for heritage management in Syria and identifies ways to build capacity.

3. DEVELOPING A REMOTE CONDITION ASSESSMENT METHODOLOGY

3.1 EXISTING MODELS, ADAPTATION, AND DESIGN

From the earliest stages of the project, CHI was interested in working with its site inventory in the Arches System developed by the Getty Conservation Institute and the World Monuments Fund (http://archesproject.org/). Arches is an open-source, geospatially enabled software platform designed for heritage management. Within Arches, separate modules exist to record threats, disturbances, condition, and management recommendations. In 2014, the Arches condition assessment module consisted of an overall condition rating and a free-text condition description. The CHI team needed something more detailed and also customized to the situation in Syria and Iraq, so other existing models were examined.

While there are now multiple projects that have developed database systems for recording damage to cultural heritage in the region such as the Syrian Directorate-General of Antiquities and Museums, Endangered Archaeology in the Middle East and North Africa, and the Syrian Heritage Archive Project, at the onset of the CHI project there were essentially no guidelines for assessments based on secondary data or that were specific to armed conflicts. During the planning stages, references and international standards on documentation were studied. Also, many generous colleagues contributed examples of condition assessment and survey forms to the project, and consultations were held with numerous heritage experts.

Based on this research, it was agreed that the CHI methodology should adhere to best practices in documentation and should be systematic, able to produce meaningful analysis, and able to be conducted by researchers working remotely without first-hand access to the cultural properties. It was important that the methodology be useful at present during the conflict as well as easily integrated with future emergency response efforts. With these factors in mind, the following three fundamental objectives were emphasized when designing the methodology: 1) to classify the causes of risk or damage, 2) to identify the effects of damage, and 3) to describe the intensity and extent of damage.

Designing the methodology began with creating standardized terminology for the condition assessments. A threat was defined as "an incident that threatens to disturb a cultural property," and a disturbance was defined as "an incident that has disturbed a cultural property." The purpose of recording threats and disturbances is to identify the causes of risk or damage. The following six broad categories were selected to classify threats and disturbances: agricultural activities, development activities, human activities, military activities, natural impacts, and site management. Each category contains approximately 10 terms (table 1). These categories, terms, and an Overall Threat Rating scale were based on the MEGA Jordan database, a precursor to the Arches Project, which has a well-developed glossary of terms (Getty Conservation Institute and World Monuments Fund 2011). These terms and definitions were adapted to fit the causes of damage observed in Syria and Iraq. This included adding new terms to existing categories, such as "Refugee Camp" to the Human Activities category, or removing terms that were not currently relevant, such as "Land Reclamation" and "Reforestation." A new category, "Military Activities," was created to include a range of damage causes linked directly to military operations.

Table 1. CHI Condition Assessments: Types of Threats and Disturbances

Category	Terms
Agriculture	Agricultural Burning, Grazing, Grove/Orchard, Irrigation, Plowing, Terracing
Development	Bulldozing/Leveling, Construction, Drilling, Inundation by Dam, Mining/Quarrying, Road Work, Trenching, Vibrations, Modern Town
Human Activity	Controlled Fire, Dumping, Illegal Excavation, Modern Burials, Theft, Vandalism, Water Damage, Refugee Camp/Encampment, Reuse of Ancient Building Materials, Reuse of Ancient Structure (Non-combatant)
Military Activity	Airstrike, Chemical Agent, Construction (Military), Earthworks/Roadworks, Explosives, Gunfire/Light Weaponry, Landmine, Occupation/Militarization, Reuse of Ancient/Historic Structure (Combatant), Tunneling, Vandalism/Intentional Destruction (Combatant), Vehicle/Heavy Weaponry
Natural Impacts	Collapse, Earthquake, Erosion, Environmental Conditions (Light/Temperature/Relative Humidity), Fire, Flooding/Rain, Land/Rock Slide, Pest Infestation, Rising Damp, Vegetation (Non-agricultural)
Site Management	Compromised Administrative Access, Maintenance, Inappropriate/Unstable Conservation/Restoration, Tourism/Visitor Activities

The condition of a cultural property was adapted from the MEGA Jordan database and defined as "an indication to what degree an entire site or element is physically stable, and is or is not experiencing active deterioration." The condition rating scale from MEGA Jordan provided the basis for the CHI overall condition rating scale along with some modifications to the definitions (ratings include Good, Fair, Poor, Very Bad, Destroyed, and Non-extant).

Next, CHI developed a way to record the effects of damage at a more in-depth but systematic level of detail. Inspiration was drawn from the Evaluation section on assessment forms designed by the National Center for Preservation Technology and Training (2011), which approaches the assessment by component parts and ranks the intensity of the damage. Using this model, CHI created terminology and definitions for a broad list of condition issues (table 2). It was particularly challenging to design a list that could be useful for all of the heritage types in the CHI inventory, from cultural sites to movable objects and collections.

CHI also adopted an estimated damage scale to record the percentage of the property that has been damaged (1–10%, 10–30%, 30–60%, 60–90%, 90–100%) and created terminology and definitions for three broad categories of cultural heritage components that may have been adversely affected. These categories of components include immovable cultural heritage and facilities, movable cultural heritage, and administrative infrastructures (table 3). This was inspired by the Material section of the Field Guide Assessment Form created by Heritage Preservation (2006), and it allows for more detailed recording of the extent of the damage.

Due to the remote nature of the assessments (primarily the highly varied quality and availability of data for each particular site or object), it was recognized that it would not always be possible to record the intensity and extent of the damage. However, incorporating such a level of detail in the methodology allows the recording of intensity and extent in the occasional instances when such information is available, and it also allows the system to be more compatible with future on-the-ground assessments.

Table 2. CHI Condition Assessments: Condition Issues

Terms	Definitions
Collapsed/Off Foundation	Buildings or structural elements such as walls or archaeological baulks have collapsed or are no longer on their foundation.
Losses/Destroyed Elements	Areas where original material has been lost or destroyed, such as missing elements and holes; for archaeological strata, this could also include loss of access to the strata due to new construction.
Breaks/Detached Elements	Breaks in, or delamination of, a structure resulting in loose, unsecured parts not firmly held in place; depending on the severity, elements may be partially detached, able to be detached, or completely detached.
Cracks/Tears	Cracks, splits, fissures, or tears in a material without complete separation of the parts.
Leaning/Mechanical Damage	Architectural or structural element is leaning or exhibits mechanical damages including distortion, warps, or dents.
Flaking/Friable Surface	Surface phenomena that include flaking, peeling, tenting, lifting, powdering, or the tendency to crumble easily and that often result in loss; commonly but not exclusively applicable to surface coatings such as paint.
Corrosion	Corrosion is the gradual deterioration of materials, typically metals and metal alloys, by chemical reactions with their environment.
Mold/Mildew	Mold, mildew, or microorganisms are the result of a biological infestation or growth of various types of fungi on the surface of a material.
Soil/Accretions/Discoloration	Layers of dirt, grime, sediment, soil, or other matter that have accumulated on a surface; or a change in the original color of a material due to deterioration or the foreign substances that are embedded in the substrate and cannot easily be removed.
Graffiti	Writing or drawings that have been drawn, scratched, or sprayed on the surface.
Fire Damage	Damage from fire and smoke, including burned materials and soot accumulation.
Water Damage	Damage from water, including waterlogged and wet materials.

Once the initial terminology and assessment procedures were agreed on, a platform was needed to test and revise the methodology, so CHI created a condition assessment database using FileMaker Pro (fig. 6). The condition assessments are digitally stored alongside CHI's site inventory, media index, incident reports, heritage observations, and satellite imagery assessments. All of the terms and definitions are included on the right-hand side of the assessment page for easy reference while working. By scrolling down the assessment page, the following sections can be viewed: Condition Summary, Threats and Disturbances, Condition Issues, and Rapid Assessment Priority.

Table 3. CHI Condition Assessments: Cultural Heritage Components

Categories	Terms
Immovable Cultural Heritage/Facilities	Archaeological Strata/Sub-surface Materials, Foundation/ Floor, Walls/Columns (Other Structural Elements), Roof, Windows/Doors, Ceiling, Decorative Architectural Features (Three-Dimensional), Façade/Surface Coverings, Infrastructure
Movable Cultural Heritage	Books, Paper, Photographs/Film, Wood, Textile, Stone, Metal, Ceramic, Glass, Mosaic, Furniture, Painting
Administrative Infrastructure	Housing for Display/Storage, Office/Laboratory Equipment, Office/Laboratory Furnishings, Administrative Files

3.2 TESTING AND REVISION

Once the database was built, testing of the methodology began by CHI team members and with the assistance of outside consultants. Initial testing resulted in numerous adjustments to the terminology and the layout of the assessment form, and the more notable changes are described here. A section for recording the sources of data was added using checkboxes for some of CHI's most common sources as

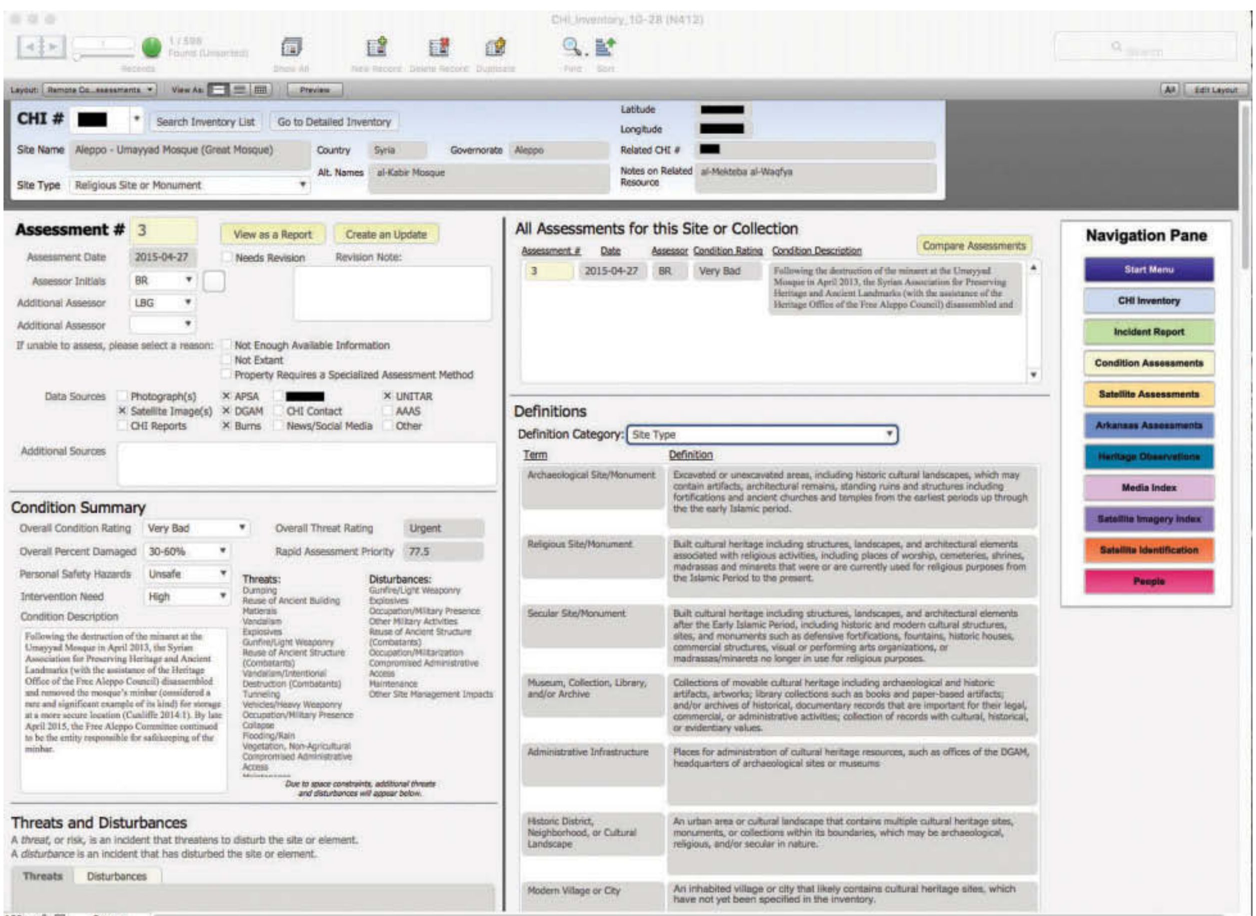

Fig. 6. CHI's Condition Assessment Form in its FileMaker Pro project database (Courtesy of ASOR CHI)

well as an open text field. Since the assessments are compiled from numerous sources rather than first-hand observations, this complex issue is unique to remote assessments and may still need development. It was also realized that the methodology needed to accommodate potential revisions or updates when new data becomes available. This challenge was met with the development of protocols for revisions or updates and the development within the FileMaker Pro platform of a series of checkboxes, open text fields, and portals to display all assessments in the database for a particular site or collection.

While the aforementioned changes were primarily procedural, some revisions were made to the underlying methodology itself. A section on "significance" that had been previously developed in the draft form was eliminated due to the complexities of evaluating authenticity and integrity. However, a new metric was developed to quantify the priority for first-hand assessments that takes significance into account. The value is based on the following seven weighted factors, which result in a numerical score, out of a total possible of 100 points: condition rating, potential risks, inherent material vulnerability, significance, accessibility, permissions, and occupation. This value will help to prioritize primary field assessments when conditions permit.

4. PRELIMINARY RESULTS: ALEPPO

By the summer of 2016, CHI had assessed more than 600 properties using this methodology. This section will demonstrate how this data can be analyzed, using Aleppo as a case study. The assessments presented here were conducted in the late summer and fall of 2015 and do not reflect damage to sites in Aleppo that may have occurred from December 2015 to the present. In figure 7, the border of the Old City of Aleppo as designated on the World Heritage List is marked in red. Within the CHI inventory, there are approximately 350 cultural properties in Aleppo.

The CHI remote condition assessment methodology was unable to be carried out for 38 of these properties, which are historic neighborhoods that require a more specialized assessment. However, the individual properties within these neighborhoods were assessed. Table 4 shows the distribution of the overall condition ratings for the properties. Fifteen sites received the highest possible condition rating of "Good," while 11 sites received a rating of "Destroyed." For 48 properties, there was not enough information to make an assessment. It is possible the unassessed sites are in good or fair condition, since no information has been available about them, but at present their status is uncertain. Figure 8 maps the distribution of the condition ratings for the 264 properties that could be evaluated. Of the assessed sites, 45% were in good to fair condition. Those in the poorest condition are grouped to the southwest of the citadel, where the fighting has been the most intense.

Table 5 shows a breakdown of the overall percentage of a cultural property that is damaged. At approximately half the sites that were assessed, CHI was unable to determine the percentage of the site that was damaged based on available information. These numbers show that while a condition rating could be assigned based on our data, it was far more difficult to discern the extent of the damage. Figure 9 presents the distribution of the percentage damaged, excluding those with the overall percent damaged marked as unknown. Similar to the condition rating, the properties with the greatest extent of damage are found in areas where the fighting has been the most intense.

The threat of damage or continued damage to sites in Aleppo is displayed in Table 6. Perceived threats include all categories listed in Table 1, from the risk of combat-related damage to deterioration caused by underlying condition issues. At 74% of the properties, the risk is considered to be high to urgent, indicating that substantial damage will occur soon or immediately if mitigating actions are not taken. While the properties in the poorest condition with the greatest extent of damage were concentrated near the west of the citadel, the distribution seen in figure 10 shows that the threat of damage remains quite high for properties located throughout the Old City.

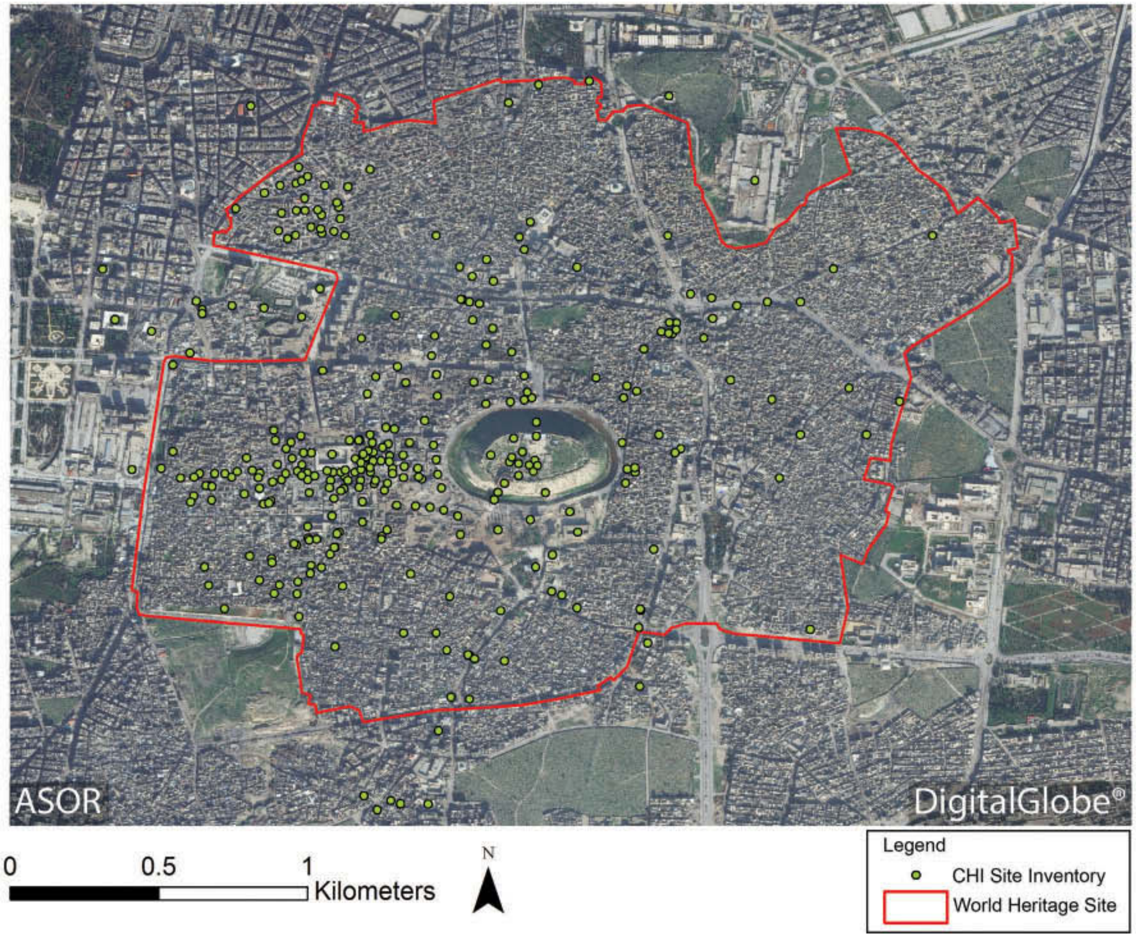

Fig. 7. Distribution of cultural heritage entities in Aleppo from the CHI Inventory (Courtesy of DigitalGlobe/ASOR CHI)

Using the CHI assessment methodology, types of damage or disturbances can be studied by category (Table 1). Figure 11 is a map of sites that have been impacted by either military or human activities. Shown in red, 151 properties have been damaged by military activities, shown in yellow, three properties have been damaged by human activities, and shown in orange, 28 properties have been affected by both categories of disturbances.

Table 4. Aleppo: Overall Condition (of 312 Cultural Properties)

Rating	Number of Properties	Percentage of Assessed Sites
Good	15	5%
Fair	104	33%
Poor	62	20%
Very Bad	72	23%
Destroyed	22	4%
Not Enough Information	48	15%

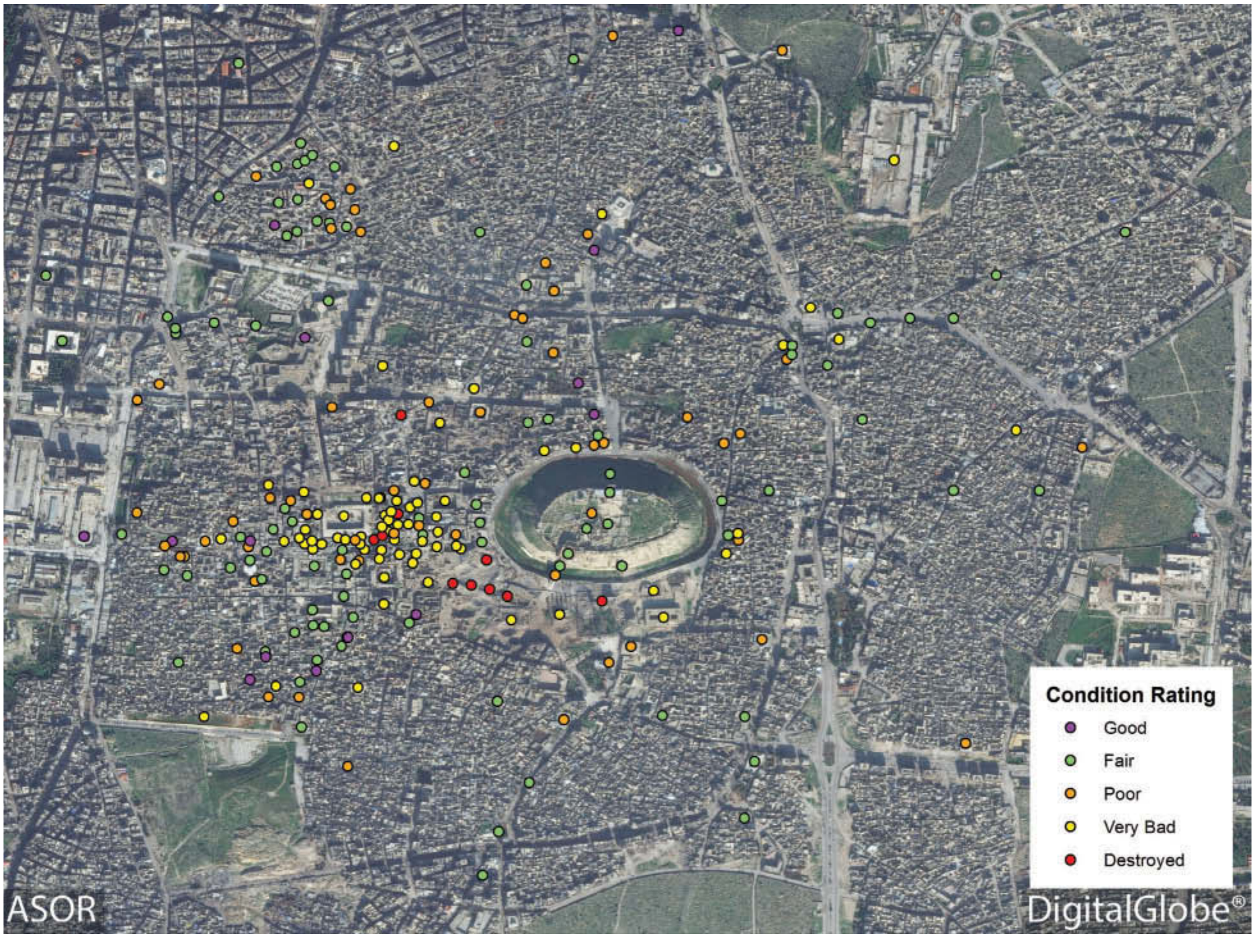

Fig. 8. Distribution of condition ratings for cultural heritage entities in Aleppo (Courtesy of DigitalGlobe/ASOR CHI)

Types of damage can also be examined individually. For example, figure 12 shows the distribution of tunneling (i.e. the excavation of tunnels underground for military purposes such as explosions). Shown in orange, 54 properties in Aleppo have been impacted by tunneling. Alternatively, figure 13 shows the distribution of 13 properties impacted by theft, a factor in the CHI Human Activity category. Furthermore,

Table 5. Aleppo: Percentage of a Site that is Damaged (of 264 Cultural Properties)

Rating	Number of Properties	Percentage of Assessed Sites
None	21	8%
1–10%	22	8%
10–30%	28	11%
30–60%	25	9%
60–90%	21	8%
90–100%	13	5%
Unknown	134	51%

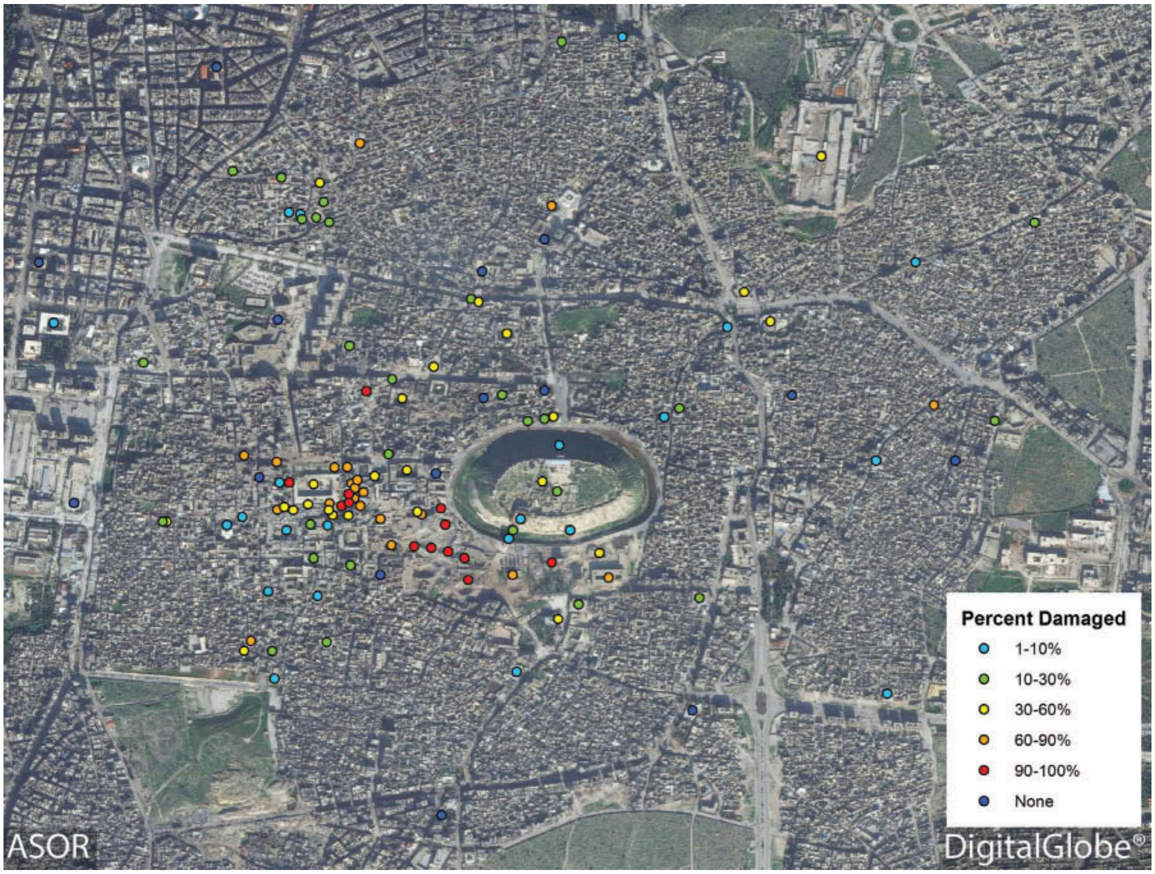

Fig. 9. Distribution of overall percentage damaged for cultural heritage entities in Aleppo (Courtesy of DigitalGlobe/ ASOR CHI)

individual condition issues can also be examined. Seen in figure 14 are cultural properties with documented fire damage or collapsed structural elements, and those affected both by fire damage and structural collapse.

The final assessment parameter to be illustrated is the rapid assessment priority (described previously in section 3.2). Of the 264 properties in Aleppo that were assessed, 44 properties that scored above 75 are presented in figure 15, from blue to red, with the highest-ranked property in red. This ranking could help determine the priority for primary field documentation that could be carried out as soon as conditions permit. For example, if there were time constraints, a route could be mapped to reach the top prioritized sites in the area. This first-hand documentation would allow experts to assess the overall heritage situation and identify emergency protection measures.

Table 6. Aleppo: Overall Threat Rating (Of 264 Cultural Properties)

Rating	Number of Properties	Percentage of Assessed Sites
Low	15	6%
Medium	53	20%
High	114	43%
Urgent	82	31%

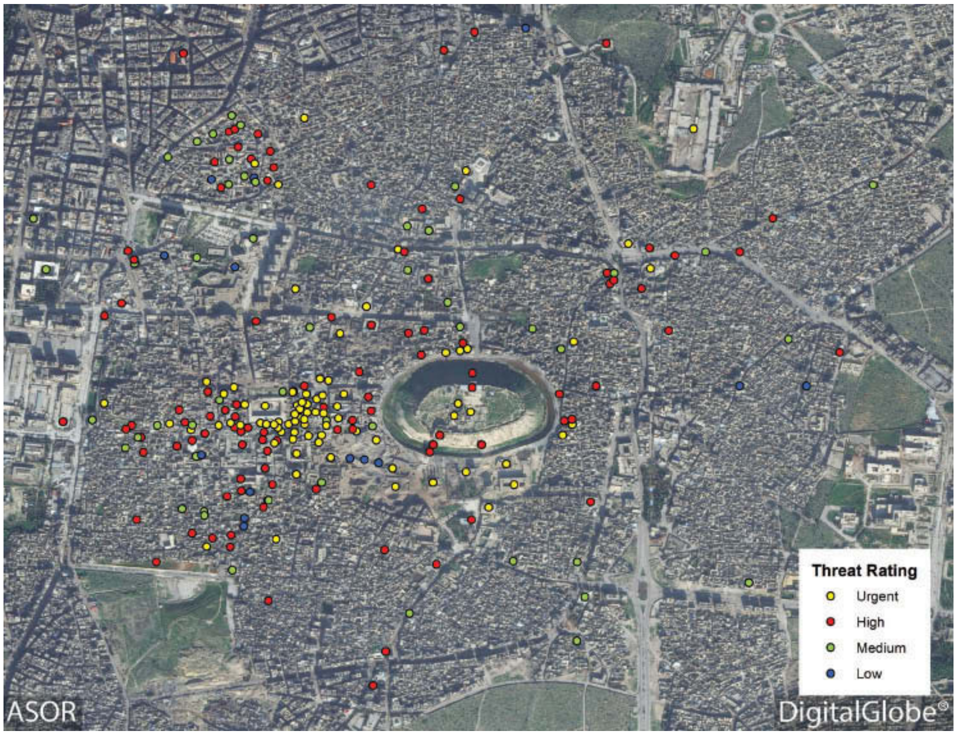

Fig. 10. Distribution of overall threat rating for cultural heritage entities in Aleppo (Courtesy of DigitalGlobe/ASOR CHI)

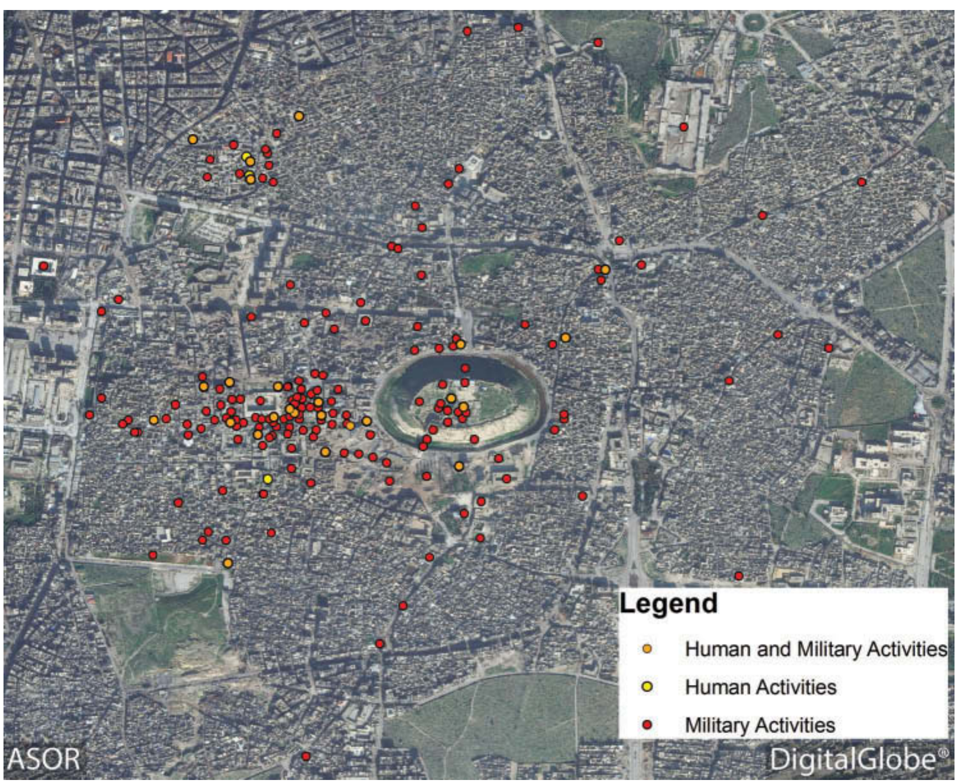

Fig. 11. Distribution of cultural heritage entities in Aleppo damaged by military and human activities (Courtesy of DigitalGlobe/ASOR CHI)

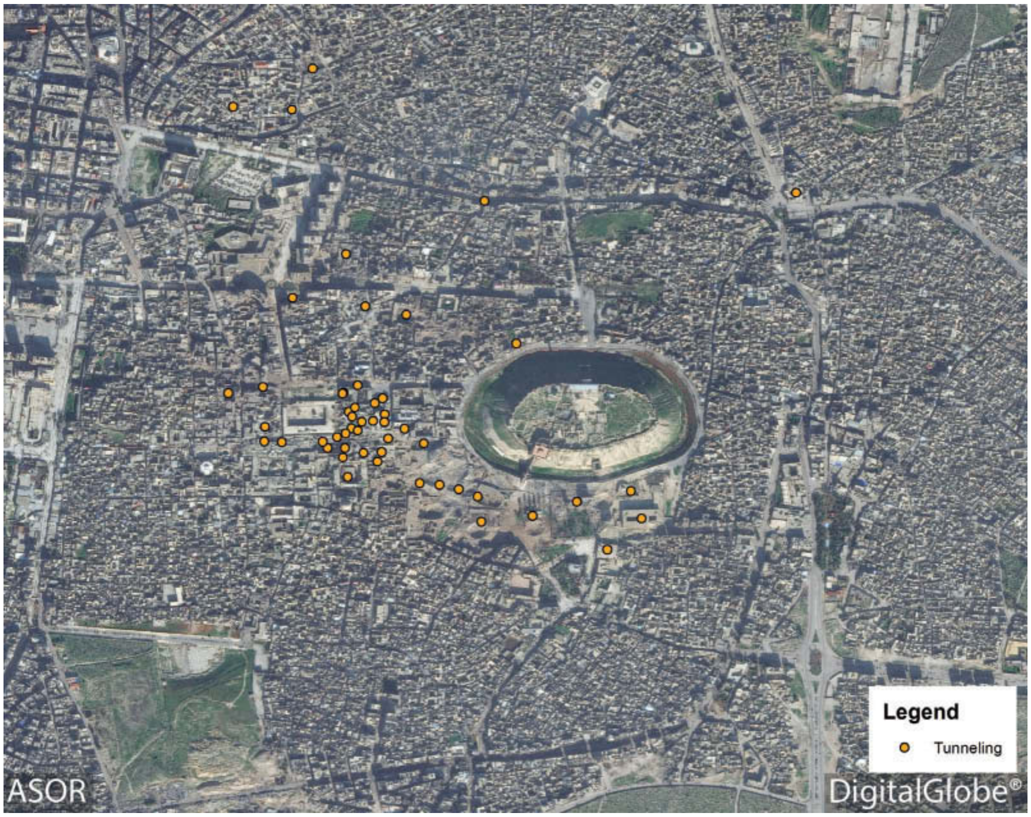

Fig. 12. Distribution of cultural heritage entities in Aleppo damaged tunneling (Courtesy of DigitalGlobe/ASOR CHI)

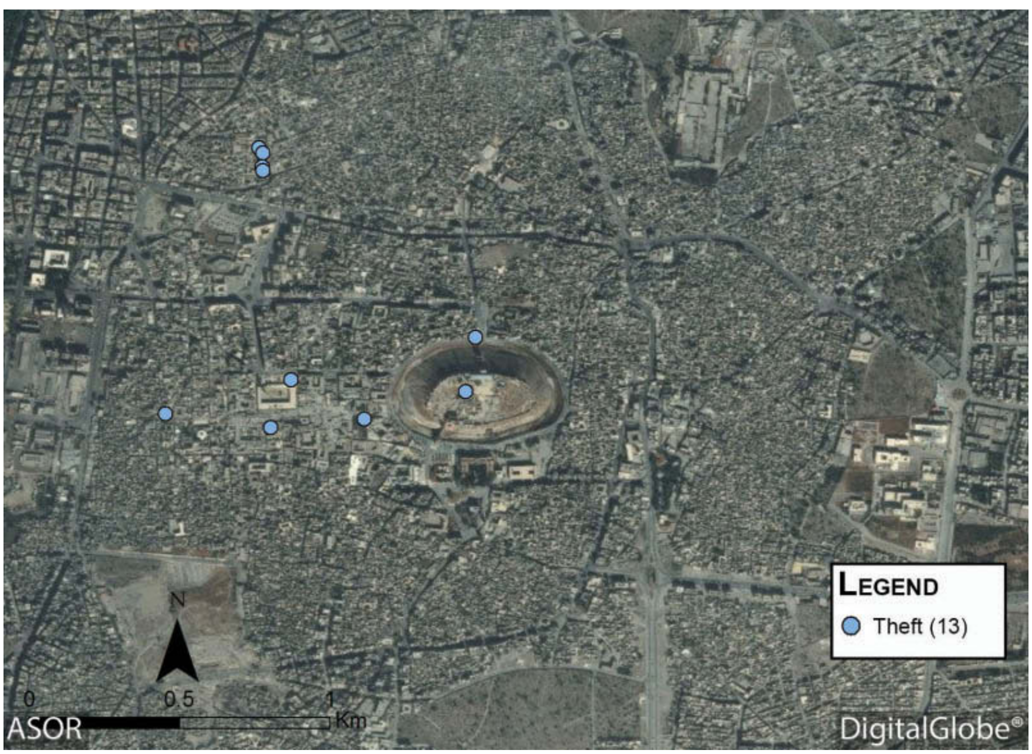

Fig. 13. Distribution of cultural heritage entities in Aleppo impacted by theft (Courtesy of DigitalGlobe/ASOR CHI)

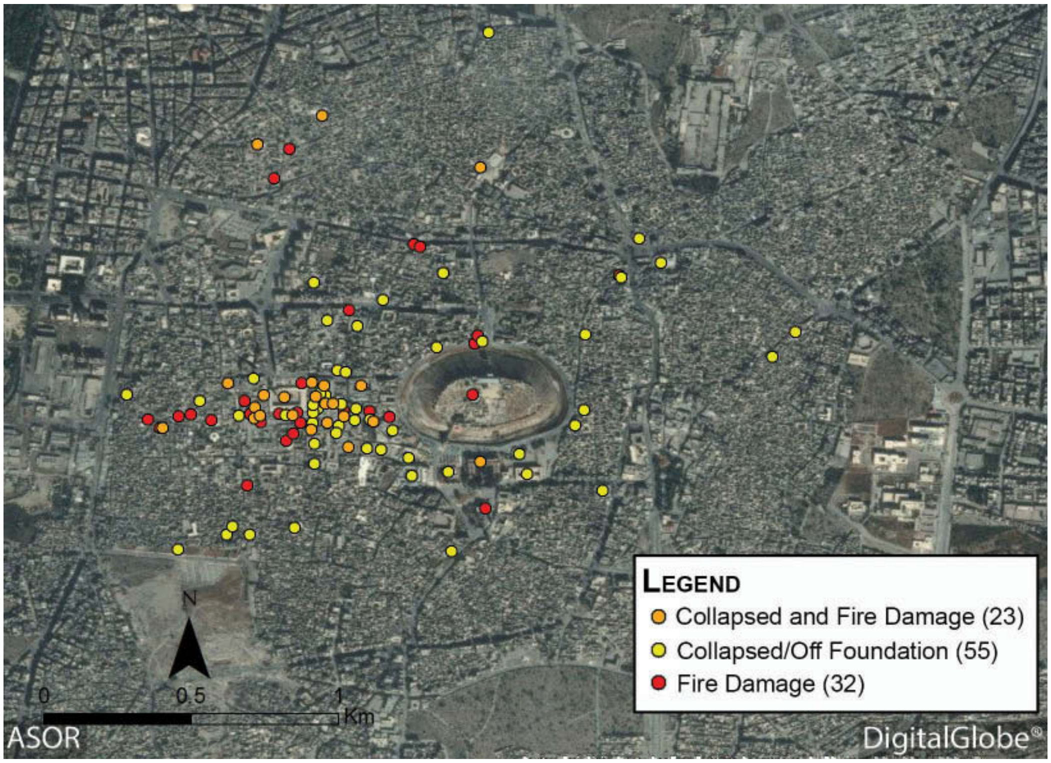

Fig. 14. Distribution of cultural heritage entities in Aleppo with fire damage and collapsed structural elements (Courtesy of DigitalGlobe/ASOR CHI)

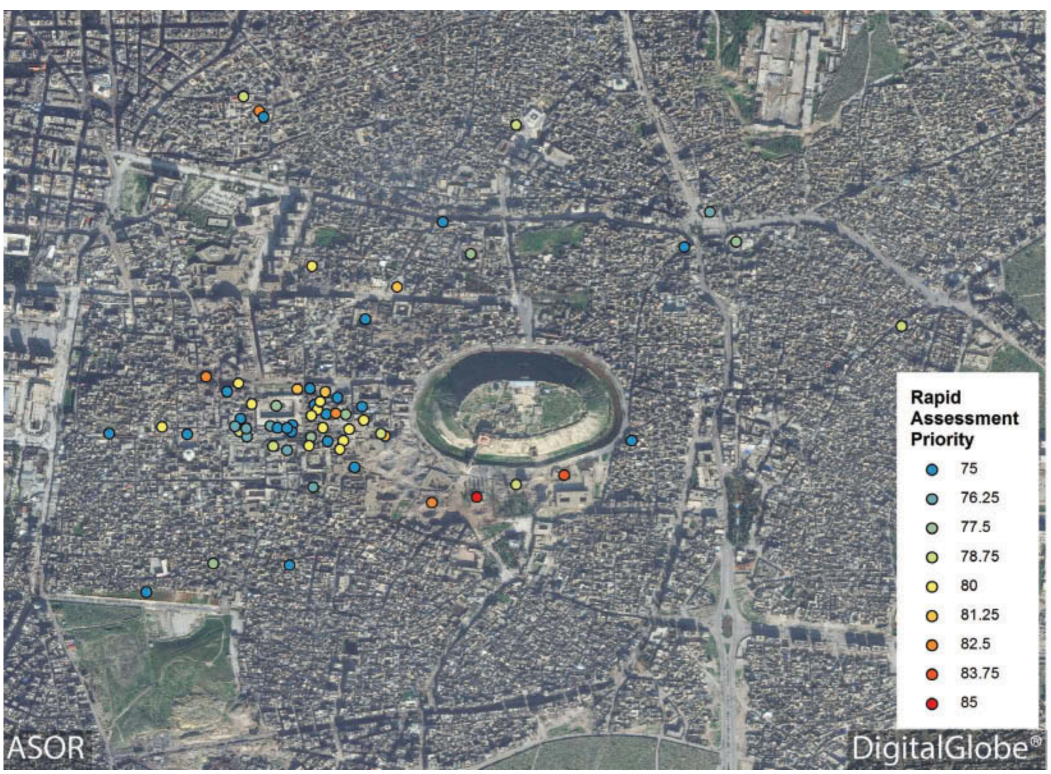

Fig. 15. Distribution of the rapid assessment priority for 44 cultural heritage entities in Aleppo (Courtesy of DigitalGlobe/ASOR CHI)

5. CONCLUSIONS

In developing this methodology, our primary challenge has been to find a way produce condition assessments in a systematic way without first-hand observations. Another challenge is the impossibility for assessors to have an intimate knowledge of each of the more than 12,000 sites in the CHI inventory. In these circumstances, one difficulty can be recognizing the line between observable fact and inference. For example, if a satellite image shows a collapsed roof, can it be presumed that the walls of the structure have been damaged as well? Without good baseline data, how do we know which damage in a photo is recent? It would be useful to somehow incorporate the concept of "confidence level" into the methodology. How confident are we in our various assessments of risk, disturbances, percentage of damage, or condition? Also, how reliable are particular data sources? Additionally, it's important to recognize that the situation on the ground is not static, so these assessments need constant updates if they are to stay relevant and useful.

Overall, the CHI methodology has tackled difficult questions to create a robust platform for documenting preservation issues during armed conflict. The system appears to be manageable for assessors working with secondary data sources; preliminary analysis has yielded results that are in line with expectations, and CHI has received positive feedback from our international colleagues who are also working on developing best practices for this type of work. Lastly, the methodology remains flexible and open to change and revision.

For the future, CHI is currently working on assessments for all of the properties that have been covered in our weekly reporting series, and plan to move on to other heavily impacted areas after that. The next significant change will be to integrate the condition assessment database with Arches when the new version, Arches 4, is released. Incorporating our assessments into Arches will facilitate working geospatially to view condition information and to further explore patterns and relationships between properties. Some of the anticipated updates to Arches include the ability for increased customization of the condition assessment module and mobile data collection. Hence, CHI is developing rapid assessment forms for on-the-ground documentation that could be used within such a mobile platform.

To conclude, this article has discussed how the CHI project collects, archives, and analyzes information about status of heritage sites and collections in Syria and Iraq during the current crisis. It has also demonstrated how this information can be used to systematically document the causes, effects, and extent of damage to these cultural properties. Ultimately, it is hoped that this work will improve our understanding of the types and patterns of risk and damage to cultural properties, in order to better protect and manage heritage during periods of armed conflict.

ACKNOWLEDGMENTS

This research would not be possible without the hard work of our dedicated ASOR CHI team and volunteers, and the support of our funders, especially the US Department of State.

NOTES

1. For more on the development of the regional conflict, see Rodgers, L., D. Gritten, J. Offer, and P. Asare (2016) or Institute for the Study of War (2016).

2. For more on satellite imagery-based analysis of archaeological sites in Syria during the conflict, see Casana (2015).

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THE EFFECT OF AN UNEXPECTED SPRING THAW IN MONTREAL: NATURAL DISASTER AS "FIFTH BUSINESS"

BRITTANY WEBSTER, ANNE MACKAY, AND ALEXANDER GABOV

Totem urbain/Histoire en dentelles by Pierre Granche pays homage to past and present Montreal, its geography, and its culture. Composed of 15 elements in brass and six levels of glass panes and fragments atop an aluminum substructure, the entire sculpture both figuratively and literally bridges the old and new McCord Museum edifice. Completed in 1992, the sculpture remains one of Granche's major public commissions.

Although regular maintenance tracked and mitigated preservation issues typical in the care of an outdoor sculpture, the sudden and violent impact on the sculpture from falling ice on the morning of March 11, 2015, led to the complete dismantling and conservation of the artwork. The accident not only allowed for the repair and replacement of damaged elements but also provided an occasion to improve the structural stability and durability of the work.

The fall of ice from the cornice of the museum recalls the fateful snowball thrown by Percy Boyd Staunton in the iconic Canadian novel *Fifth Business* by Robertson Davies. As the effects of that snowball reverberate throughout the remainder of the book, so did the impact of the ice: although devastating to the sculpture, it set in motion the type of discussion and conservation treatment needed to preserve this emblematic Canadian artwork for decades to come.

KEYWORDS: Pierre Granche, Outdoor sculpture, Brass, Aluminum, Glass, Ice damage, Fifth Business

1. INTRODUCTION: FIFTH BUSINESS

In the preface to Robertson Davies' novel, he defines Fifth Business as follows:

> Those roles which, being neither those of Hero nor Heroine, Confidante nor Villain, but which were nonetheless essential to bring about the recognition or the denouement, were called the Fifth Business in drama and opera companies organized according to the old style; the player who acted these parts was often referred to as Fifth Business. (Davies 2014, vi)

The novel opens with Dunstan Ramsey and Percy Boyd Staunton as children, sledding in the wintertime. Walking home, Percy launches a snowball at Dunstan. Although none of the characters realize it at the time, from that point forward, Dunstan Ramsey is cast in the lifelong role of Fifth Business and that event will forever bind the lives of all involved.

As conservators of outdoor public artworks, we are often called upon to assess the condition, treat, and make recommendations for the future preservation of a work of art. Sometimes conservators are contacted due to accidents or natural disasters. Rather than concentrate on the negative aspects of such an event, we tried to see it as a starting point to better understand and treat the artwork: the effects of public interaction, the artwork's material composition, and Pierre Granche's method of creating the artwork.

2. THE ARTIST: PIERRE GRANCHE

Pierre Granche (1948–1997) was an influential figure in Quebec's artistic community and a strong advocate for the integration of public art with architecture. After graduating from the École des beaux-arts de Montréal in 1969, Granche pursued advanced studies in sculpture at the Université de Vincennes in Paris (University of Montreal 2013). As a teacher at the Université de Montréal from 1975 until his death, Granche helped found the studio arts section in the art history department and often involved his students in art projects, teaching by example. Granche created more than 100 works of art, and many of his public artworks, such as *Comme si le temps...de la rue* and *Système*, can be found in Montreal's metro stations and public spaces.

Fig. 1. Artist Pierre Granche standing beside the completed artwork *Totem urbain/Histoire en dentelles*, ca. 1992, 304.8 x 609.6 x 122 cm, McCord Museum, M992.112.1.1-2 (Courtesy of McCord Museum)

Granche had an architectural understanding of space and created artworks that not only spoke to the history of a site but to human interaction. He was involved in the creation of his artworks throughout the entire process, from months of research while conceptualizing a design to manufacturing individual elements in his workshop (Benoit and Surugiu n.d., 3-4). Thus, each of Granche's choices, from materials used to placement of individual elements, play an important role in the realization of his artworks.

3. THE ARTWORK: *TOTEM URBAIN/HISTOIRE EN DENTELLES*

Totem urbain/Histoire en dentelles was completed in 1992, for the official reopening of the expanded McCord Museum in Montreal. The artwork was purchased by the museum as part of the Quebec government's Art and Architecture Integration program (la Politique d'intégration des arts à l'architecture et à l'environnement), wherein part of the construction budget, typically 1% of a publicly funded structure, is devoted to the commission or purchase of an artwork for permanent integration into the building or public space.

The outdoor sculpture measuring 10 ft. high x 20 ft. wide x 4 ft. deep rests atop a custom-built limestone niche along Victoria Street. Placed in front of a large window, the sculpture is visible both outdoors from street level and from the interior of the museum. In the evening, spotlights beneath the glass and inside the brass "camera" element dramatically illuminate the sculpture.

Totem urbain/Histoire en dentelles is one of Granche's most intricate and recognizable sculptures in Montreal, forming an integral part of the history of the McCord Museum. Paying homage to both past and present Montreal, its geography and culture, the artwork draws on imagery from different periods in the history of Montreal. Granche, pictured beside the artwork in figure 1, references Montreal's legends and traditional trades, as well as the McCord Museum's costume and textile collection and Notman Photographic Archives.

Fig. 2. Detail of missing glass shards, *Totem urbain/Histoire en dentelles*, 2013 (Courtesy of McCord Museum)

4. PREVIOUS INTERVENTIONS AND CONDITION

Over the course of 23 years, the sculpture had begun to show signs of deterioration, including pieces of glass pried loose by the public (fig. 2), the dismantling and moving of one of the brass figures overnight, issues with moisture entering between the layers of glass and subsequent algae growth (fig. 3), and accumulated dirt and debris. Many of the screws attaching brass panels corroded, making access below the glass table very difficult and preventing the spotlights' lamps from being changed.

Fig. 3. Detail of moisture and algae growth between layers of glass, *Totem urbain/Histoire en dentelles*, 2011 (Courtesy of McCord Museum)

Fig. 4. Detail of a brass figure retired to the McCord's storage vault in 2000, *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov)

Prior to spring 2015, the artwork's condition had been documented since 2000 by Anne MacKay and by several conservators, including Dolléans Inc., Nathalie Richard, and the Centre de conservation du Québec. Small interventions such as cleaning and graffiti removal had also taken place. As pieces of glass or elements of the sculpture became loose or detached, the museum brought them indoors and housed them in storage until they could be reintegrated (fig. 4).

5. NATURAL DISASTER: AN UNEXPECTED SPRING THAW

On March 11, 2015, in the early morning hours, a large block of ice fell from the cornice of the McCord Museum, gained momentum over several stories, and smashed through the north end of the sculpture below. A security camera on Victoria Street captured some of the resultant damage on film, as ice and broken shards of glass were thrown into the street by the impact. Figure 5 highlights some of the resultant damage at the north end of the artwork.

Just as the fateful snowball in *Fifth Business* set in motion a series of events, so too did the falling ice at the McCord Museum. Although undeniably devastating for the artwork, the unexpected natural disaster created a conservation opportunity not only to repair the sculpture's damaged elements but to reconsider the original materials used and how they had aged, address security issues, and start a dialogue concerning the artist's intentions and public interaction.

6. TREATMENT

Conservation takes many forms, and often when it comes to outdoor public artwork, conservators are called upon to deal with extreme circumstances such as vandalism, natural disasters, and severe

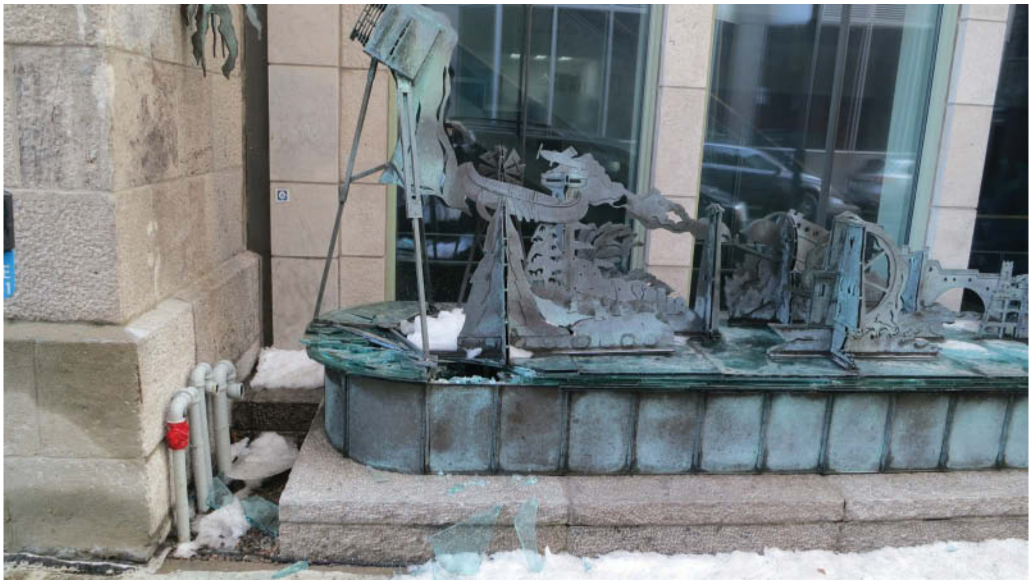


Fig. 5. The damaged artwork *Totem urbain/Histoire en dentelles*, March 2015 (Courtesy of Anne MacKay, McCord Museum)

deterioration. Over the course of eight weeks, *Totem urbain/Histoire en dentelles* was completely dismantled and rebuilt. Treatment, carried out by Conservation of Sculptures, Monuments and Objects (CSMO) involved research into the artist's methods of creating the sculpture, mapping out the location of individual elements, and recreating the broken and unsalvageable layered glass element.

6.1 ENCLOSURE AND TAKING STOCK

CSMO began work in early August, with a view toward finishing by October 4, as the McCord Museum had permission from the city to close off Victoria Street to traffic for this period. Work began with pretreatment photography, photogrammetry, taking down the temporary wood protection, and building an enclosure around the entire sculpture and surrounding sidewalk (fig. 6).

The artwork was carefully dismantled, and CSMO staff named and documented the placement of each of the 14 brass elements on the glass and 9 brass spacers between glass panes. The entire artwork needed cleaning, there was some structural damage to the substructure, and a significant amount of glass needed replacing. Masonite templates were cut to the size of each of the 10 sections of glass to mark existing anchor holes and determine new anchor holes as needed. These became the templates that were sent to the glass company at a later stage.

6.2 LAYERED GLASS: DISMANTLING AND OPTIONS

When reviewing the artist's proposal and associated documentation, and in speaking with museum staff who remembered the installation process, it was clear that the creation of the artwork was a team effort. The layered glass component was assembled in situ from commercial glazing off-cuts. Granche and his team worked organically, breaking glass panes and piecing them together according to his desired aesthetic appearance. According to an interview in 2012 with the artist's daughter Catherine, "the purpose of the glass is to reproduce the movement of water and during its restoration the most important aspect is to preserve the colour and thickness of individual glass pieces" (Poisson 2012).

As conservators, we were very aware of the importance and intrinsic value in each of Granche's choices, including the color and thickness of glass panes. As the layered glass component was disassembled, it was discovered that aside from silicone, another adhesive had also been generously applied in many areas

Fig. 6. View of interior of enclosure and artwork *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov, CSMO)

to attach glass shards. Tests with various solvents revealed that the separation and cleaning of individual pieces would not be viable given the budget and time frame. Thus, we decided to replace the entire multilayered glass component, recreating the artist's technique and matching the glass color and thickness, to ensure that the entire piece would appear unified. A hole was cut out in the north side of the shelter, walls were extended to accommodate a large bin, and all glass was carefully removed by hand.

Discussions concerning public safety, should the layered glass element be subject to impact damage in future, led to the consideration of other types of glass for either the top or both top and bottom layers of solid 15-mm glass panes. Informed by the experience of MD Glass Tempering Limited, discussions centered around the benefits of using tempered and laminated glass and took into consideration our timeline, budget, safety factors, aesthetic appearance, and artistic intent.

Tempered glass requires that a film be adhered to the glass pane so that once broken, pieces remain in place. Normally, caulk is applied to all edges and the assembly is framed to hold everything together. There was thus concern that in our situation the unframed film would be less predictable in terms of adhesion and reaction to glass breaks. Furthermore, questions arose concerning the film's ability to stay in place and withstand an outdoor environment over time.

A sample of laminated glass was created for review and was found to be visually unacceptable due to the additional thickness required and horizontal seam created by the laminate interlayer. Regular glass was decided upon for all levels of the glass element due to the preferred aesthetic it affords in keeping with the artist's vision.

6.3 ALUMINUM SUBSTRUCTURE

The bent horizontal crossbar at the north end of the sculpture was realigned and two vertical aluminum braces were manufactured to better support the substructure at each end.

When removing brass panels along the west side of the sculpture to access the interior, a thick layer of aluminum oxide was noted. According to the artist's specifications, the aluminum substructure

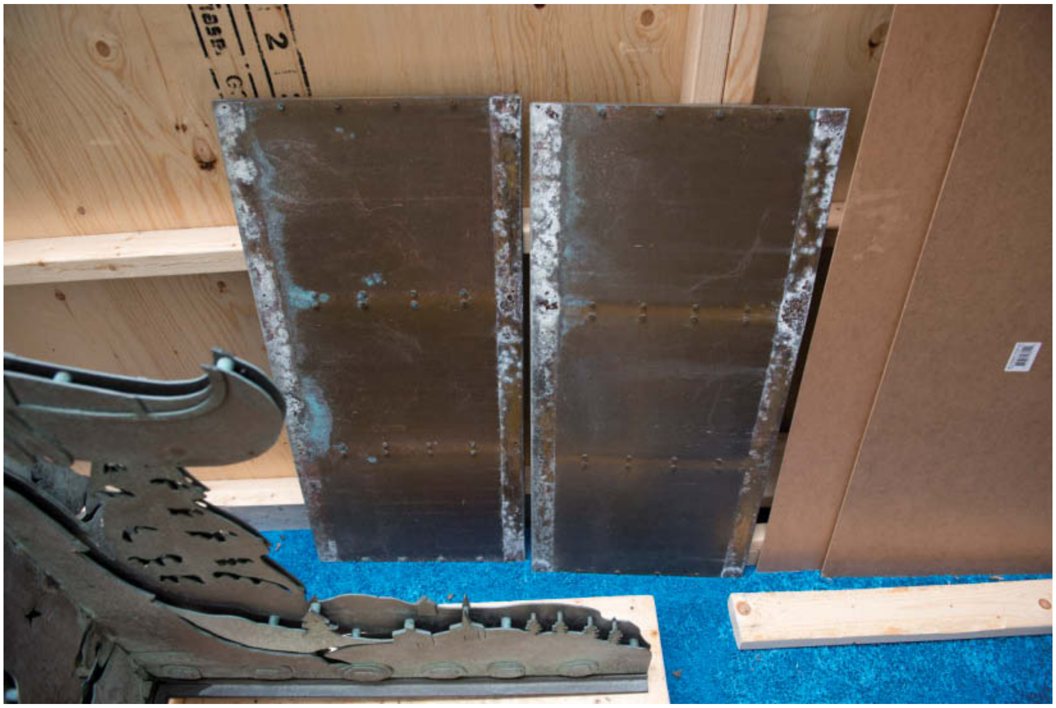


Fig. 7. Detail of corrosion products on brass panels, *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov, CSMO)

has a mill finish ("fini moulin") that naturally oxidizes as it is exposed to air and moisture. In the presence of atmospheric moisture and salt, wherever the aluminum substructure came into direct contact with the brass panels, galvanic corrosion was encouraged. Given that aluminum is the less noble alloy of the pair, it was preferentially corroded (fig. 7).

Due to the corroded copper screws holding panels in place and built-up aluminum corrosion, undoing the brass panels necessitated shearing off the individual sections, with a risk of damage. It was therefore decided to clean and coat the exposed aluminum with paint to isolate it from the brass and use a metal oil in areas where the aluminum had not been exposed. The corrosion is a problem that will need to be addressed in the future, approximately 75 years from now.

6.4 BRASS FIGURES MOUNTED ON GLASS

Brass figures were cleaned with an anionic detergent and rinsed outdoors. At this time, any residues and graffiti were removed using fine tools and custom poultices, taking care not to disrupt the established green patina on brass figures. Silicone was removed from the base of brass elements using fine tools, and they were treated with a solution of 2.5% benzotriazole (BTA) in B-72, as several bases showed signs of bronze disease (fig. 8). This will also provide some protection from moisture for the undersides of brass figures.

6.5 RECREATING THE LAYERED GLASS

Once glass panes had been cut and finished, with predrilled holes, the glass table was carefully recreated. This was done one layer at a time, ensuring that all anchor holes were given ample space and joints were staggered, to recreate the artist's original organic water-like appearance. Rather than replicate the exact size and shape of glass pieces, we sought to replicate the artist's technique and aimed to capture the same feeling of flowing water, referencing photographs taken prior to dismantling. We tested various

Fig. 8. Detail of suspected bronze disease on the underside of the brass figure, *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov, CSMO)

techniques when smashing the glass panes, including leaving the pane in its wrapper, scoring the glass before hitting it, and changing the impact angle and part of the hammer used (figs. 9, 10).

Each broken edge piece was smoothed with a belt sander to ensure that no sharp edges remained, and we tried to bridge broken shards over previous layers' gaps to reinforce the strength of the assembly. This stage of the project took the most amount of time overall.

6.6 METHOD OF ANCHORAGE

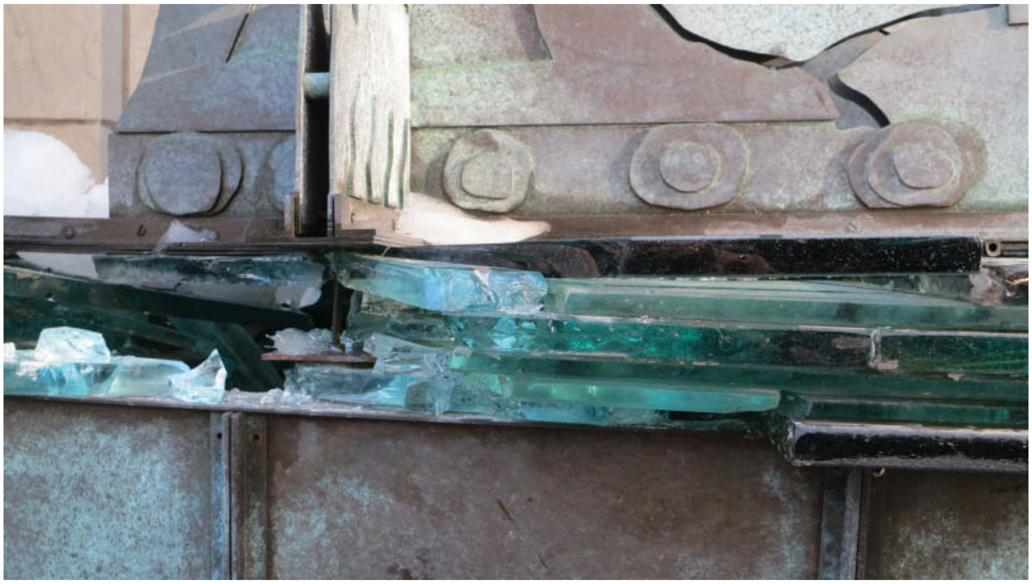
One of the main areas of concern in terms of artwork safety was the method with which the artist had anchored individual brass figures to the glass. Granche worked from the bottom up, wherein each of the 14 brass elements were screwed to brass L-brackets on the base of both sides, which in turn were screwed to a cross-shaped flat piece of brass; threaded rods were inserted into small brass plates and secured with a nut under the brass plate (figs. 11, 12). The threaded rods and plate were placed on the fourth layer of glass from the top, and remaining glass shard layers were stacked around the rod. For the final glass layer, a corresponding hole with a slightly larger diameter was drilled into the glass and glass panes were lowered over the upright rods. Silicone sealant was used to fill the gap between the rods and glass holes, and corresponding holes were drilled into the cruciform bases. Each brass element was secured to the glass by first applying silicone to the base and then lowering it over the rod(s) and securing with a nut from above.

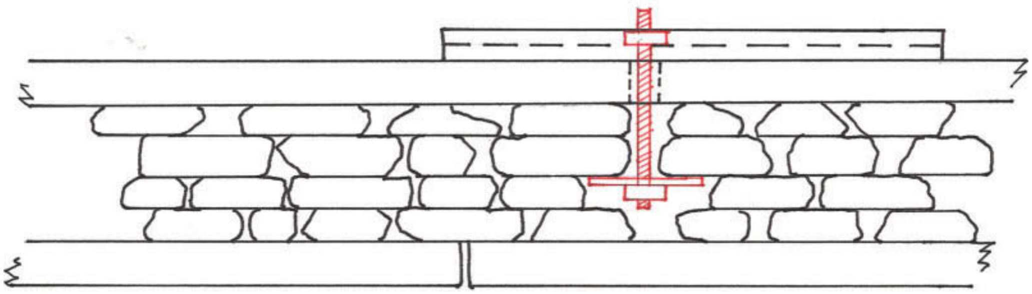
This method of connection was both visible and easy to unfasten, witnessed in 2000 when one of the brass figures was undone and shifted slightly on the glass base during the night. In addition, once the brass figures were removed, the associated anchors tended to fall inside the multilayered glass, making reattachment with the original anchors very difficult.

CSMO modified the artist's method of attachment for the 2015 reinstallation, requiring anchors to be accessed from below the glass table (fig. 13). Similar threaded rods were sourced and cut to accommodate all six layers of glass, and holes were predrilled through the top and bottom glass panes to

Figs. 9, 10. Smashing the glass panes to recreate the layered glass component, *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov, CSMO)

allow for the anchors to be dropped all the way through and tightened from below. Original materials were reused, with additional copper nuts and Plexiglas spacers added between the metal and glass plates for further support. Double upper nuts were secured in place with epoxy and sealed with polyurethane sealant to discourage the public from attempting to undo the nuts from above. In the future, to unfasten the anchors, one must enter from beneath the glass component of the sculpture, accessed by one of the brass side panels on the west.





Figs. 11, 12. Detail of the anchor, *Totem urbain/Histoire en dentelles*, 2015, and a diagram of the artist's system of anchorage (Courtesy of Anne MacKay, McCord Museum)

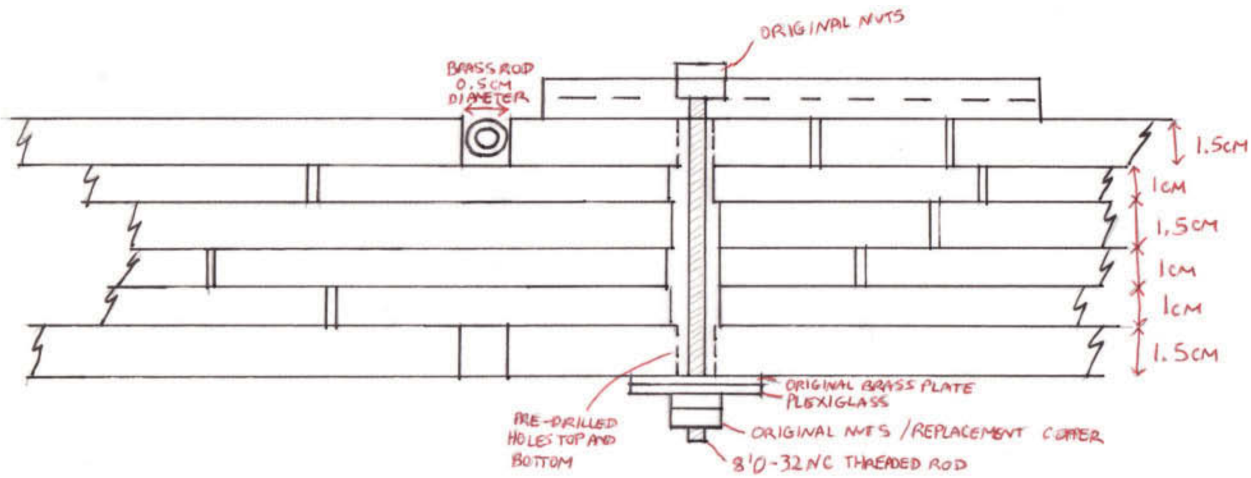


Fig. 13. Diagram of new system of anchorage, 2015 (Courtesy of Brittany Webster, CSMO)

6.7 LIGHTING

Sometimes problems in accessing certain elements lead to a disconnect between the artwork and the artist's original vision—for example, difficulty in reaching the interior light bulbs of *Totem urbain/ Histoire en dentelles* prevented them from being changed. Previously, incandescent bulbs were specified by

Fig. 14. Updated lighting, *Totem urbain/Histoire en dentelles*, 2015 (Courtesy of Alexander Gabov, CSMO)

the artist; however, the heat they produced, combined with accumulated salt and water during the winter and spring, likely contributed to the corrosion of metal components.

The defunct lighting was updated to accommodate LEDs, which will not produce as much heat as incandescent bulbs (fig. 14). A color temperature of 3000 K was chosen for both the "camera" element and inside the sculpture's base, as this is similar in color to the original lighting used.

7. MAINTENANCE

Visual inspection, documentation, and cleaning of the artwork by a conservator will be carried out on a yearly basis to track the sculpture's condition over time. For the next five years, CSMO will carry out the assessment, based on nonintrusive methods of investigation, which may include the use of microscopic digital photography, photogrammetry, and solvent testing.

All joints and points of connection between materials will be inspected for structural integrity, concentrating on modes of water ingress and corrosion build-up on the aluminum substructure. Conservation materials used (including caulking, sealant, replacement screws, and glass) will be monitored for signs of degradation such as corrosion, biological growth, and physical damage.

Both the sculpture and surrounding area will be cleaned using a conservation-grade detergent and rinsed with water to neutralize salts and wash off the sculpture. Any remnants of graffiti, residues, and/or organic matter not removed by the pressure washer will be removed using a combination of solvents, custom poultices, and fine tools. Care will be taken to minimize any change to the brass patina of metal components and rinse cleaned areas.

Following cleaning, an assessment report will be provided to the McCord Museum, outlining a detailed summary of the sculpture's condition; recommendations, including ongoing maintenance; and prioritized conservation treatments such as repairs and restoration.

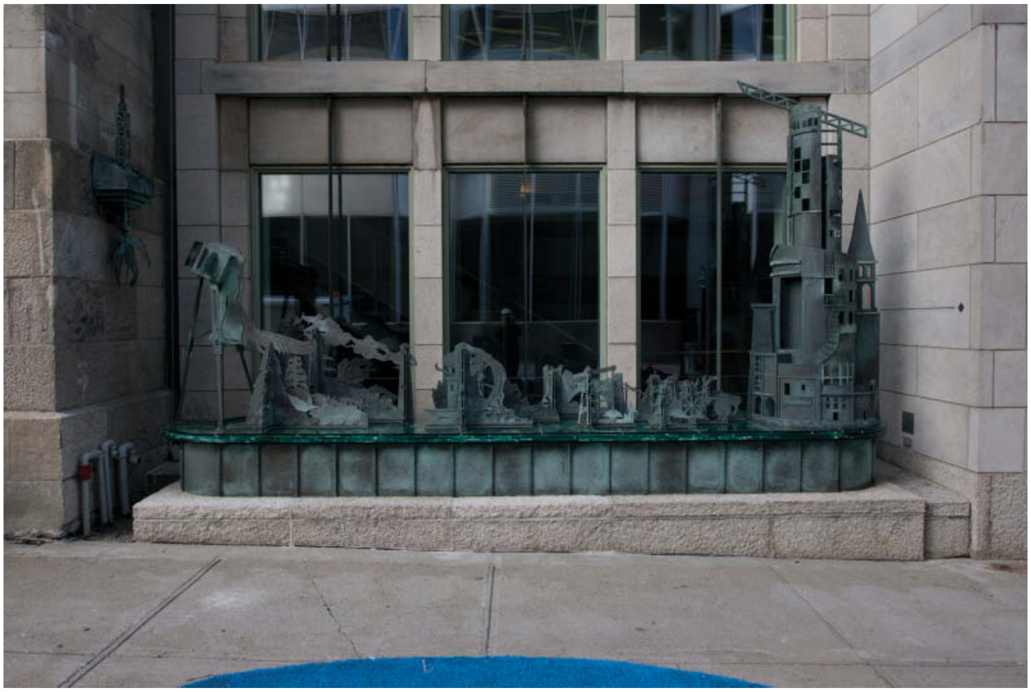


Fig. 15. *Totem urbain/Histoire en dentelles* after treatment, 2015 (Courtesy of Alexander Gabov, CSMO).

8. CONCLUSION

With the sculpture completed, the McCord Museum has also installed metal L-brackets along the cornice to prevent ice from accumulating and falling at this point in the future. Like Percy's snowball from the novel *Fifth Business*, the incident of falling ice at the McCord Museum had disastrous repercussions but nonetheless has played an important supporting role in this sculpture's story. Seeing the restored sculpture, especially illuminated at night, gives a sense of Granche's vision of Montreal, past and present. It is our hope that this vision will live on for centuries to come and shape the lives of future generations in Montreal (fig. 15).

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SOURCES OF MATERIALS

Aluminum braces
Russel Metals
191 Dalton Ave.
Kingston, ON K7K 6C2
613-542-5200
http://www.russelmetals.com/EN/Pages/Home.aspx

Benzotriazole (BTA)
Cole-Parmer Canada
210-5101 Buchan Street
Montreal, QC H4P 2R9
800-363-5900
https://www.coleparmer.ca

Copper screws, Threaded copper rods, Plexiglas
Canadian Tire
59 Bath Rd.
Kingston, ON K7L 5G3
800-387-8803
http://www.canadiantire.ca/en.html

Glass
MD Glass Tempering Ltd./Verre Trempe MD Ltee.
5825 Rue Donahue
Saint-Laurent, QC H4S 1C3
514-335-6219
http://www.mpglass.ca

Macropoxy 646
Sherwin-Williams Canada Inc.
180 Brunel Rd.
Mississauga, ON L4Z 1T5
800-524-5979
https://protective.sherwin-williams.com

Metal oil
HD Supply Brafasco
1407 John Counter Blvd.
Kingston, ON K7K 6A9
613-544-4427
https://brafasco.com

Orvus WA Paste
TSC Kingston
1093 John Counter Blvd.
Kingston, ON K7K 6C7
613-546-5561
http://www.tscstores.com

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Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190-1746
805-682-9843
http://www.conservationsupportsystems.com

Tinted wax
Lee Valley
590 King St. West
Toronto, ON M5V 1M3
800-267-8767
http://www.leevalley.com/en

Tremsil 600 Silicone Sealant
Rigney Building Supplies
5 Terry Fox Dr.
Kingston, ON K7K 6Y7
613-544-9145
http://rigneybuildingsupplies.com

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THE RESCUE AND CONSERVATION OF THE LOST SHUL MURAL

RICHARD L. KERSCHNER AND CONSTANCE S. SILVER

This article describes how an interdisciplinary team worked together over two years to stabilize, protect, and move a 105-year-old triptych mural from the former Chai Adam Synagogue to the Ohavi Zedek Synagogue in Burlington, Vermont. The mural is a rare surviving example of traditional Eastern European painted synagogue art following the destruction of nearly every synagogue in Eastern Europe during the Holocaust. Flaking paint was consolidated and secured to the plaster, and layers of darkened varnish and dirt were partially removed from the mural. To ensure the mural's safety during the relocation process, it was faced with Crepeline adhered with Paraloid B67 followed by cyclododecane reinforced with fiberglass Micro-mesh. Foam-lined plywood panels were secured against the faced mural to provide uniform, rigid support during the move. A permanent steel framework was built around the roof section of the apse that contained the mural to minimize movement of the plaster-on-lath during extrication and transport of the mural, and to enable the mural to be suspended safely in the lobby of Ohavi Zedek Synagogue.

KEYWORDS: Cleaning, Consolidant, Cyclododecane, Facing, Framework, Move, Mural, Plaster-on-lath, Synagogue, Varnish

1. INTRODUCTION

In 1910, a young Lithuanian poet, performer, playwright, and artist named Ben Zion Joseph Black was commissioned to paint the interior of the Chai Adam Synagogue in Burlington, Vermont.[1] The only historic photo of Chai Adam's early interior shows the original painted walls and the lower half of the mural (fig. 1). The entire ceiling had also been painted as a blue open sky, complete with birds, musical instruments, and cherubs. Black worked for six months to paint the mural, walls, and ceiling of the synagogue for a fee of $200.

Chai Adam Synagogue was decommissioned in 1939 and repurposed, first as a dry goods store and later as a carpet shop and warehouse. In 1986, it changed hands again and was retrofitted as apartments. Although elements of the original historic interior were lost with each renovation, the subsequent owners apparently recognized that the 155-square-foot triptych mural painted on the plaster ceiling of the apse was significant and should not be destroyed.

When the building was sold in 2012, the historians tracking the mural realized that the only way to preserve this unique work of religious art was to remove it from the building and decided they would have to raise funds to support the move. Samuel D. Gruber, PhD, an internationally recognized expert on Jewish art and the historic preservation of Jewish sites and monuments, was engaged to research the mural's historical significance. After viewing and studying the mural, he concluded that:

> "The mural is a rare survivor of the rich Jewish artistic tradition in Eastern Europe. This world of Jewish art was nearly completely destroyed in the Holocaust and remains poorly understood. It is a rare and striking painting, one of only a small number of extant synagogue murals in North America painted by immigrant Jewish artists for congregations that were still tied to their distant homelands, the Yiddish language and traditional Jewish religious practice. Nothing quite like this survives in Europe, and no mural in the United States equals the Lost Shul Mural in size, scope, completeness and Jewish meaning. Only a few highly damaged painted fragments survive from all the synagogues in Lithuania, most notably from Cekiske, the town of origin for many of Burlington's Jews." (Gruber 2014)

This narrative describes how the interdisciplinary team of conservators, conservation scientists, engineers, historians, preservation carpenters, steel fabricators, riggers, a general contractor, and an architect rescued and conserved the Lost Shul Mural.

Fig. 1. Historic photo of Chai Adam interior (Courtesy of Lost Shul Mural Project)

2. RESCUING THE MURAL

Conservator Richard Kerschner first viewed the Lost Shul Mural in October 1986, four years after he was hired to establish conservation at the Shelburne Museum. Aaron Goldberg, a local lawyer and volunteer archivist at the nearby Ohavi Zedek Synagogue, requested his advice on the condition and possible disposition of the mural (fig. 2).

The building had been sold and was in the process of being retrofitted as apartments. The decorated walls and ceiling of the building had been gutted many years before and the owner was ready to destroy the large mural that was in her way. The floor of the upstairs apartment was already in place, allowing easy access to the mural. Goldberg was desperately seeking a plan to save the mural, possibly by arranging for its transfer to another organization that could move it to a safe but accessible location. Although the colors were muted by darkened varnish, the mural was in good structural condition with

Fig. 2. Lost Shul Mural as it appeared in 1986 before being isolated behind a wall, 335 x 640 x 275 cm (11 x 21 x 9 ft.) (Courtesy of Lost Shul Mural Project)

only minor losses to the paint. Kerschner recognized that the relocation of the mural would be difficult and expensive, and after consulting with Shelburne Museum's director, informed Goldberg that the mural did not fit with the museum's collecting mission and that the museum could not accept or move it. He suggested that an alternative to destroying the mural would be to build a wall in front of it. Goldberg convinced the owner that this was a reasonable solution; the wall was constructed in the bedroom of the east upstairs apartment, and the conversion of the building to apartments was completed.

Goldberg could not forget about the mural and over the next 25 years he continued to research its history. In 2010, Goldberg and his co-archivist, Jeff Potash, formed the Lost Shul Mural Committee at Ohavi Zedek Synagogue, but were unable to obtain the rights to the mural from the building owner. However, in November 2012, the apartment building was sold and the new owner agreed to donate the mural to Ohavi Zedek if the Lost Shul Mural Committee would remove it and restore the building and apartment. Ohavi Zedek rented the apartment that contained the mural and the interior wall covering the mural was removed.

As the insulation was peeled back, it was disturbing to observe the mural's condition (fig. 3). Despite instructions given to the building owner, the mural had not been properly protected when the wall was constructed and fiberglass insulation had been placed directly against the paint in many areas. Large areas of paint were flaking from the plaster. Close comparison to 1986 photos indicated that the areas with the worst flaking had shown cracks and cupping paint even before the mural was isolated behind the wall. However, the widely ranging environmental conditions in the empty wall cavity between the slate roof and the mural aggravated flaking and caused paint to detach.

The surface of the mural had deteriorated more in the 26 years behind a "protective" wall than in the previous 76 years it was open and visible on the ceiling of the synagogue and carpet warehouse. What

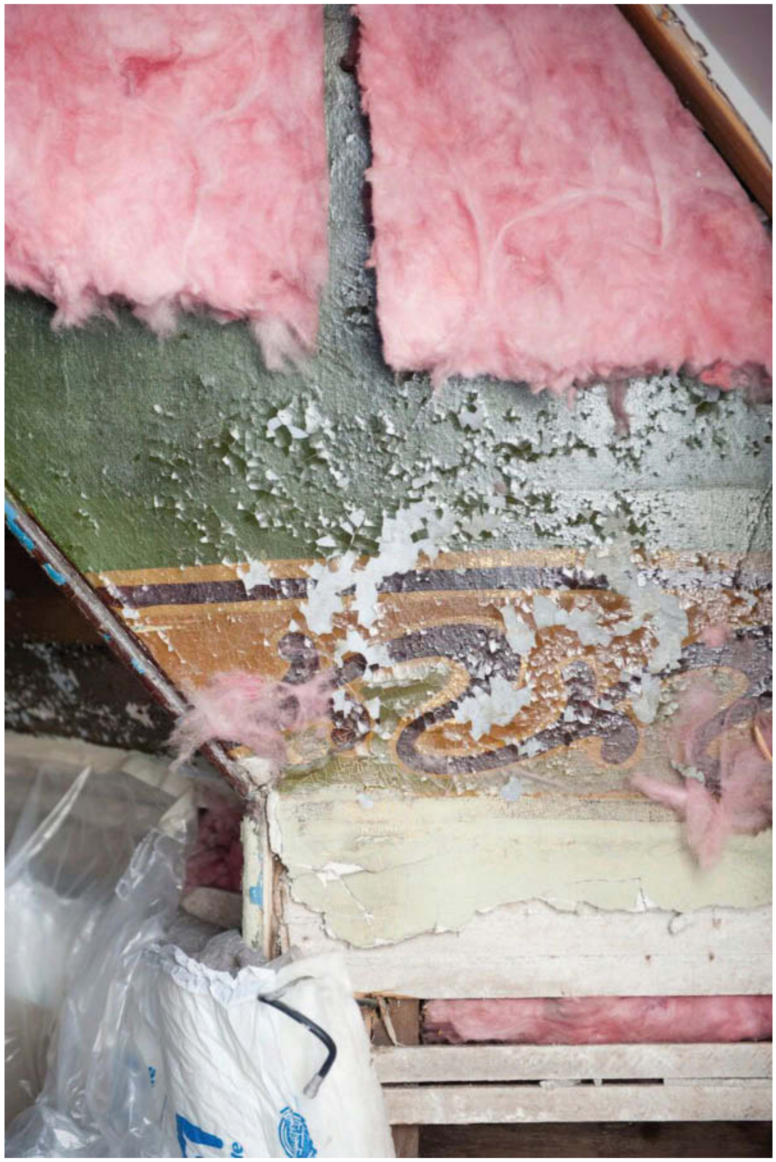

Fig. 3. Condition of mural on removal of wall and insulation (Courtesy of Lost Shul Mural Project)

had been estimated as about four square feet of paint loss of the 155-square-foot painting in 1986 had increased to about 15 square feet of loss, with paint actively flaking over the entire mural. Fortunately, 90 percent of the painted mural had survived and could be saved if the flaking could be consolidated.

3. CONSERVATION TREATMENT

Kerschner was engaged to advise on conservation of the mural and review treatment proposals. He joined the Lost Shul Mural Committee that now included the two archivists who were co-directing the project and a local architect. Mural conservator Constance Silver was hired and began treatment in January 2014, working through May to consolidate and reattach flaking paint, perform cleaning tests, and remove darkened varnish and dirt from selected portions of the mural. After extensive testing, Silver settled on a consolidation technique she had used successfully in the early 1990s on an oil-on-plaster

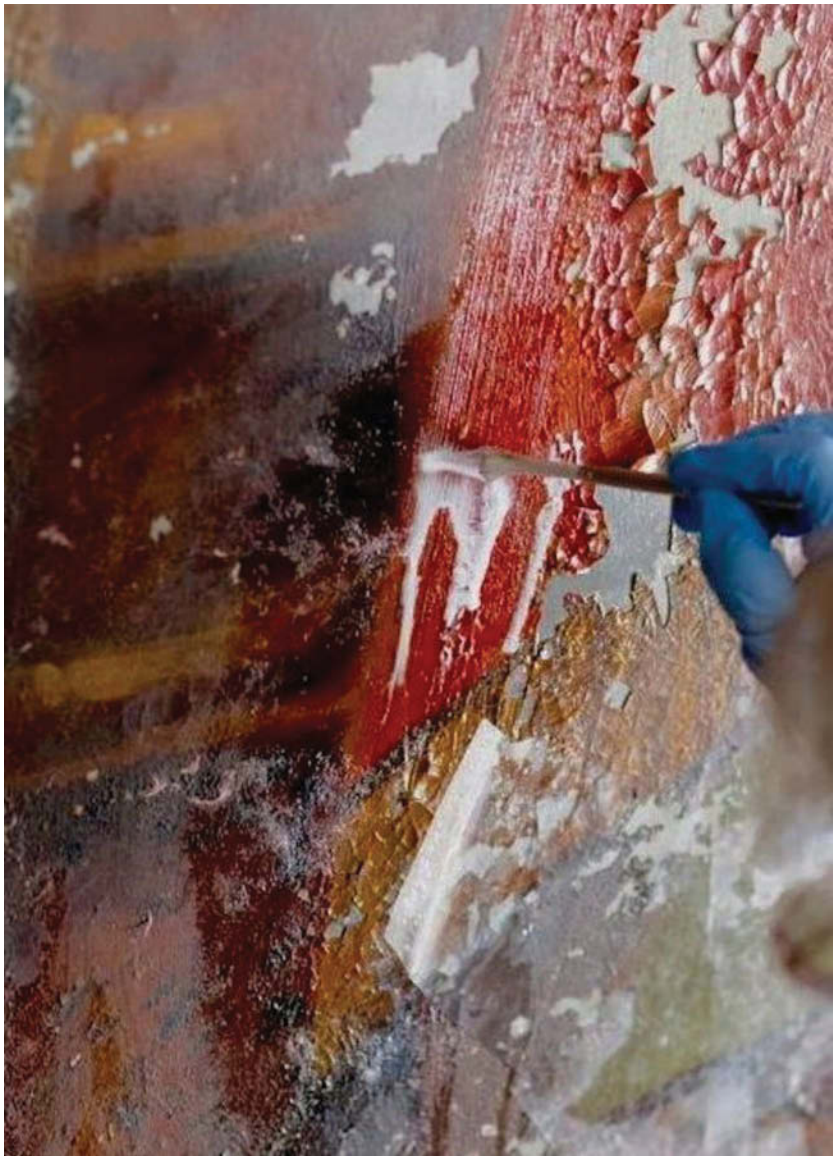

Fig. 4. Applying BEVA D8 to areas of flaking paint (Courtesy of Constance Silver)

mural in similar condition. The chosen consolidant was BEVA D8, an aqueous, non-ionic dispersion of ethylene vinyl acetate diluted 50 percent with distilled water.

The area to be consolidated was misted with distilled water with a drop of Woolite added as a surfactant. The misting wet all the surfaces of the deformed paint, and the wetting of the substrate relaxed the detached and curled paint and eased it back into contact with the plaster through capillary action. BEVA D8 was flowed onto the fragile, wetted surface from an eyedropper or soft brush (fig. 4).

The consolidant followed the path of the wetting agent, penetrating behind each flake. The treated area was allowed to dry slightly. Curled and flaking paint was then gently pressed back into plane using a baby wipe. The soft baby wipe allowed manipulation of the paint without it sticking to the fabric and also absorbed excess BEVA D8. This was an important step, required to avoid "gluing" grime and discolored varnish to the surface of the painting, which would complicate their eventual removal. Firm pressure was applied to the treated area with a flexible rubber bone folder through silicone-release Mylar to coax flakes flat and confirm the bond between the paint and the plaster. The treated area was further

Fig. 5. Detail of the partially consolidated sun (Courtesy of Constance Silver)

pressed into plane and heat-set with a tacking iron. A small travel iron was used to confirm adhesion to the plaster of larger contiguous areas of treated paint. Consolidation proceeded slowly in small areas from the bottom of each panel to the top (fig. 5).

Paint samples were extracted and submitted to conservator Susan Buck for cross section analysis to guide the complicated cleaning process and to identify glazes and over-paint (fig. 6). These two cross sections identified paint stratigraphy as three to four layers of early distemper wall paint directly on top of the plaster, followed by a thin coat of off-white paint and three more coats of a tan distemper paint. The mural oil paint consists of a white base coat followed by design colors, then two layers of varnish. Occasionally, glazes were used to enrich the colors, and the right sample shows a brown glaze directly on top of the orange paint. A total of 18 paint samples were analyzed.

Early cleaning tests revealed several technical issues. A layer of coal soot strongly adhered to the paint by the oil-laden varnish was the most complex cleaning problem. Black, brown, and many red paint areas were sensitive to cleaning agents, as were the brown columns and pediments because they contain multiple layers of thin glazes. All of these areas required slow and careful cleaning. Cleaning tests indicated that the varnish layers were soluble in xylene, isopropanol, and benzyl alcohol or various combinations thereof. Dirt and old varnish were removed by applying a benzyl alcohol-based solvent gel through wet-strength tissue. After the tissue was removed, dissolved varnish and soot were gently dislodged with a brush and cleared from the surface using cotton. Dwell time of the solvent-laden wet-strength tissue varied depending on the thickness of the varnish and the sensitivity of the underlying paint colors and glazes. Consolidation was completed and about 50 percent of the darkened varnish was

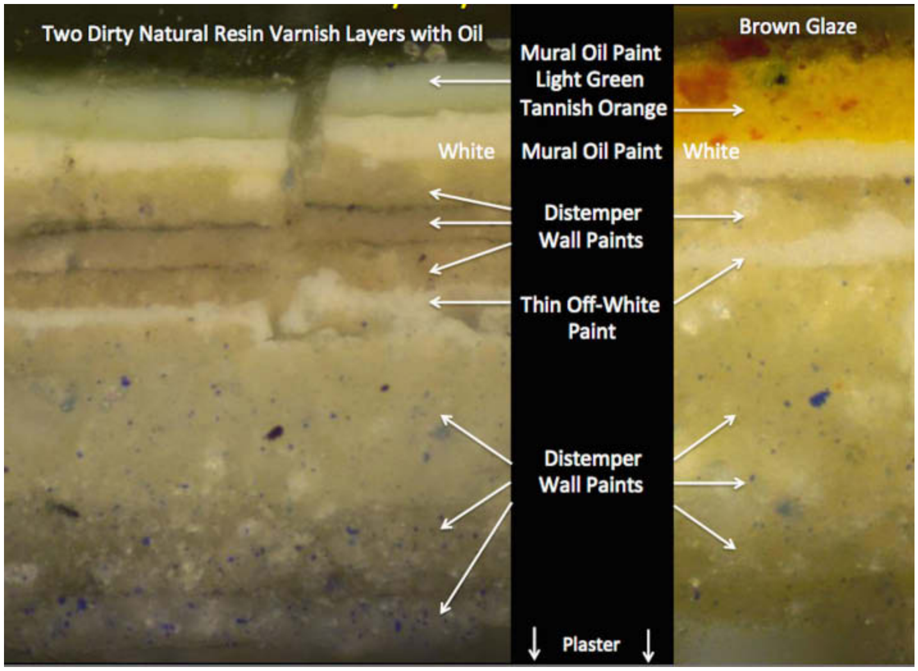

Fig. 6. Two cross sections of mural paint layers (Courtesy of Susan Buck)

removed before the mural was moved (fig. 7). Cleaning was not completed at that time since funds were still being raised to cover the cost of conserving and moving the mural. Cleaned "windows" created by removing discolored and dirty varnish layers helped fuel fundraising efforts as they were tantalizing clues to the vibrant colors hidden beneath the soot and darkened varnishes.

Fig. 7. Consolidated and partially cleaned mural prior to move (Courtesy of Lost Shul Mural Project)

4. PREPARING THE MURAL FOR THE MOVE

By early June 2014, the local fundraising committee had secured sufficient funding to proceed with the move, and the Lost Shul Mural Project Team was expanded to include a consulting engineer, general contractor, steel fabricators, and a rigger and crane service. Two full-time carpenters were hired for 18 months to separate the entire apse roof section that contained the mural from the building, and to restore the historic structure by building a new apse roof after the mural was moved to Ohavi Zedek Synagogue. The co-directors retained Kerschner to advise on historic and conservation materials and coordinate conservation treatment and moving the mural. Consulting engineer and clerk of the works Robert Neeld worked with the general contractor to select and advise subcontractors to design and build the protective structure, design and construct a steel framework around the apse roof section, and move and install the roof section that contained the mural at Ohavi Zedek Synagogue.

4.1 THE PROTECTIVE STRUCTURE

The mural had been painted on the plaster-on-lath ceiling attached to the inside of the rafters that supported the slate roof on the apse of the Chai Adam Synagogue (fig. 8). The two-story protective structure built to enclose the apse of the building (fig. 9) was completed well before one of the coldest and snowiest winters on record. Windows were included in the structure to allow light into the first-floor apartment, and sliding doors on the second floor provided access to load in steel for the framework and other materials. A propane heater was installed on the second floor of the structure to temper environmental conditions in the portion of the building that surrounded the mural.

Fig. 8. The apse of the former Chai Adam Synagogue (Courtesy of Lost Shul Mural Project and Bob Neeld, PE)

Fig. 9. Protective structure enclosing the apse (Courtesy of Lost Shul Mural Project and Bob Neeld, PE)

4.2 ASSESSING, STABILIZING, AND FACING THE MURAL

During September, the slates and wood sheathing boards were removed to access the back of the laths that supported the plaster ceiling on which the mural was painted.[9] The slates were numbered and stored for replacement on the new roof. Great care was taken to cut rather than pull nails so as not to move the rafters and risk breaking the fragile plaster "keys." As the original sheathing boards were removed, the roof structure was strengthened and made more rigid by reinforcing all the rafter attachments with steel angle brackets.

Attention turned to further evaluation of the plaster substrate and the plaster keys. The historic method of applying plaster to a ceiling or wall was to first nail wooden laths to wall and ceiling joists, allowing spaces of approximately three-eighths of an inch between the laths. Keys are formed when wet plaster fills the spaces between the wooden laths and curls around the back edges of the laths before the plaster sets. Once set, these plaster keys secure the plaster to the laths. If the plaster is weak, the keys can break and the plaster can separate from the wall. Preservation scientist Norman Weiss and conservator Irving Slavid of Monument Conservation Collaborative Materials, Inc., were contracted to analyze the plaster, develop methods to strengthen the plaster keys, and perform the work. Their analysis of samples indicated that the plaster was sandy and quite weak. They recommended strengthening the keys from the back with three applications of Conservare HTC (hydroxylating conversion treatment). After visiting the site and observing the lath and plaster from the back, Weiss also recommended extending the keys over the back of the laths using VoidSpan CG70 Fine Grout (fig. 10). After the keys were strengthened and extended, half-inch MDO plywood was chosen to replace the old sheathing boards to better stabilize the entire structure. Marvelseal 360 was ironed onto the plywood and edges were sealed with aluminum tape to slow humidity changes within the roof/wall structure.

Facings were applied to the front of the mural to protect and secure the paint and plaster during the move. First, the paint was faced with Crepeline adhered with Paraloid B67. However, a stronger facing was required to hold the plaster together in the event that the mural was jarred during movement. A lightly self-adhering fiberglass micro-mesh, designed for repairing drywall, was applied over the Crepeline facing and covered with cyclododecane, a wax-like material that melts at 142°F. (Rowe and Rozeik 2008) The solid cyclododecane was heated in a double boiler and applied as a liquid with large paintbrushes to a thickness of about one-eighth of an inch (fig. 11). Not only is cyclododecane a very

Fig. 10. Reverse of the mural showing plaster keys from the back and the newly created key extensions, metal reinforcing brackets, and new plywood roof sheathing (Courtesy of Bob Neeld, PE)

strong adhesive; it sublimes on exposure to air, changing directly from a solid to a gas and simply disappearing over time without the use of solvents or mechanical manipulation.

Constance Silver had previously used cyclododecane to consolidate small fragments of Egyptian mud-plaster wall murals that she treated in 2006. In 2002, a team of conservators led by Perry Huston used cyclododecane reinforced with gauze to face the 1932 David Siqueiros mural *Mexico Today* in preparation for its move to the Santa Barbara Museum of Art. In 2012, the Getty Conservation Institute posted a YouTube video on the project (Santa Barbara Museum of Art 2012). It was reassuring how similar these two mural-move projects were, especially since the Lost Shul Mural conservation actions were developed quite independently.

Eighteen inches of plaster bordering the bottom of the mural and two 6-inch-wide vertical strips of plaster bordering the left and right sides of the mural had to be removed so that the three large adjoined triangular sections of the mural could be separated from the rest of the building (fig. 2). In preparation for detachment, a double facing of Crepeline and cyclododecane over fiberglass mesh was applied to the front of the plaster and reinforced with short pieces of wood lath (fig. 12). Master carpenter Ray O'Connor worked with conservator Silver to remove the plaster borders. A hacksaw blade was inserted behind the plaster and used to cut through the plaster keys, freeing the half-inch layer of the faced painted plaster from the lath. After these sections of plaster were removed, it was possible to detach the exposed laths without damaging the plaster at the perimeter of the mural. Removing the laths revealed the apse roof rafters where they joined the end wall of the building and the apse wall joists where they met the base of the roof. It was then possible to saw through the nails connecting the roof rafters and wall joists to the rest of the building and completely separate the apse roof that contained the mural from the structure.

Fig. 11. The left side of the mural is faced with Crepeline. The right side has cyclododecane applied over fiberglass Micromesh on top of the Crepeline facing (Courtesy of Bob Neeld, PE)

4.3 BUILDING THE STEEL FRAMEWORK AND PROTECTING THE PLASTER

A steel framework was custom-built around the apse roof section that contained the mural assembly following plans created by the project's engineering firm. Though such frameworks usually are designed to restrict movement of the protected structure to 1/10 of an inch, this framework was designed to restrict movement to one 1/100 of an inch because of the fragility of the plaster keys. A three-dimensional detailing model was created from extensive existing building documentation to allow most of the steel to be prefabricated and carefully inserted into place without need for modification. Efforts to keep welding off-site and bolt the framework together around the mural proved too complicated, so the framework was welded together on-site. Fire blankets protected the back of the mural assembly and a fire watch was implemented during and after welding. The framework was required not only to securing the mural during removal and transport, but also to enable the mural assembly to be suspended from the steel-reinforced ceiling of the lobby of Ohavi Zedek Synagogue.

As the framework was being constructed, polyethylene sheet was secured over the mural to prevent the cyclododecane from subliming too quickly, and to provide a barrier between the mural and the foam pads that would protect and secure the plaster during the move. The beam across the front of the mural was required to stabilize the framework during the move and to support a floor in front of the mural to facilitate bracing of the foam pads (fig. 13).

Foam padded panels were built to secure the plaster substrate in place in case sudden jolts broke plaster keys during the move. They were constructed of MDO plywood covered with 1.5-inch urethane open-cell foam wrapped with Tyvek. The panels were pressed firmly against the mural and temporarily braced while a wooden frame was built to secure them in place. The wooden frame allowed pressure to be applied evenly to compress the foam against the plaster. The panels were hinged so that they could be carefully tilted back from the top down to check for loose plaster after the move.

A cross-section of the mural assembly after detachment from the building is shown in figure 14. The steel frame is labeled in yellow. Marvelseal covers the back of the plywood roof sheathing to mitigate

Fig. 12. Removal of painted plaster borders from lath (Courtesy of Lost Shul Mural Project)

humidity changes within the roof cavity. The ends of the laths nailed to the front of the rafters are visible. The layer of plaster on which the mural is painted covers the laths, and it is possible to view the keys that were formed when the wet plaster was forced into the spaces between the laths. Black ZIP Tape covers and seals the edge of the plaster and lath. The foam padding is pressed and secured against the face of the mural by the wooden frame.

While the mural was being prepared to move, the lobby of the Ohavi Zedek Synagogue was being prepared to receive it. The synagogue was built in 1952 and is an exemplar mid-century modern design. Although not designed to house the mural, the lobby is a perfect height and width. A steel-beam superstructure was fabricated and installed in the lobby to support the suspended three-ton mural assembly. A sturdy platform was built in front of the entrance to receive the mural and the glass wall had to be removed for the mural to enter the lobby, and then be rebuilt (fig. 15).

Fig. 13. Plywood and foam pad being positioned on the front of the mural over top of a polyethylene protective covering (Courtesy of Lost Shul Mural Project)

5. MOVING THE MURAL

After nine months of preparation, move day (May 6, 2015) dawned bright, warm, and sunny. The first action was to remove the roof to provide access to the mural. A crane lifted the roof and lowered it to the ground, where it was settled on rollers and pushed down the street and out of the way (fig. 16). Lifting straps and chains were attached to lifting points on the steel framework that surrounded the mural. The entire apse roof section had been jacked up a few inches the day before to insure that it was detached from the building. Once the steel-enclosed apse roof was completely supported by the crane, it separated easily from the building.

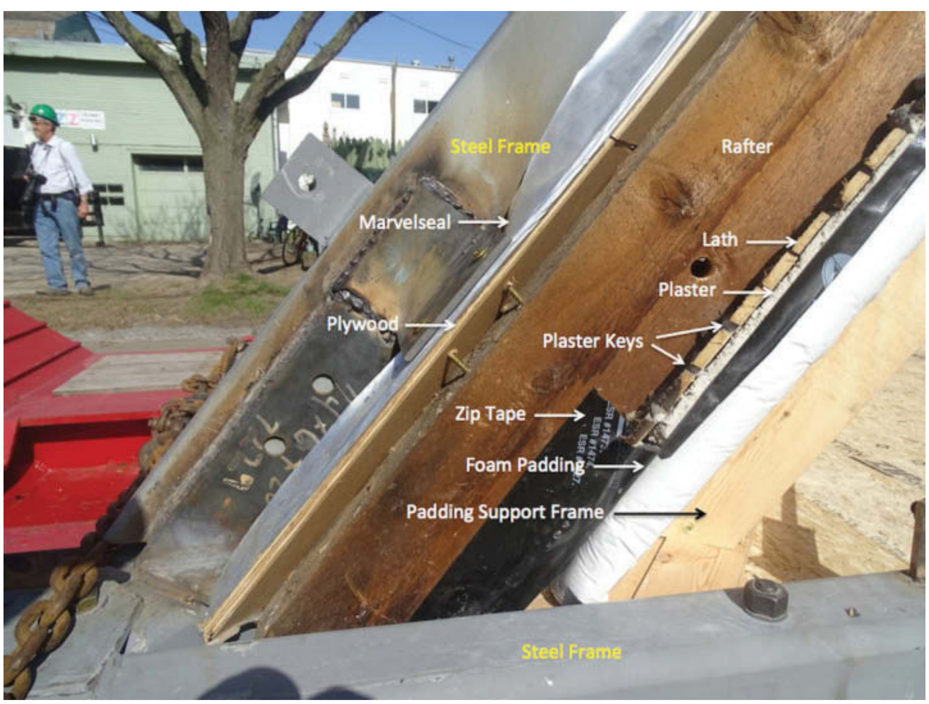

Fig. 14. Cross-section of roof structure and mural (Courtesy of Bob Neeld, PE)

Fig. 15. Entrance to Ohavi Zedek, the new home for the Lost Shul Mural (Courtesy of Lost Shul Mural Project)

The steel-framed and padded mural floated slowly upward, and a few minutes later it was resting on the bed of the waiting truck. As the truck moved away from the building, the roof was rolled up the street and lifted back into place to protect the open end of the building during the construction of the new apse roof, complete with the original slate.

Fig. 16. Crane removing roof (Courtesy of Lost Shul Mural Project)

Fig. 17. Mural being moved to platform (Courtesy of Bob Neeld, PE)

Trees had been trimmed back from the road and potholes had been filled to insure a smooth ride for the delicate cargo. The slow, careful, and uneventful 0.3-mile journey to Ohavi Zedek Synagogue took only about 15 minutes. As soon as the crane had replaced the roof on the protective structure, it drove to the end of the temporary access road that had been built across the lawn at Ohavi Zedek. The truck transporting the mural had to drive up the synagogue's wide entrance to position the mural on the building side of the utility wires and within safe reach of the crane. Steel plates covered the walkway to protect it from cracking under the weight of the truck and mural.

The crane lifted the mural from the truck and moved it to a custom-built platform (fig. 17). Several methods of moving the mural from the truck into the building had been discussed including using forklifts to lift the mural, drive it into the lobby and raise it into position. After much discussion, all agreed that the safest method was to attach temporary wheels to the bottom of the steel support structure, then use manpower to roll the 7,500-pound structure into the lobby and carefully maneuver it into position. The mural rolled into the opening with 1 inch of clearance at the top (fig. 18).

All were relieved that the move had been completed without so much as a bump to the mural. Although it would be two more weeks before the protective padding could be removed, we were confident that no damage to the plaster would be found as the mural had been under close observation from the time it separated from the apartment building until it was positioned in the Ohavi Zedek lobby. The entire move that was planned for 11 hours had been completed in less than four hours, a testament to meticulous planning.

6. INSTALLATION AND DISPLAY

A week later, four chain lifts were suspended from the steel support beams and the steel framework containing the mural was lifted to its permanent viewing height of 11 feet, the same height from which it was last viewed by men praying in the Chai Adam Synagogue in 1939. The mural was suspended from five 3/4-inch diameter steel rods, each of which alone could support the 6,500-pound weight of the mural. The foam pads were carefully removed and there was no evidence of any loosening or detachment

Fig. 18. Mural being rolled into the building (Courtesy of Bob Neeld, PE)

of the plaster substrate. The plywood floor was removed and the front stiffening beam and floor steel supports were unbolted from the rest of the structure (fig. 19).

The conservators had predicted that the cyclododecane would sublime in about three months, so the grand unveiling was planned for early August. Figure 20 shows the back of the mural assembly, the

Fig. 19. Mural lifted to viewing height and steel floor support being removed (Courtesy of Bob Neeld, PE)

Fig. 20. Mural suspended at viewing height in final configuration (Courtesy of Bob Neeld, PE)

steel framework and suspending rods. Lighting Services Inc. LumeLEX 2024 dedicated LED track lights are visible on the west wall, as are Hunter Douglas designer screen shades that block 90% of the western light when lowered in the late afternoon (fig. 20). As the temperature at the height of the mural was about 15°F warmer than at occupant level, a destratification fan was mounted at the ceiling peak to ensure even mixing of the air. Real-time temperature and humidity readings from sensors mounted high and low on the wall are transmitted to the Internet by a Hobo RX3000 Remote Monitoring Station. These data are used to optimize the speed of the fan for effective mixing and low noise. A PEM2 data logger and eClimateNotebook are also used to monitor environmental conditions.

7. COMPLETING CONSERVATION TREATMENT

Mural conservator Silver returned in November 2015 to refine cleaning methods to completely remove discolored varnish and grime from a total of about 10 square feet of the mural. The time required to clean, fill, and in-paint representative areas of loss was quantified to inform an estimate for the final stage of conservation treatment that may also include restoration of missing design areas.

While performing several test cleanings, she determined that the B67 facing was more difficult to remove than anticipated and the historic varnish layers were less soluble than before the mural was faced and moved. It is possible that application of the hot cyclododecane increased crosslinking in the varnish layers, or perhaps chemical components of the cyclododecane changed varnish solubility parameters. Although the cleaning is somewhat more challenging, it is still possible to safely remove the varnish layers, soot, and grime to reveal the vibrant original colors. These test cleanings indicated that benzyl alcohol and NMP (N-methyl-2-pyrrolidone) gels are effective in removing the varnish layers. The heavy fixed soiling embedded in early varnish layers can be removed using diluted Enviro Klean 2010 All Surface Cleaner, a mild aqueous cleaner composed of an alcohol with a chelating agent. The cleaning tests also confirmed that the paint is stable and well attached to the plaster. In fact, now that the entire wall structure is in a stable environment, many cracks through the plaster that had developed while the mural was walled up have closed.

8. CONCLUSIONS

The clerk of the works for this project, the head of a major Burlington, Vermont, engineering firm, frequently commented on the complexity of this multidisciplinary project. Although experienced in managing engineering aspects of much larger projects, he noted that working with unknowns inherent in historic materials and structures, such as the condition of the plaster keys or the strength of the 100-year-old plaster, and specialized products such as cyclododecane, Marvelseal, and Conservare Hydroxylating Conversion Treatment added a degree of uncertainty and complexity not inherent in more conventional engineering projects.

The knowledge and advice of an experienced conservator familiar with object conservation materials and techniques as well as various aspects of building preservation was essential to inform and coordinate actions of the treatment conservator, carpenters, conservation scientists, general contractor, architect, engineers, steel fabricators, and riggers. The coordinating conservator also informed and advised the project managers on curatorial decisions required at various stages of the project.

The successful move of this mural is largely attributable to the skills, ingenuity, can-do attitude and caution that master carpenter Ray O'Connor and his skilled and careful assistants brought to the project every day. Their exemplar efforts confirmed just how critical highly skilled and cooperative craft professionals are in solving technical problems and keeping such complicated projects on track.

The two-year rescue of the mural is complete. The mural assembly supported by its metal framework is safely suspended in its permanent exhibition space (fig. 21). The new owners of the Lost Shul Mural are pleased with the suspended presentation of the mural and do not intend to further integrate the century-old mural assembly into the mid-century building lobby. Decisions are still being

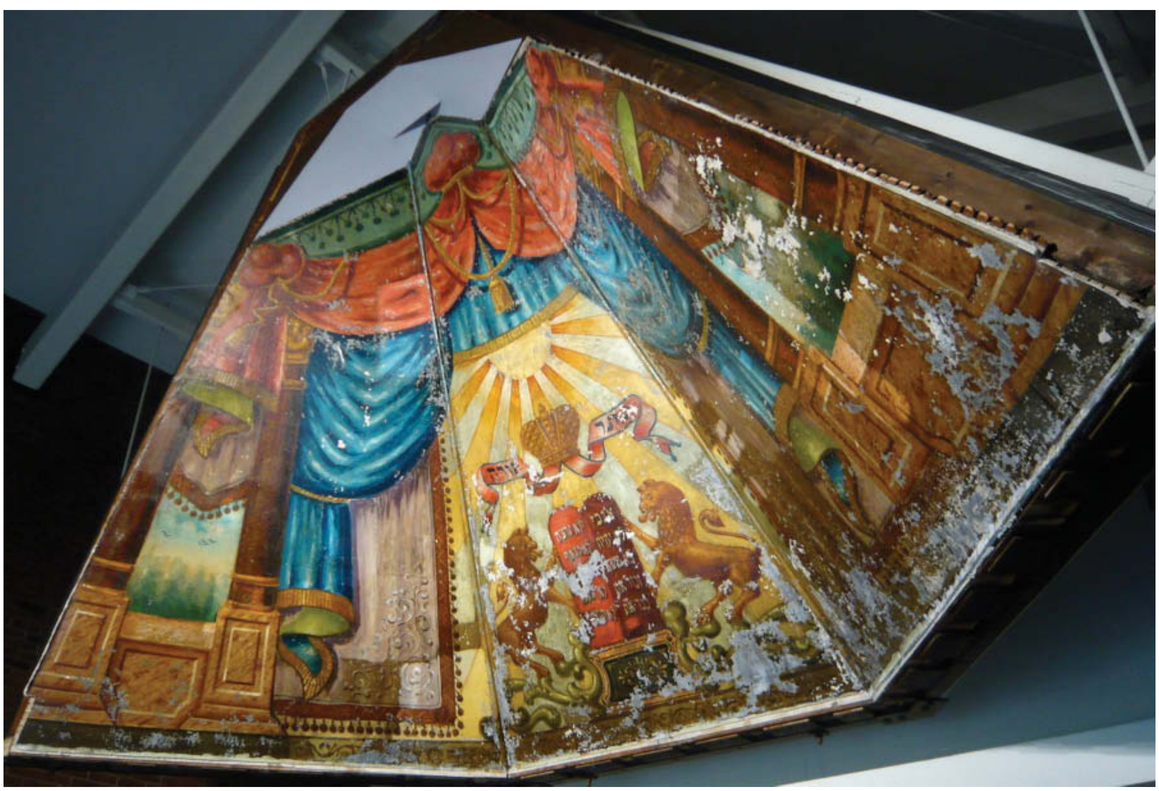

Fig. 21. Lost Shul Mural, final configuration in lobby of Ohavi Zedek Synagogue, May 2016 (Courtesy Richard Kerschner)

made regarding reintegration of paint losses that occurred over the nearly 40 years the mural was isolated behind the apartment wall. Efforts are underway to raise the funds required to complete conservation treatment and to establish a permanent educational exhibit in a public space adjoining the lobby of Ohavi Zedek Synagogue. The exhibit will celebrate Burlington's historic immigrant community and feature the rescue, conservation, and interpretation of the Lost Shul Mural.

ACKNOWLEDGMENTS

The following individuals and organizations are recognized for their contribution to this project. Ohavi Zedek Synagogue; Aaron Goldberg and Jeffery Potash, Lost Shul Mural Project co-directors; Marcel Beaudin, architect; Samuel D. Gruber, PhD, historian; Bob Neeld, PE, President, Engineering Ventures; Bob Schwartz, President, Great Northern Construction; Ray O'Conner, master carpenter; Norman Weiss and Irving Slavid, MCC Materials, Inc.; Susan Buck, conservator and paint analyst; Demag Riggers and Crane Service; and Reliance Steel.

NOTE

1. Additional information on the Lost Shul Mural project can be found at http://www.lostshulmural.org (accessed June 20, 2016).

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SOURCES OF MATERIALS

Paraloid B67, BEVA D8, Crepeline
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0735
http://www.talasonline.com/

Conservare HCT (Hydroxylating Conversion Treatment)
Prosoco, Inc.
371 Greenway Circle
Lawrence, KS 66046
800-255-4255
http://www.prosoco.com/

Cyclododecane
Kremer Pigments Inc.
247 West 29th Street
New York, NY 10001
212-219-2394
http://www.kremerpigments.com/

EnviroKlean 2010 All Surface Cleaner
Trowel Trades Supply Inc.
206 Hegeman Ave.
Colchester, VT 05446
602-655-3166
http://www.prosoco.com/where-to-buy

Hunter Douglas Designer Screen Shades, 90% light blocking
21 Church St.
Burlington, VT 05401-4417
802-862-6701
http://www.tinashomedesigns.com/

LumeLEX 2024 Series (dedicated LED Track Lighting)
Lighting Services Inc.
2 Holt Dr.
Stony Point, NY 10980
845-942-6200
http://www.lightingservicesinc.com/

Marvelseal 360
University Products Inc.
517 Main Street
Holyoke, MA 01040
413-532-3372
http://www.universityproducts.com/

VoidSpan CG70 Fine Grout
VoidSpan Technologies, LLC
60 Washington St.
Salem, MA 01970
800-966-8643
http://www.voidspan.com/

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RED FLAMES, SILVER LININGS

MIMI LEVEQUE AND ERIC WOLIN

On August 15, 2009, an accidental fire broke out at the Ropes Mansion, a historic property owned and operated by the Peabody Essex Museum in Salem, Massachusetts. The fire forced museum staff to confront an emergency requiring a decisive response to safeguard a unique structure and its associated collection. The fire challenged the Peabody Essex Museum's notion of disaster preparedness and subjected local first responders and, later, museum responders to a harrowing experience. Key communication infrastructures in place on the day of the fire and networks of relationships forged well before the fire helped mitigate the impact of the fire. This article will discuss the immediate response to the fire, the recovery program developed to treat the damaged art objects, and the reinterpretation and installation of conserved objects into a rehabilitated Ropes Mansion.

KEYWORDS: Disaster preparedness, Fire, Water damage, Soot, Peabody Essex Museum, Ropes Mansion, COSTEP MA

1. INTRODUCTION

Can an emergency that threatens the destruction of an important historic house and all of its contents ever be considered a good thing for a museum to experience? I suspect most everyone concerned with the care and preservation of objects would quickly and unequivocally say no. This article argues that a 2009 fire at the Ropes Mansion of the Peabody Essex Museum (PEM) can be viewed both as a culmination of unfortunate circumstances and as a profound disaster averted thanks to an immediate, coordinated, and thoughtful response along with a carefully planned recovery (fig. 1).

The Ropes Mansion, located at 318 Essex Street in Salem, Massachusetts, is listed in the National Register of Historic Places. Built in 1927, it was purchased in 1768 by Judge Nathaniel Ropes II and was occupied continuously by the family until 1907. Before cataloguing the unfortunate circumstances, it bears mentioning that the importance of the Ropes Mansion extends far beyond the building itself. An impressive collection of fine and decorative arts were amassed by the Ropes family during their occupation spanning more than a century, but so, too, were hundreds of utilitarian objects and household wares, objects rarely so well preserved. This legacy, along with an exhaustive archive of family papers, chronicles 139 years of domestic life in Salem in a way that is unparalleled. The Ropes Family Papers (MSS 190) are currently archived within the Phillips Library of the PEM. All of these materials were stored in the house at the time of the fire.

2. THE EVENT AND THE RESPONSE

In 2009, the PEM determined that it was necessary to repaint the entire exterior of the house. More than 280 years of paint buildup and degradation compelled the PEM to remove existing paint layers before applying new ones. The PEM's Director of Security and Facilities, Bob Monk, following regulations and recommendations issued by the local historical commission and federal agencies, determined that the use of heat was the best option to soften the accumulated paint to the extent that it could be scraped away by hand. Understanding the inherent risk involved in using heat, Bob mandated three safeguards that the crew of contracted painters must follow at all times: (1) a specific electric paint stripper was to be used by the painting contractor, (2) a designated fire watcher must be present, and (3) a member of the PEM security department staff would be present.

Fig. 1. The Ropes Mansion, Peabody Essex Museum (Courtesy of Mimi Leveque)

Two of these three safeguards were not in place the morning of the fire. Veering outside of their mandate, the painting contractors decided to work—unannounced—on a Saturday morning, one of the hottest days of the summer, with an unauthorized heat gun that they felt was better suited to remove paint from the woodwork near the eaves. Rather than softening the paint, the high temperature of the heat gun vaporized it, causing a small fire to form. The fire watcher did produce an extinguisher that apparently put out the fire. Soon thereafter, the painters stopped working to eat lunch, not realizing that sparks from the fire had been blown by their heat gun through the eaves into the attic of the house, igniting a slow, smoldering fire within the insulation.

Around noon, during the painters' lunch break, a member of the museum's security staff arrived at Ropes to open and inspect the house prior to a scheduled tour at 1 p.m. As the guard initiated his protocols, the fire alarm sounded. The alarm, linked to the museum's security operations center, triggered an immediate call to the Salem Fire Department. Within minutes, a dispatched unit arrived at Ropes (fig. 2). Owing to the close relationship that PEM has established with Salem first responders, fostered by the Salem chapter of the Coordinated Statewide Emergency Preparedness in Massachusetts (COSTEP MA), the fire department was aware of the property and its needs upon arrival and they were prepared to be proactive to preserve the collection.[1]

Importantly, the fire department knew that no one resided at the Ropes Mansion, and hearing from the PEM security guard that no one was inside the house, fire personnel immediately began the work to extinguish the fire. The few minutes saved by this exchange likely prevented the fire from spreading beyond the attic of the house.

Long before any PEM staff had mobilized, fire department personnel were taking steps to safeguard the collection from water and smoke damage. Their efforts were chiefly focused on carefully moving furnishings from the edges of each room to the center and covering them with protective tarps (fig. 3) based on protocols established with the PEM.

As Salem's first responders were doing their job, PEM initiated a mobilization effort. Following our disaster plan, a series of communications were issued to key museum personnel. One of the first calls

Fig. 2. Fire department responding to the fire (Courtesy of Frank Cutietta)

Fig. 3. Dining room furnishings moved and tarped by the Salem Fire Department (Courtesy of PEM staff)

placed was to the "Collection Emergency" cell phone, which is in Head of Collection Management Eric Wolin's possession 24/7. Living well outside of Salem, he was not the first to arrive on scene, but the names and numbers of the response team were programmed into the cell phone and he notified them immediately about the nature and scope of the fire.

PEM staff converged on Ropes from near and far to assess the situation and formulate an action plan. The security perimeter established by the Salem Fire Department was relaxed the moment human safety was not at risk—another example of coordination between first responders and PEM staff that allowed response and recovery efforts to initiate. This would not have been permitted if that relationship had not existed. When the assembled PEM personnel were allowed to enter, the imperative to completely evacuate the house of objects quickly became apparent.

The volume of water required to extinguish the fire had permeated most areas and floors of the house. It poured down from the attic behind walls and through gaps in floors and ceilings, soaking carpeting, upholstery, wallpaper, and objects along its path. Not everything had been protected by the tarps—objects in pantries and cupboards were soaked, and mirrors and other framed pieces on the walls had been too large or cumbersome to be moved, so there was extensive wetting of those objects (figs. 4a, 4b).

The initial assessment revealed that PEM personnel were not sufficiently equipped or staffed to address the urgency and scale of this task alone. A call was quickly placed to a Salem-based moving company, T.E. Andresen, with whom PEM has strong ties. By amazing luck, they had the capacity to immediately provide packing materials, trucks, and brawn to assist in the evacuation of objects from Ropes. As additional resources were en route, PEM staff began to triage especially vulnerable or precious objects (fig. 5).

Not every object required an immediate or exhaustive intervention. For example, simply drying an important Queen Anne chest-on-chest in situ, then draping it with polyethylene sheeting provided sufficient protection to allow staff to address higher priorities elsewhere. The chest-on-chest was safely moved as soon as there was adequate clearance (figs. 6a, 6b).

The majority of the objects large and small were dried, packed, and delivered to the Cotting-Smith Assembly House, another 18th century property owned by PEM just a few blocks away from Ropes.[2] Of the many silver linings, the fact that this popular venue for summer weddings had not been rented the day of the fire is particularly striking. Teams formed at Ropes to efficiently containerize and load out objects; while at Cotting-Smith, teams received objects, recycled certain transit containers, and populated the largely empty first and second floors of the house with furniture (fig. 7a) and packed boxes (fig. 7b).

Late into the night of August 15, PEM staff worked to complete the evacuation of threatened objects from Ropes. A small selection of photographs, books, textiles, and other objects requiring immediate intervention by conservators were transported to the PEM conservation lab so that emergency treatments could be initiated. Textiles and works on paper were rinsed and blotted to remove discolored water and prevent permanent staining. Precious small objects, such as jewelry, were moved to secure storage at the museum.

Beyond first responders, PEM staff, and local movers, additional resources were called in to address critical needs. Again, with great good fortune, every resource—electricians, structural engineers, steeplejacks, and water damage mitigation professionals—prioritized PEM's needs and provided immediate support to the response and recovery effort. On the day of the fire, once the building was completely checked (fig. 8), the structural recovery of Ropes commenced. The roof was stabilized and patched to ensure that it was structurally stable and water tight. Additionally, fans, dehumidifiers, and blowers circulating hot, dry air through networks of flexible plastic tubes placed in strategically cut holes in ceilings removed moisture and prevented the growth of mold (fig. 9).

Fig. 4a. Glassware in wall cabinets filled with contaminated water in the ground floor's china room; 4b. Water cascading into the ground floor's butler's pantry (Courtesy of PEM staff)

Fig. 5. Triage in the kitchen (Courtesy of PEM staff)

3. RECOVERY

The next step was the recovery phase. While renovations began on the mansion—including redoing all wiring, adding fire suppression and climate control systems, and reconstruction of all the interior spaces—the conservation team began to assess the scope of the project with the objects moved to the Cotting-Smith Assembly House. We were faced with a daunting task. Not only did we have hundreds of packed boxes and pieces of furniture, but every drawer, trunk, and chest was also full of items. The collection comprises more than 3000 objects, and we were about to have to deal with them all.

Rather than attempting to move objects back to the conservation lab at the museum, we decided to create conservation treatment spaces in Cotting-Smith for the initial recovery work. We divided the available personnel into two groups. Contract Furniture Conservator Chris Thomson oversaw the treatment of furniture with her assistant Gregg Porter and Conservation Technician Joanna Sese (fig. 10). Mimi Leveque supervised the remainder of the treatments and coordinated the project with Assistant Registrar Katie White to manage the data.[3]

As it was intended for catering large functions and therefore was fitted with sinks, countertops, and storage cabinets, Cotting-Smith's service kitchen was ideal for object conservation, while the furniture could be tackled all over the house. As the work proceeded, we expanded into other areas of the house to have dry, flat places to examine paintings, works on paper, and photographs. Work even moved outside when we needed better ventilation and light.

Everything needed to be unpacked, identified with the Ropes Mansion inventory, condition reported, and recorded. Each object was photographed and numbered when needed (fig. 11). Mimi kept a separate daily log of all objects treated and at what point in the treatment they were in. This proved to be very helpful for tracking complex objects whose treatments might span many weeks. We worked closely with the Curator of American Decorative Arts Dean Lahikainen and reviewed all treatment plans

Fig. 6a. Chest on stand in bedroom after the fire; 6b. Draped chest on stand (Courtesy of PEM staff)

Fig. 7a. Furniture placed in the Cotting-Smith parlor; 7b. Packed boxes stored in an upstairs room at Cotting-Smith (Courtesy of Katie White)

Fig. 8. Bob Monk, PEM's Director of Facilities, inspects attic spaces with the fire department (Courtesy of PEM staff)

Fig. 9. Dehumidifiers and blowers in place to reduce humidity (Courtesy of Kathy Tarantola)

with him in advance. Packed books were sorted out and delivered to the PEM's Phillips Library staff for cataloguing.

As the work progressed, we were happy to see that the packing had been excellent—no objects were broken during the move out of the Ropes Mansion. Most of the condition issues were due to

Fig. 10. Furniture conservation team Joanna Sese, Gregg Porter, and Chris Thomson determining treatment protocols (Courtesy of Mimi Leveque)

Fig. 11. Conservation intern Rebecca Barber numbering glassware (Courtesy of Mimi Leveque)

exposure to soot or water combined with pre-existing issues. Each object was initially vacuumed to remove soot and dust (fig. 12). Soot combined with dust was most problematic on organic objects such as baskets; for some, vacuuming was inadequate and they required more thorough cleaning. Many inorganic objects could be washed, especially the enormous amounts of ceramics and glass; there were 300 pieces of Irish crystal, and one set of china alone had 345 pieces, which together comprised the largest surviving early 19th century set of tableware. The water from fire suppression had caused the failure of many old glued repairs, so those had to be treated.

Fig. 12. Vacuuming baskets to remove soot and dust by Rebecca Barber and Katie White (Courtesy of Mimi Leveque)

Metal objects had become corroded from exposure to the contaminated water. Corrosion was primarily removed mechanically. Some utility items, such as fireplace equipment, had been inadvertently left behind at the Ropes Mansion, where they corroded further, requiring far more time to clean. The polishing of bright metals was deferred until just prior to the reopening of the mansion.

The pieces of furniture had numerous problems, such as water stains and soot from the fire that had settled on old wax and dust. The conditions were complicated by the variable state of each object prior to the fire, where some had light-damaged finishes that had become water soluble or old polish residue on and around metal hardware. As a result, no one set of treatments could be used on all of the objects. Each piece of furniture was reviewed by the furniture conservators, and the curator and given a 3 x 5 card with the treatments required; white cards indicated those to be done only by the furniture conservators, and purple cards signified objects safe to be treated by interns or collections staff.

We had a few surprises. For example, the packing and handling of old mirrors had released spatters of mercury over the objects and into the packing materials. We had the liquid mercury professionally removed and all packing materials properly disposed of, and then we sealed gaps on the backs of all mirrors with strips of thick Japanese *kozo* tissue to avoid as much further leakage as possible.

The treatment of the works on works on paper, photographs, and books was overseen by PEM Paper Conservator Kathryn (Casey) Carey. All objects were treated, but some of the more fragile works, such as the silhouettes, were reproduced for display in the Ropes Mansion to prevent further damage due to light exposure.

4. REINSTALLATION

Once the objects had been treated and the house renovations completed, the task of reinstalling the Ropes Mansion was taken on by the special projects team, headed by Angela Segalla, and the collection

Fig. 13. Snow piles in front of the Ropes Mansion on the reinstallation day (Courtesy of Angela Segalla)

management group, led by Eric Wolin, under the rubric of Exhibition Planning. As the objects were treated, they were moved to the museum's off-site storage for housing and documentation, where the collection will remain except for objects that were specifically chosen to go back into the house. This will eliminate the possibility of a catastrophic loss of the entire collection, as we could have had if the fire had been worse.

Ironically, as the fire had taken place on the hottest day of one of the hottest years, the beginning of the reinstallation turned out to be scheduled right after a major snowfall in the snowiest winter ever in

Fig. 14. Recreating the bed hangings with Elizabeth Lahikainen, Meegan Williams, Paula Richter, and Ani Geragosian (Courtesy of Walter Silver)

Fig. 15a. The reinstalled china room; 15b. A reinstalled pantry (Courtesy of Mimi Leveque)

Fig. 16. Angela Segalla and Dave O'Ryan installing featured furniture on a platform in an exhibition room (Courtesy of Annie Lundsten)

Salem, 2015. The logistics of simply keeping the space clear for the truck in front of Ropes were complex (fig. 13), let alone the coordination of safely moving and reinstalling the 1000 objects chosen for display. It is an important lesson that weather plays a huge role in how well one can recover from a disaster. If the conditions had been reversed and the fire had been in the winter, the fire department would have found it difficult to approach the house and then all of the objects would have been covered in icy spray from the fire hoses, causing far more damage.

The large pieces of furniture had to be reconstructed inside the house. Pieces had to be carefully eased back together, as pegs and dowels had swollen when wetted and not gone back to their original sizes. Conservator and historic cabinetmaker Phil Lowe was brought in for that delicate task. We decided to reproduce the hangings, which then had to be fitted to the beds following the original hanging designs (fig. 14). This proved incredibly time consuming; it took 10 days to make the tester for one bed alone. The original straw and feather mattresses were used but encased in washed Tyvek to keep out pests.

Fig. 17. Room depicting the family's travels with items in an open trunk protected by acrylic case inserts (Courtesy of Mimi Leveque)

The vast quantities of china and glass were moved back into their special room (fig. 15a), and all pantries were refitted with hundreds of kitchen items (fig. 15b).

Contrary to the typical approach for historic houses that are generally interpreted at just one particular time period, the reinterpretation team decided to open the house up to telling multiple stories of the family in a diverse way, covering many periods of time over the family's long history in the house. Some of the upstairs rooms were made into galleries with objects on platforms and in exhibition cases that can be changed periodically to tell other stories so that the house always has something fresh and new to show visitors (fig. 16). As the interpretive team wanted the public to be able to wander the house with self-guided tours, few docents, and minimal security, we had to come up with creative and aesthetic barriers, such as acrylic inserts for shelves and trunks that allow clear viewing but prevent theft (fig. 17).

In the first season after the Ropes Mansion was reopened, it was an enormous hit with the public—we had more than 7000 visitors! We were delighted that our work won a Salem Preservation Award, shared with the Salem Fire Department, and we have just received a 2016 Leadership in History Award from the American Association for State and Local History for "Re-envisioning the Ropes Mansion."[4]

5. CONCLUSION

The circumstances leading to the outbreak of fire at Ropes were unfortunate, the weather conditions were extreme, and the environment in which responders mobilized was extraordinary. Nothing in the PEM disaster plan or training could fully prepare staff for what unfolded on August 15, 2009, but the fundamentals guided emergency responders and PEM staff through a difficult situation toward a satisfying outcome. We learned important lessons to guide our responses to any future emergency, particularly that fostering ongoing relationships with first responders and local providers is crucial. Establishing and maintaining thorough documentation of the collection is critical to tracking each object from the beginning to the end of the crisis. Despite the initial disaster, the Ropes Mansion has emerged in better condition and the collection far better housed and documented than it might have been without the fire—a silver lining indeed!

ACKNOWLEDGMENTS

It takes more than a village to undertake such an enormous project; it takes a metropolis! We are indebted to the wonderful members of the Salem Fire and Police Departments for their extraordinary work to save the mansion. The T.E. Andresen Moving and Storage Company helped at every phase of the project. More than 80 staff members, interns, and volunteers from the PEM assisted in the recovery, along with numerous contracted conservation professionals. The authors wish to particularly thank Bob Monk, Director of Facilities and Security, Paula Richter, Curator for Exhibitions and Research, and Angela Segalla, Assistant Head of Collection Management, who each played key roles in the recovery and provided important recollections for this article.

NOTES

1. COSTEP MA (http://mblc.state.ma.us/costepma/) is the Coordinated Statewide Emergency Preparedness program in Massachusetts. "It is a collaborative of representatives of cultural and historical institutions and agencies as well as first responder and emergency management professionals from federal, state, and municipal governments. The purpose of COSTEP MA is to build and foster a statewide emergency planning process that serves the cultural and emergency management communities and addresses disaster prevention, preparedness, response, recovery, and mitigation" (from the COSTEP MA website). PEM Security annually invites senior fire department staff to tour PEM buildings and historic properties on a rotating basis to learn about the properties.

2. PEM owns and operates 20 historic properties, both in the immediate "campus" of the museum and the nearby "McIntire Historic District."

3. Over the course of the recovery phase, the conservation team added PEM paper conservator Kathryn Carey; five preprogram conservation interns; two additional furniture conservators; and textiles, upholstery, photography, and paintings conservation specialists.

4. See the blog on the reinstallation at the PEM website: http://connected.pem.org/re-imagining-ropes/

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ISSUES AND CHALLENGES IN CONSERVATION OF LIVING MONASTIC HERITAGE IN THE TRANS-HIMALAYAN REGION OF LADAKH, INDIA

SATISH C. PANDEY, JOYOTI ROY, AND NOOR JAHAN

Ladakh's rich cultural identity is highly dependent on its institution of Buddhist monasteries known as *gompas*. These monasteries are religious and spiritual centers of Buddhism and are repositories of a rich art and cultural heritage. Having been at the crossroad of trans-Asian trade for centuries, Ladakh's cultural heritage and indigenous traditions reflect upon the influence from the cross-cultural exchanges from ancient Buddhist regions of Central Asia and Tibet. The exquisite wall paintings, *thangka* paintings (religious scroll paintings), manuscripts, and other ritual objects manifest Ladakh's unique cultural heritage. The main stakeholders of this heritage, the monastic and village communities, have limited awareness about the inherent historic, cultural, and civilizational value and importance of their own cultural heritage. This ignorance has led to lack of proper maintenance and care. Rampant unplanned modernization and civic development to promulgate tourism pose serious threats to cultural heritage. In several monasteries and other heritage monuments, traditional architecture has been destroyed and rebuilt or added using modern materials without considering their suitability and consequences in the local climate. Climate change has added to the complexities, leading to heavy rains and snowfall that have caused irreparable damage. In the absence of a consolidated heritage policy and regulations, particularly for living cultural heritage in the region, a large number of self-professed heritage conservation groups are carrying out conservation of monastic heritage. While some conservation attempts have been made responsibly, others have created an environment of mistrust and discomfort with the communities. This article aims to highlight some of the major issues and challenges in preservation of monastic heritage in Ladakh and discusses the need for ensuring sustainability in conservation interventions to save the invaluable cultural heritage in the region.

KEYWORDS: Monastic heritage, Living cultural heritage, Heritage conservation, Heritage Values and significance, Climate change, Neglect and vandalism

1. LADAKH: GEOGRAPHICAL AND HISTORICAL BACKGROUND

Ladakh is a high-altitude region in the states of Jammu and Kashmir. It is bound by the Karakoram mountain range in the north and the Himalayas in the south and is one of the most sparsely populated regions in India. The entire region is a cold desert and covers an area of 86,904 square kilometers with barren landscapes, limited natural resources, and settlements along the main river Indus and its tributaries (fig. 1), yet it has been home to a thriving culture for more than a thousand years. Being located on a highly important historic trade route linking Central Asia, China, Tibet, and India, the cultures and traditions in Ladakh show an amalgamation of different cultures from ancient to medieval periods (fig. 2). It is difficult to specify the exact date of arrival of Buddhism in Ladakh, but it is presumed to have come into contact with Tibet in the 7th century (Luczanits 2005). Kaul (1998) points that Buddhism and Hinduism coexisted in the region from the 8th century with cultural influences from Persia and western central Asia. However, with the establishment of Muslim rule in Kashmir in the 14th century, Ladakh turned to Tibet for all the cultural and religious purposes, which led to greater influence of Tibetan culture on that of Ladakh.

This high-altitude region remained closed to the world until the mid-1970s, when the first roads were opened via Srinagar (in Jammu and Kashmir) and Manali (in Himachal Pradesh) and many travelers, both Indian and foreign, explored the region and gradually exposed the mystical landscape and sociocultural practices of the region. There are several travelogue accounts of these journeys and what they revealed. After the 1980s Ladakh became an important location for adventure tourism owing to its natural landscape, wild rivers, and picturesque mountains, gradually making tourism one of the mainstays of earning in the urban centers. Nevertheless, some areas are still dependent on oasis

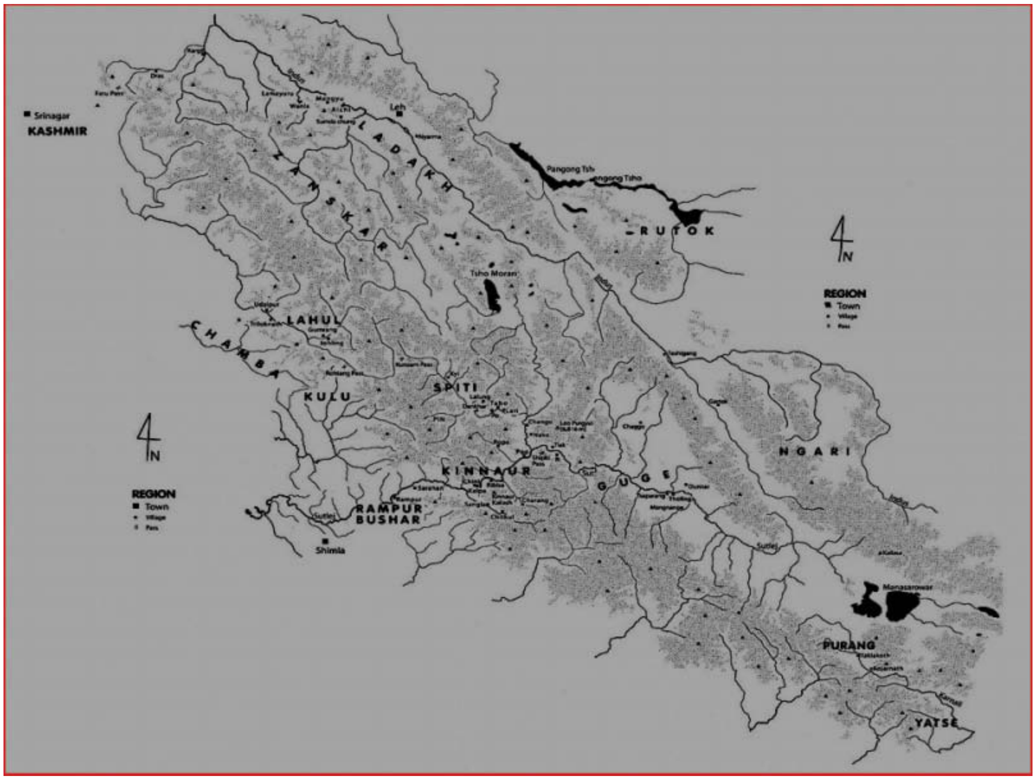

Fig. 1. Map showing geographical location of Ladakh (Courtesy of Joyoti Roy)

Fig. 2. A typical village with a monastery in the middle and traditional mud houses (Courtesy of Joyoti Roy)

cultivation and animal rearing. Ladakh inherently has a treacherous climate most of the year in which indigenous communities strive to sustain themselves with minimal resources.

The geographical isolation of the region allowed it to preserve its culture. Historic trade not only developed the area's economy but also facilitated cultural and social interactions and influences. Since India's independence, Ladakh is politically a semi-autonomous region comprising of two districts—Leh and Kargil. Leh is the capital city of Ladakh and the Ladakh Autonomous Hill Development Council (LAHDC), and the State Government of Jammu and Kashmir are responsible for its administration and governance.

2. MONASTIC HERITAGE OF LADAKH

Ladakh's cultural heritage is phenomenal and incredibly diverse. The constant contact with the cultures of its neighboring regions for centuries has resulted in a high degree of influence on the indigenous cultures and traditions. There is a visible Tibetan contribution, which has manifested in its monasteries, monuments, art forms, oral cultural traditions, folklore, festivals, and language. The earliest Buddhist heritage of Ladakh comprises of petroglyphs, *stūpas*, ancient rock carvings, and inscriptions that are found scattered throughout the region. Monastic establishments, fortresses, *thangka* paintings, manuscripts, ritual objects, and decorative elements in architecture, particularly wall paintings and wood carvings, are all exemplars of the rich artistic heritage of the region and markers of a vibrant history.

Buddhist monastic establishments of all sizes are spread across the region. Smaller monasteries are administratively set up under larger head monasteries of Buddhist sects[1]. Each sect has a religious leader and a set of teachings and practices that are propagated through monastic establishments. In ancient times the strategic positioning of monasteries was crucial, often much away from civilization, in the form of hermitages. The monasteries are either located on the slope of hills/mountains or in some cases on the flat ground in the middle of the village. Often monasteries are accompanied by other minor religious structures such as village protective shrines (*lhatos*), votive rock installations (Mani walls[2]) and *chörtens* (*stūpas* meant for storing reliquary remains or as votive structures). Most monasteries are imposing structures and are a testament to the architectural knowledge and competencies of the historic civilizations. They often expand organically as the needs and requirements of the establishment grow. These monasteries contain temple chambers and residential buildings where Buddhist monks live, study and practice their religion (fig. 3). The Buddhist temples within monastic establishments are dedicated to specific Buddhist deities and are profusely painted on their interiors with schematic wall paintings. Each temple also has images of deities sculpted in clay and painted, which is a traditional art form of Ladakh (fig. 4). Buddhist monasteries are the main repositories of heritage antiquities and artifacts and are testimony to the powerful cultural links of the past. Most of these monasteries are profusely decorated with wall paintings on their interiors and house a significant number of *thangka* paintings, manuscripts and documents, masks, exquisite costumes and textiles, wooden articles, and leather objects. (figs. 5-7). Most of the artifacts are usually part of daily monastic rituals and rites.

3. ISSUES AND CHALLENGES IN CONSERVATION

The Buddhist monasteries in Ladakh have been in constant use by the community and are central to religious and cultural practices. These repositories of cultural heritage are facing numerous challenges and many of them have undergone irreparable damage in the recent past. The issues and challenges of conservation of cultural heritage in Ladakh arise not only from the material aspects of objects and sites themselves, but also from their societal context and the functions they serve. There are several factors that

Fig. 3. A view of Phugtal monastery (Courtesy of Janhwij Sharma)

Fig. 4. Painted clay sculptures in Buddhist temples (Courtesy of Satish Pandey)

Fig. 5. Buddhist manuscripts in Phyang Monastery (Courtesy of Satish Pandey)

Fig. 6. Traditional *thangka* (scroll) paintings, Phyang Monastery (Courtesy of Satish Pandey)

Fig. 7. Wall paintings on mud plaster, Bardan monastery (Courtesy of Joyoti Roy)

contribute directly or obliquely to their deterioration and some of the most prominent causes are highlighted in this article.

3.1 EXPANSIVE TOURISM

The urban and rural centers of Ladakh have transformed very quickly in the past two decades from closed and introverted spaces to centers of great hustle and bustle spurred by a modern building spree. The brief tourist season (May to August) and the rather small agricultural cycle in Ladakh leaves little opportunity among the local community for introspection, propelled further by demands of a sharply increasing world tourist population. Ladakh is now experiencing an influx of tourism as never before, which has reflective cultural and economic consequences. The region has been drawing attention because of its unique landscape and its cultural heritage; tourists are mostly drawn to the built environment, particularly the Buddhist monasteries. The tourist data (fig. 8) indicates that the number of tourists in Ladakh has grown exponentially from just 527 tourists in 1974 when tourism was opened to 178,042 in 2011 (Pelliciardi 2010; Menon 2011). Tourism contributes to nearly 50% of the local GDP. In 2011, the number of tourists in Leh was 22% more than the local population. Limited in natural resources, this added burden of people and the slim carrying capacity is drastically depleting the life-giving resources of Ladakh, putting it at a major risk of calamities and crisis.

Because of this influx of tourism, Ladakh is now at the forefront of rapid environmental and socioeconomic changes. There has been a dynamic program of development in the region after the arrival of tourism that has brought changes in lifestyle, culture, and traditions. Tourism is now a major contributor to Ladakh's economy, but it is also having a direct and negative impact on Ladakh's sociocultural environment. In order to facilitate the growing demands of the tourists who prefer to

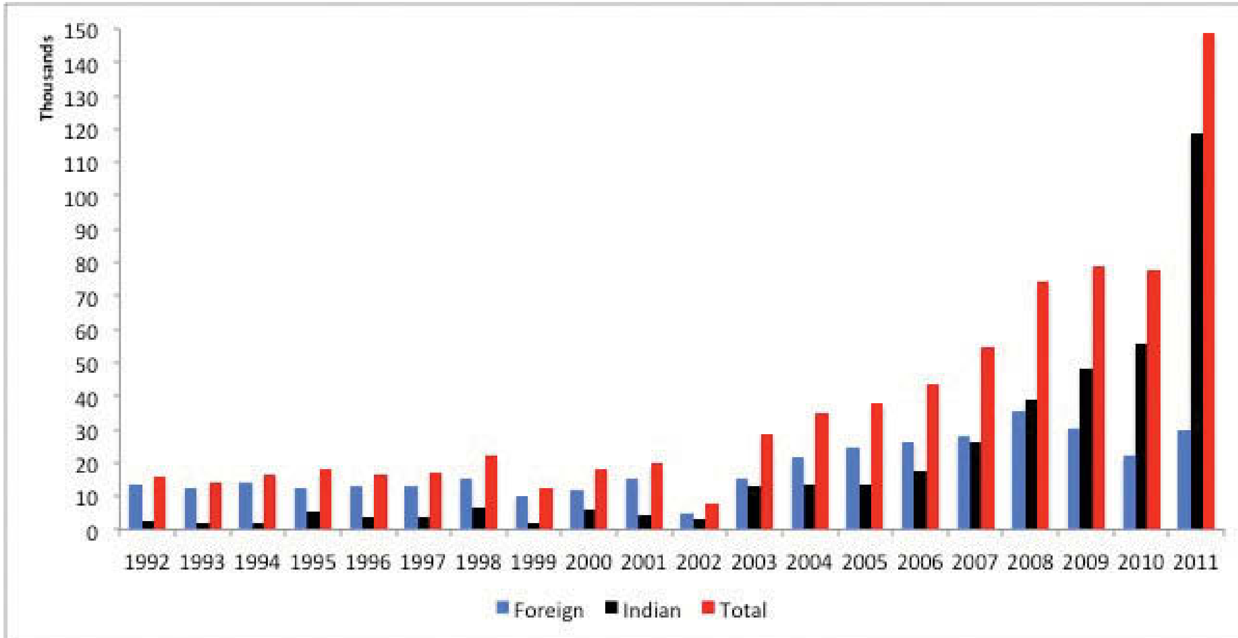

Fig. 8. Increasing footfalls in Ladakh in the past 20 years (Modified from Pelliciardi 2010)

maintain their personal standards of living, scarce resources are being overused. Several environmental issues that never occurred in the past are now apparent. Generation of large volumes of non-degradable waste, an absence of proper disposal systems, and over-usage of water (which is already scarce—traditionally the society had hit an equilibrium on usage of water from natural streams) have all led to an imbalance that is taking a toll on the region.

While the economy of Ladakh was previously self-sustaining, it now almost entirely depends on the affluence of tourists. Interdependency between Ladakhis has plummeted and the traditional economy has migrated to a tourism-related model where all profits earned by transactions related to tourism are being diverted towards expansion activities within the tourism sector. Hence, only the actors of this touristic market get the benefits from this economy. This in turn expands as the dependency on the influx of tourism makes the local population more and more dependent on an outside population, which can collapse any day. Other grave hazards of tourism include pollution, which has increased due to a large number of motorized vehicles that tourists demand. This has impacted air quality in the urban centers, which is dangerous for a microclimate like Ladakh. Tourists and migrants have also affected the aspirations of the local population in terms of living standards, causing them to abandon their traditional practices and adopt foreign trends in eating, washing, dressing, mobility, etc. This has steered them away from care of their historic structures and cultural heritage, as they tend to deem them old-fashioned and unnecessary to invest in, both culturally and economically. Residential houses are increasingly being converted into hotels and guesthouses or are used for other commercial activities (fig. 9).

Monasteries have become commercialized due to their exposure to modernization. Entering the sacred space now has a price and tourists are willing to buy tickets in order to visit these sites. To make it convenient for the tourists, most of the major monasteries are now well connected with drivable roads, as opposed to the former hermit nature of these sites that called for spiritual and meditative encounters. Construction of roads through hills leads to disturbances in the natural geological setup and also causes vibrations in these ancient structures, which gradually adds to their damage. In a strange unforeseen manner, tourism has also led to increasing numbers of thefts of religious artifacts from monasteries and other holy sites. Nearly unheard of in the traditional Ladakhi society, theft is now a common complaint.

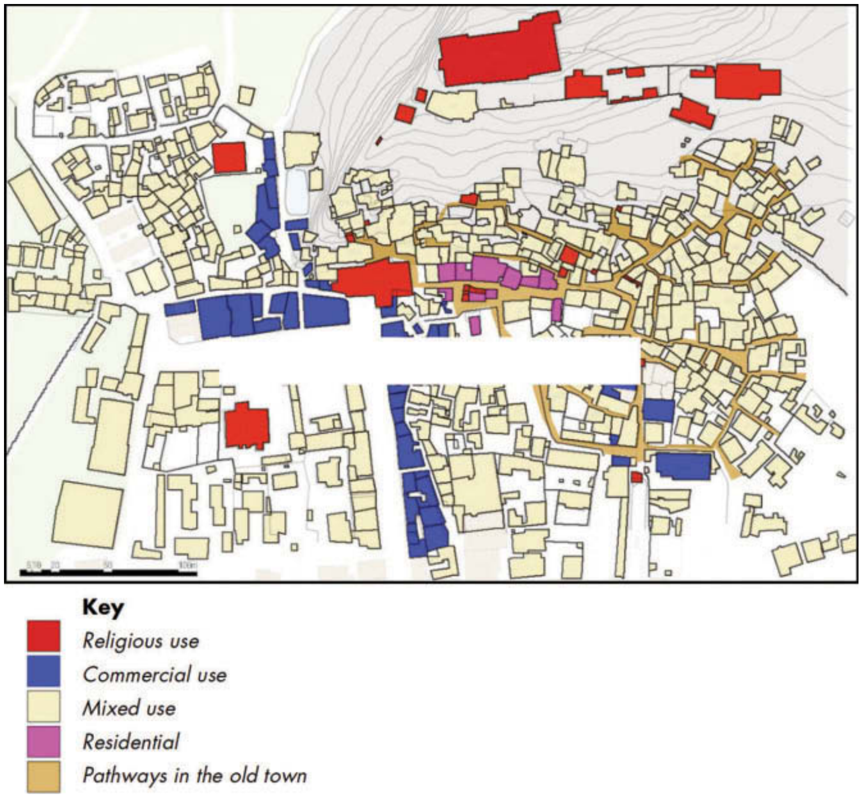

Fig. 9. Land use patterns in Leh area show that spaces are increasingly being used for mixed purposes (Courtesy of Tibet Heritage Fund)

The monasteries and other holy sites lack surveillance and security and opportunists tend to take advantage and steal portable and unprotected artifacts. The theft of the central wooden panel with an image of Buddha from the 13th century *Sumdah Chun stūpa* is an example. Vandalism or mechanical interactions with the historic site are common challenges; tourists often walk with disregard and start trampling on the artifacts, causing changes to their condition and to the integrity of historic components.

3.2 RELIGIOUS PRACTICES

The Buddhist monasteries of Ladakh are living heritage sites where everyday rites and rituals are performed. The mornings in each monastery start with religious chants by the monks. Lighting of oil lamps and burning juniper incense for purification of the space is an imperative part of daily ritual. Although these rituals are important to keep the religious space alive, they often have detrimental effects on heritage materials. Burning oil lamps inside the temples and shrines is a custom that originates from a long tradition. It is a practice to invoke the spirits residing in the temples, but the smoke from these oil lamps bonds as soot on the surfaces of the artifacts and paintings. Burning oil lamps inside the monasteries since time immemorial has left an alarming amount of soot deposits on wall paintings inside the temples (fig. 10). It is also customary in every monastery to make figures of barley flour and butter called *mchod-pa* or *torma*[3], which are elaborately used as an offering to the Buddhist deities and spirits living in the monasteries as part of daily rituals intended to achieve favors of the Buddhist deities. As these are organic, edible materials, they attract rodents, insect pests, and other microorganisms, which often leads to severe damage to the objects of significance (fig. 11).

The community engages with religious structures and objects differently than historians and heritage practitioners do. When a religious object is broken, torn, or partially lost, the religious value

Fig. 10. Wall paintings covered with thick layers of soot, Dzonkul monastery (Courtesy of Joyoti Roy)

Fig. 11. Preparation of barley flour and butter figures (*mchod-pa* or *torma*) for religious offerings (Courtesy of N. Jahan)

decreases and in most cases, especially when it comes to worn or damaged religious texts, they are burned or enshrined in a *stūpa,* or in some cases immersed in the river as they become deconsecrated and lose their power or function. Such practices, albeit considered rituals by the monks and local believers, have often led to the loss of significant heritage objects. There is a risk that some of these "not fit for worship" objects may be stolen and restored, and then reach the illicit art market. Similarly, monastic establishments have specific arrangements for storage of religious and ritual objects, but more often than not, such storage spaces are not appropriate and there is always a risk of theft and damage. Historically, many items like the traditional costumes and masks that are used in religious dances only once a year during the monastery festival are often stored in trunks and boxes. Traditionally, the objects were either stored in wooden boxes or leather trunks, which acted as a buffer against the external environment. Today, modern materials such as metal trunks are being used, which create microenvironments for the artifacts and accelerate their deterioration process (fig. 12).

3.3 MODERNIZATION AND NEGLECT

Other factors include interventions on heritage structures and abandonment of old structures by local communities. The traditional building materials used in Ladakh are stone, earth, and wood. The foundation and ground level of the buildings are usually built using stones and mud mortar, while in the upper levels, sun-baked mud bricks are used. The roofs have a flat surface, which is prepared by plastering

Fig. 12. Traditional wooden trunks for storing *thangka* paintings are being replaced by metal trunks (Courtesy of Satish Pandey)

the surface with mud and clay on top of wooden beams. The traditional architecture is very well suited to the climate and geography of Ladakh. The sun-baked mud bricks and mud plaster absorb heat from the strong sun during the daytime and emanate it during the cold nights. Mud plaster provides insulation for walls, floors, and ceilings.

However, along with the many benefits of traditional architecture, there are certain drawbacks—the traditional materials are very susceptible to liquid infiltration, be it from rain or snowfall, which is causing a major problem today. The flat roof system allows water to accumulate on the surface and slowly penetrate inside the building (fig. 13). Another disadvantage arises from the use of timber for construction of roofs; the wood tends to contract and expand due to extreme temperature contrasts, causing cracks. In spite of these shortcomings, traditional materials do well if maintained regularly in the traditional manner.

Unfortunately, with the changes in the Ladakhi lifestyle, maintenance is never undertaken in time or is often done with modern, incompatible materials that are even more harmful for the health of old structures. The availability and affordability of new construction materials in the market has also led to a change in preferences (Johnson 2014). New houses are usually built with concrete instead of traditional mud as the latter is now regarded as backwards and unfashionable by some people (Alexander 2007). In the conventional Ladakhi culture, the ancient monasteries are considered more sacred then the newer ones, as it is believed that the older monasteries have collected more blessings. Such monasteries, therefore, are commonly looked after by the local communities as a votive act, leading to localized

Fig. 13. Mud streaks on wall paintings due to water ingress, Sani monastery, Ladakh (Courtesy of Joyoti Roy)

attempts of repairs and maintenance. Villages across the region have developed their own systems to maintain their tangible and intangible heritage over the centuries. Traditional management systems have ensured that heritage and resources, both built and natural, are constantly maintained, repaired and in some cases renewed so that they continue to serve the needs of the community. The process of renewal, repair, and restoration is often preceded by religious rituals carried out to ensure that sacred spirits that reside all around are not disturbed. (Sharma and Weber 2011). In recent times, however, use of improper material such as cement or unskilled interventions for maintenance and repairs have resulted in several issues.

3.4 HERITAGE CONSERVATION INITIATIVES

When drivable roads were constructed in the early 1970s, tourists, historians, conservators, anthropologists, scholars, and social activists reached Ladakh and stayed for long periods of time, studying and understanding the indigenous culture and traditions and how they are transforming with time. They closely interacted with the local people and also documented their practices. David L. Snellgrove and his associate Tazeusz Skorupsky travelled all over Ladakh and Zangskar in the 1970s and documented the monastic establishments and their arts. Helena Norberg-Hodge, an author and filmmaker, documented the life of Ladakhi community and wrote about them in her well-known book *Ancient Futures: Learning from Ladakh* (Norberg-Hodge 1991). Ladakh's serene cold climate and adventurous treks attracted numerous Indian and foreign tourists, and the mystic practices and unique lifestyle encouraged scholars to observe and study them.

Most of the monasteries in Ladakh are privately managed and only a handful of them are looked after and protected by the government. Ease of access for private individuals and religious leaders heading the monasteries allows foreign nationals to interact with monks and religious leaders. Further, a promise of funds and expertise in conservation become lucrative inducements for owners of monasteries to engage with foreign agencies and individuals. Such practices have had their merits and demerits. While on the one hand, the long history of heritage conservation practices in the Western world has often allowed for such conservation projects to be systematically planned and implemented in phases, more often than not such projects do not take into account the religious values and significance of the heritage, which is what the Ladakhi community is most concerned about (Sharma 2009). In India, the technical expertise in heritage conservation has been very limited and there are several instances of failed or even disastrous conservation interventions. Such interventions often disregard or fail to take into account the sentiments of the community, who often find conservation interventions confusing and undesirable. Between the early 1980s and 1990s, many such conservation projects were envisaged and implemented in Ladakh, both in large monasteries as well as in small village temples, which have exquisite art and antiquity collections.

In Buddhist practices of Ladakh, the art historical value of paintings or objects does not necessarily have much significance. It is believed that living spirits inhabit the image and if an image is damaged, it is a bad omen for the community. The purpose of this repair is, therefore, not to restore the art historical significance and aesthetic quality of the image, but to contain its sacredness by completing the icon. As such, in many cases where the image is missing or incomplete, there are attempts to make these images complete again. There are several cases of such interventions and one of the most important examples is the wall paintings in the Hemis monastery, which have been repainted with modern paint. Another example is the central figure in cave no. 5 of the Saspol village, where an amateur local artist has painted the lost image of Buddha. Similar cases can be seen at the Karsha monastery in the Zangskar region and the temple complex in the Mangyu village, where the historic wall paintings have been overpainted (figs. 14, 15). While restoration in religious parlance may have been achieved in these cases, the art historical integrity did not survive.

Fig. 14. Artist recreating wall paintings in Hemis monastery (Courtesy of Satish Pandey)

Fig. 15. Overpainted areas in wall paintings of Karsha monastery (Courtesy of Joyoti Roy)

Lack of awareness of important structures almost always leads to negligence and therefore to partial or complete loss. There are several examples of historic buildings being destroyed in order to make way for new construction. In some cases, concrete was used due to limited knowledge of original technique and traditional materials, causing long-term damage. For instance, the 15th-century Red Temple (Lhakhang Marpo) in Hunder village was demolished by the Hunder Welfare Society in 2012 and replaced with a concrete structure (fig. 16). The decision to demolish the ancient temple was made because the community did not gauge the importance of the historicity of the ancient temple and its original components. The wall paintings and sculptures were removed and discarded to make way for new paintings and sculptures.

Overall, it is the opinion of the authors that there has been a complete lack of interaction between the institutions and/or individuals working with heritage and the community. This has led to a situation where the concerns and apprehensions of the community have never been understood and dealt with appropriately. As a result, most of the conservation initiatives are isolated and develop without a consistent approach towards sustainable conservation and holistic development.

3.5 CLIMATE CHANGE

Climate change is a global issue and the region of Ladakh is not untouched by its consequences. The evidence of climate change can be seen through personal observations and studies conducted in recent years. Ladakh is a high-altitude, arid mountain region known for its extreme climatic conditions and challenging mountainous terrain. Climate change is affecting the landscape and cultural heritage of the region. The annual snowfall has decreased notably in the last couple of decades and glaciers are melting at an alarming rate. The excessive glacier melts during the summers have resulted in floods and heavy damage to people, livestock, and buildings. In August 2010, an extremely localized cloudburst set off a flash flood in Leh and surrounding villages. Ladakh had not encountered a natural disaster of such a magnitude in the recorded past. The flash flood caused fatalities, lands were buried under mudslides, and roads were washed away. The amount of rainfall has increased significantly in the past decade and the region is now experiencing short but heavy downpours that the traditional mud structures are not equipped to withstand. The hefty rainfall leads to water seepage in these old structures, causing structural damage as well as triggering difficulties for the articles kept inside. In the long run, the melting glaciers of the Himalayas and the Karakoram mountain ranges also threaten these heritage structures. The climatic change is progressive and hence is the prime source of danger to the heritage of Ladakh.

4. NEED FOR SUSTAINABLE APPROACHES IN CONSERVATION

In recent years, conservation has evolved as a discipline that is based on methods, as opposed to conventional practice involving merely empirical knowledge (Phillipot 1996). There are various approaches to conservation that have developed since the inception of the field and their application has been continuously discussed and debated. The conventional approach of conservation focuses on conservation of materials or fabric and is an expert-driven approach in which the community has no role (Poulios 2010a, 2010b, 2014). A value-based approach that expanded on the conventional material-based approach is considered more appropriate as it includes community stakeholders in conservation decisions and interventions—a more democratic process (de la Torre 2002; Wijesuriya 2007; Poulios 2010a, 2010b, 2014). The value-based approach has largely been accepted and applied worldwide. However, more recently, Poulios (2010a, 2010b, 2014) proposed a new *living cultural heritage* approach, which emphasizes livingness, continuity, and renewal, and prioritizes the functions of the living heritage over its fabric. Although the aim of this article is not to debate the merits of these conservation approaches, it is pertinent to point out that the material- or value-based approaches cannot be completely overlooked in

Fig. 16a. Exterior of the Red Temple in Hunder village before it was destroyed; 16b. Original interior of the temple

Fig. 16c. Rebuilt concrete structure (Courtesy of N. Jahan)

the case of conservation of cultural heritage in Ladakh. The cultural heritage in this region is not just a continuing tradition; it also has archaeological/historic and aesthetic value that has been passed on for centuries. It would therefore be detrimental to ignore the values and significance of the heritage, giving priority to its function alone. However, a balanced approach incorporating archaeological, historic, aesthetic, and functional values of the heritage can perhaps ensure sustainability in conservation interventions and an unhindered continuity of the traditional practices and culture.

The current conservation interventions in the hill region are sporadic and the goal of achieving sustainability is far-fetched. Aspirations of many national and international organizations and groups that wish to rescue the ancient art and culture of Ladakh for posterity have risen exponentially in the last few years. These organizations and groups approach individual monasteries in order to initiate conservation projects and often bring funding from external sources. An environment in which initiatives to preserve the cultural heritage are taken on by local stakeholders usually makes for an ideal beginning. Conservators, heritage practitioners, architects, etc., can subsequently be brought on board to carry out systematic conservation interventions. In the long run, such initiatives will sustain the interest of local stakeholders and maintain quality in conservation interventions. Contrarily, in cases where conservation agencies try to intervene and act as vanguards of heritage, the process is slower, not always efficient, and may often lead to conflicts where the stakeholder and the conservator do not understand each other's priorities, leading to compromises that may ultimately be detrimental to heritage resources.

On the other hand, in a place like Ladakh, where people have been living in an extremely sequestered environment, an awareness of the importance of heritage has appeared only recently. The local communities need to appreciate that their heritage is not just valuable to them alone but is also historically significant to a global community. This is evident from the fact that a substantial number of people visit the region and value it for its historic edifices and unique cultural practices that are markers of civilizational history. Therefore, for all conservation initiatives, there should be an active dialogue between conservation agencies and local communities, simultaneously bearing in mind the universal historical significance of the region.

5. CONCLUSION

The conservation of Ladakh's cultural heritage needs a multipronged approach. Its delicate climatic balance, cultural resources, and intangible heritage all depend upon each other and conservation interventions must take into account all of these aspects. The rampant growth of tourism and uncontrolled development in the region may appear as positive signs, but if the carrying capacity of the hill town is not considered carefully, its natural resources will give way to natural and man-made disasters as it has in the recent past. In such a scenario, policy makers have to mindfully draft a comprehensive conservation policy that can achieve balance between the need to preserve local practices and traditions and the historic materiality of the region's cultural fabric. Cultural heritage manifests in religious spaces that are functional elements in traditional practices and therefore should form the core of any conservation initiative. One such brilliant example is Bhutan, where the number of tourists is constrained by the government in the interest of its delicate microclimate.

The government and local administrative bodies will need to take up the responsibility of making policy decisions to create checks and balances in civic development and tourism-related issues. Educational and awareness programs, engaging interactions between stakeholders, policy makers, and conservation experts can play important roles. The regional leadership will need to take proactive steps and develop appropriate policies and acts for conservation of cultural heritage in Ladakh in order to strike an ideal equilibrium between ancient value systems and modern developmental strategies so that cultural heritage—both tangible and intangible—are protected and preserved.

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NOTES

1. Four sects of Buddhism were established in Ladakh at different points of time in history. Monasteries under the influence of *Ge-lug* (*dge-lugs)* and *Drigung Kagyu* (*bri-gung-bka-rgud*) are more commonly found in the region. However, monasteries under the *Sakya* (*sa-skya*) and *Nyingma* (*rnyin-ma*) schools are lesser in number.

2. Mani walls found in the villages of Ladakh are several feet in height and 3–4 feet in width and are decorated with Mani stones inscribed with religious hymns or carvings of incarnations of Buddha. The Mani stones are supposed to protect the village from bad omens.

3. *Mchod-pa* or *torma* are figures prepared with roasted barley dough, hardened butter, milk, curd, sugar, etc., as offerings in Tibetan Buddhism. These are usually made into different compositions, shapes, colors, and designs depending on the kind of rituals to be performed.

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THE TREATMENT AND INSTALLATION OF A MONUMENTAL CEDAR SCULPTURE BY URSULA VON RYDINGSVARD

EMILY HAMILTON

Ursula von Rydingsvard (1942–) is best known for her large-scale, structurally complex sculptures made from cedar beams, which are often displayed outdoors. These works change in dimension due to shifting environmental conditions and may require supportive armatures and ongoing maintenance treatments to prevent pest and environmental damage. This article will address the treatment and installation of *Czara z Babelkami* (2006) at the San Francisco Museum of Modern Art as part of the inaugural exhibition in its renovated galleries. The treatment involved close collaboration with the artist's studio to plane and stabilize sections of the work in response to previous dimensional changes. A surface treatment and long-term maintenance plan involving the use of a biocide and wood sealant was also devised with the studio. This collaboration provided valuable insight into the construction of the work, parameters for acceptable changes, and a broader perspective of how this artist's work is treated in other settings. Given the high seismic activity in San Francisco, a structural armature was designed in partnership with an engineer to support the work in case of an earthquake. The armature was designed to stabilize the work while allowing flexibility for further dimensional changes in response to outdoor environmental conditions. Installation on a newly renovated fifth-floor terrace space necessitated extensive planning to move the sections safely with a crane and forklift, serving as a case study of project planning in unknown spaces.

KEYWORDS: Ursula von Rydingsvard, Wood, Outdoor sculpture, Borate, Artist collaboration, Mount

1. INTRODUCTION

The installation of *Czara z Babelkami* (fig. 1) by Ursula von Rydingsvard at the San Francisco Museum of Modern Art (SFMOMA) involved close collaboration with the artist's studio to address structural issues and formulate a long-term maintenance plan. Ursula von Rydingsvard is best known for her large-scale, structurally complex sculptures made from cedar beams. She was born in Germany in 1942 and the early years of her life were spent in Polish refugee camps. Her family relocated to the United States in 1950 and she continues to work in New York City, maintaining a studio with several assistants. Large-scale sculptures in cedar have been her primary focus, though she also works in other media including bronze and resin (Phillips 2011).

2. CONSTRUCTION

The construction of von Rydingsvard's sculptures is both technically methodical and deeply personal, as she often develops imagery from her memories. She uses beams of Western red cedar sourced from British Columbia, carefully milled to fit evenly and create a neutral starting point for her work. She painstakingly cuts, assembles, and adheres the beams, and sometimes rubs powdered graphite into the exterior. The results are intricately textured structures that variously resemble vessels, dwellings, and geological formations (fig. 2).

Many of the artist's sculptures are related to specific memories, and the subject of *Czara z Babelkami* is a sweater that was one of the few items of clothing she had during her time in the refugee camps. As she explained:

> "I had a sweater as a little girl (in the refugee camps in Germany), and it was hand-knit out of unbleached wool from sheep. It had wonderful *babelkami* (popcorn stitches) on it, on the grid that was at the top part of the body. And of course, in no time at all (because it was not as though I had more than one of these . . . it was actually the only sweater I had during all those years) it got worn on the sleeve, around the shoulders and around the belly, so that it was kind of wayward. The grid got disrupted. It went organically wayward. It started flowing. It started falling. So I used that, or a kind of intrigue with that, in part, as a source of my imagery for this enormous bowl." (*Czara z Babelkami* 2016)

Fig. 1. Ursula von Rydingsvard, Artist, *Czara z Babelkami*, 2006, cedar, 513 x 317.5 x 188 cm, San Francisco Museum of Modern Art, 2013.169 (Courtesy of Ursula von Rydingsvard, photograph by Katherine Du Tiel)

Fig. 2. Detail of *Czara z Babelkami* showing intricately textured surfaces (Courtesy of Ursula von Rydingsvard, photograph by James Gouldthorpe)

The structure of the sculpture consists of 15 sections that stack vertically. In each section, a varying number of wooden crossbeams are stacked and adhered with resorcinol glue, an adhesive made of resorcinol-formaldehyde resin and hardener that is commonly used in aircraft and boat construction. Wooden dowels extend through the beams for support. Each section is labeled with a number and an orientation (fig. 3). Two aluminum dowels are placed between adjacent sections for alignment. This sculpture took the studio about one year to make and is nearly 17 ft. tall. In some of her works, von Rydingsvard rubs graphite into the surfaces to create tonal effects. *Czara z Babelkami* was not made with a surface graphite layer, which was an important detail for later evaluating the condition of the wood and devising a maintenance plan.

The sculpture was first shown in Madison Square Park in New York City. It was then moved to the residence of a private owner in Long Island and the work was later gifted to SFMOMA in 2013.

3. CONDITION AND STUDIO CONTACT

The 2016 installation was the first occasion for SFMOMA to exhibit this sculpture, and since we had not worked with it before, we conducted an initial review in summer 2015. We observed that the surfaces had weathered and changed in color from brown to gray, and wanted to review this with the artist to understand the acceptable parameters for change in her work. I reached out to the studio through Galerie Lelong and learned that the shift in color was not an aesthetic concern, as the artist liked the weathered appearance. This contact opened the door to more extensive conversation about condition, installation, and long-term care. The studio is closely involved with the installation and maintenance of her works and had directly overseen the two previous installations of this work. Sean Weeks-Earp, the studio manager, expressed concerns about the condition of the work based on this experience.

Fig. 3. Detail of *Czara z Babelkami*. Top side of section shows number, orientation, and crossbeams (Courtesy of Ursula von Rydingsvard, photograph by Emily Hamilton)

Sean shared that the studio had previously treated the work. Cracks and gaps had been shimmed from the outside with thin sections of cedar, improving the outside appearance of the work but potentially masking larger weaknesses. He was also concerned that the sections had warped and were no longer planar. This would cause small but visible gaps between the sections and put uneven pressure on the wood.

4. TREATMENT

To address these issues, we arranged for Sean to spend two weeks working together with our staff in November 2015. Our plan was that Sean would lead the project, with assistance from two to three SFMOMA preparators each day at an off-site storage facility. My role was to coordinate the project logistics, work with Sean on the details of the treatment plan, and manage the documentation of the project. Sean and I had some initial conversations about the treatment plan before his arrival, but it was difficult to fully assess the issues until we were together in front of the work.

One of the surprises was the sheer scope of work. Upon close review, we learned that the previous mount design had caused major structural problems. That design involved inserting steel rods through the lowest five sections, which locked the sections together and caused significant damage as the wood expanded and contracted with environmental fluctuations. These were not apparent in our previous review because the sections had been stacked in storage, making it impossible to see the tops or insides (figs. 4a, 4b).

These structural cracks had to be stabilized before the leveling of the sections could take place, so we undertook the most challenging component of the project first. To address the cracks, we considered two options. The first was to inject adhesive into the gaps, bridging spaces of up to half an inch with adhesive. However, we were concerned about how strong those bonds could really be, so we opted for a more dramatic but hopefully more effective plan—to complete the breaks by sawing the sections in two, remove the shims from the previous treatment, and re-adhere the pieces after drawing them as close together as possible with clamps. Thankfully, most of the cracks had occurred along the joins between the wood, so completing the separation largely involved sawing through the adhesive line.

Another point of discussion was the choice of adhesives. Sean had previous experience using Sikaflex 291 and Gorilla Glue, both polyurethane adhesives, on similar treatment projects. Though satisfied to use these products, he was open to suggestions for other adhesives as long as we could source them quickly. I was reluctant to use these two adhesives, particularly Gorilla Glue, due to ingrained biases against the instability, irreversibility, and inflexibility of polyurethanes. However, my experience with large outdoor wooden pieces was limited, and since this is a very different type of application than we generally encounter at SFMOMA, we reached out to other colleagues who are scientists, architectural conservators, or work with large wood objects such as totem poles.

Based on the advice received, we decided to use a flexible epoxy system made by Advanced Repair Technology. This system was recommended for its strength, durability, and flexibility, which would allow the wood to expand and contract. With this system, the surfaces of the wood were primed with a product called Prime-A-Trate, a bonding agent that sinks deeply into the wood. After allowing the primer to sit for 10 minutes, the epoxy Flex-tec HV is ejected from a gun than premixes two components (figs. 5a, 5b). The epoxy cures fully within 24 hours. We added new cedar shims where substantial gaps were present and overall these sections were much more stable after treatment.

We were satisfied with this adhesive choice, but after the treatment was completed I was interested to see an article by Rian Deurenberg-Wilkinson (2015) addressing adhesives for outdoor wooden sculpture. Her study identified a polyurethane product manufactured by 3M as the best choice for these kinds of applications based on weather resistance, flexibility, gap-filling capability, and longevity. For future study, I would be interested to learn how the Flex-tec product would fare in the tests run for

Fig. 4a. Crack caused by previous mount as viewed from above; 4b. View from the side (Courtesy of Ursula von Rydingsvard, photographs by Emily Hamilton)

her study. We observed that some of the earlier repairs on our sculpture that were done with Gorilla Glue have already failed, but other polyurethanes may be appropriate.

After stabilizing the cracked lower sections, we then began to level the warped sections to make them planar. To do this, we relied on Sean's knowledge and previous experience. He created what he called a "caveman's CNC milling machine" from spare parts that the storage facility had on site (fig. 6). He leveled each piece by identifying high and low points with a laser level and then scored the surface with a circular saw to delineate how deeply to plane the surfaces (fig. 7).

Fig. 5a. Brush application of Prime-A-Trate to separated sections; 5b. Application of Flex-tec HV epoxy (Courtesy of Ursula von Rydingsvard, photographs by Emily Hamilton)

Fig. 6. Sean Weeks-Earp identifies high and low points in a section using a laser level and customized setup (Courtesy of Ursula von Rydingsvard, photograph by James Gouldthorpe)

SFMOMA preparators then planed each piece to his specifications on both sides, removing no more than a quarter of an inch from any given area and reducing the overall height of the sculpture by less than 1 inch (fig. 8). Areas where the crossbeams had been damaged by the previous mount were routed out and replaced with new cedar beams (fig. 9). As part of the treatment, two additional holes for dowels were drilled between sections, making a total of four aligning aluminum dowels. This was done to increase stability in the event of seismic activity, as recommended by the engineer retained to design a new mount for the sculpture (see section 6).

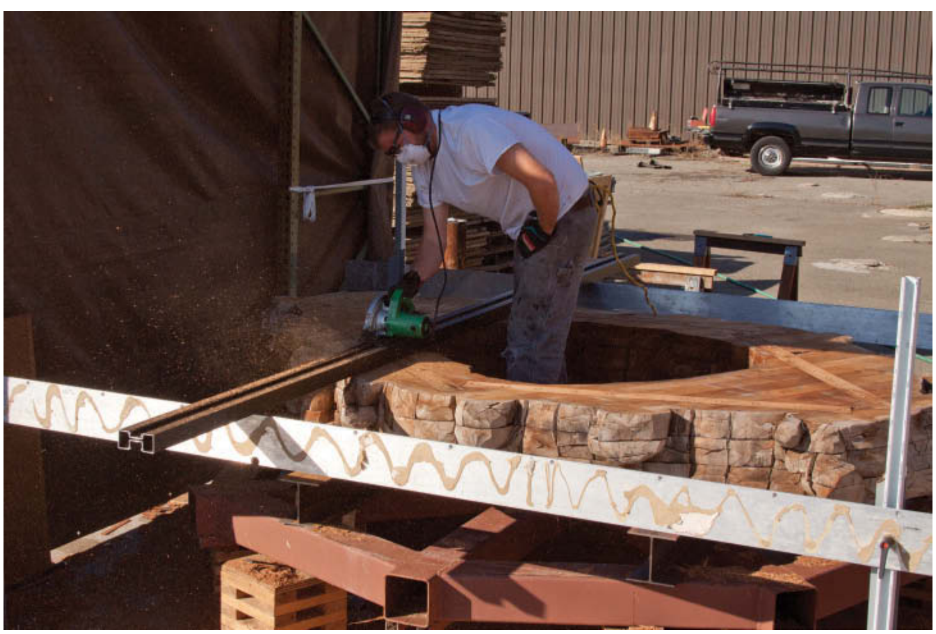

Fig. 7. Sean Weeks-Earp marks the depth of material to remove using a circular saw (Courtesy of Ursula von Rydingsvard, photograph by James Gouldthorpe)

Fig. 8. Planing of a section to the determined measurements (Courtesy of Ursula von Rydingsvard, photograph by James Gouldthorpe)

Finally, during the course of the treatment we observed small areas of rotting wood in the two uppermost sections. These developed in proximity to where a screen was placed in between the two sections to catch leaves and other debris. Though the screen was an effective barrier, it was not cleared regularly and damp leaves held moisture against the wood. The rotting wood was removed and the areas were treated with Abatron LiquidWood, which gives structural strength to compromised wood, and WoodEpox, an adhesive putty filler. This type of damage is preventable through routine clearing of screens and removal of debris.

Fig. 9. Routing out a crossbeam that was damaged by the previous mount. The damaged area was then replaced with a new cedar crossbeam (Courtesy of Ursula von Rydingsvard, Photograph by James Gouldthorpe)

5. MAINTENANCE

One concern we had about this process was whether warping would continue to happen and if we would need to anticipate this scale of treatment again. We were curious if this kind of treatment was necessary for all similar works, or if there was something that could be done to prevent it. Sean noted that in his experience, regular maintenance application of a wood sealant often prevented warping, and for this sculpture the maintenance had lapsed in previous years. He was not aware of any sculptures that have had to be planed more than once, and gave several examples of works that have been installed outside for decades without ever requiring this. He identified the von Rydingsvard sculpture at the Nelson Atkins Museum in Kansas City as one that has been maintained particularly well over several decades, and stressed that with regular maintenance these sculptures can last a very long time (Weeks-Earp, pers. comm.).

The studio is keenly involved in the maintenance of von Rydingsvard's outdoor sculptures. They composed detailed written instructions that they share upon request. They also follow up directly with private owners to ask if maintenance is performed and make themselves available to do it. The maintenance that the studio recommends includes regularly cleaning the sculpture of debris, applying a biocide to reduce biological growth and pests, and applying a sealant.

The studio's guidelines were immensely helpful to SFMOMA in formulating a maintenance plan, though we diverged from their specific product recommendations. The studio recommends Storm Stain, a biocide containing zinc naphthenate. SFMOMA decided not to use this product because Storm Stain is known to have a strong lingering smell. Since the sculpture was installed in an outdoor café space where people would be sitting near it, we needed to find a product that would be less intrusive. For our initial treatment before installation, we decided to use Boracare, a borate-based pest control product. After rinsing the surfaces thoroughly with water to remove dust and debris, we applied 10 gallons of this product, diluted 1:1 in warm water and applied with a pump sprayer overall (fig. 10). We also inserted

Fig. 10. Rinsing the sculpture with water prior to Boracare application (Courtesy of Ursula von Rydingsvard, photograph by Rowan Geiger)

Bor-8 rods, a solid borate product, into the old mount holes. This product dissolves into the wood as the moisture content rises and slowly disperses the borates over time. The studio recommends using TWP sealant, but because of California's VOC (volatile organic compound) laws, the product couldn't be shipped to us. Instead, we used X-100 Natural Seal Wood Protective in clear, which has been used in other outdoor wood applications in the cultural heritage sector. We applied four gallons of this product to the sculpture using a pump sprayer and brushes, but will likely use more the next time we do this treatment to achieve more complete coverage.

The schedule for product application varies depending on climate and object history, as the sculptures generally need more regular application in their first few years. We anticipate applying a biocide to ours on an annual basis and a sealant as needed, depending on when the surfaces no longer repel water.

Since *Czara z Babelkami* was not made with graphite on the surfaces, maintaining a graphite layer is not part of the maintenance of this work. The studio has experience in treatment of graphite layers and should be contacted for specific guidance for works where this is a factor.

6. SEISMIC STABILITY

Given SFMOMA's location in San Francisco, a mount that would stabilize the sculpture in the event of an earthquake was critical not only for the art, but also for the safety of visitors and staff. Paul Rodler, a seismic engineer, was retained to design an appropriate mounting system. This design went through several iterations in response to feedback from the artist's studio about what has and hasn't worked well for her other sculptures. The studio stressed their preference for passive supports that allow the wood to expand and contract. Mounts that have attempted to lock sections in position, such as the previous mount used on SFMOMA's sculpture, have generally caused more harm than good.

We eventually decided on a mount that incorporated a large x-shaped steel base with a central beam welded to the middle (fig. 11). The beam was designed with two sections that could be bolted together, making it easier to transport the separate elements. Pressure-fit posts extend on four sides from the central beam, which will prevent the sculpture from moving significantly in an earthquake but allow for normal dimensional changes (fig. 12).

7. INSTALLATION

The installation of large sculptures is always a team effort involving people with differing roles and areas of expertise. This installation involved three distinct groups: SFMOMA, who coordinated the logistics related to our building; Sheedy Drayage Co., the crane company; and Atthowe Fine Arts services, a local company that served as the installation manager and coordinated transit. There were a number of unknowns with this sculpture since we hadn't installed it before, and an additional factor was that given the building construction, we were using a new crane path. This led to much discussion of the best course of movement, and many meetings later, we finally settled on a plan that balanced safety of the art and need for efficiency.

We partially assembled the sculpture on the street near the crane, placing the lowest section on its mount and a support of high-density polyethylene (HDPE) sheet with channels cut to encourage drainage. Sections were moved using steel beams that were temporarily attached to the tops of the sculptures to distribute the weight (fig. 13). After the lower units were assembled, the crane brought it as a unit to its final position in the fifth-floor terrace. We brought the remaining sections up on stacked pallets and assembled the remainder of the sculpture on the terrace using the crane (fig. 14). This would not have been possible without a highly precise crane that could respond as needed to align the sections.

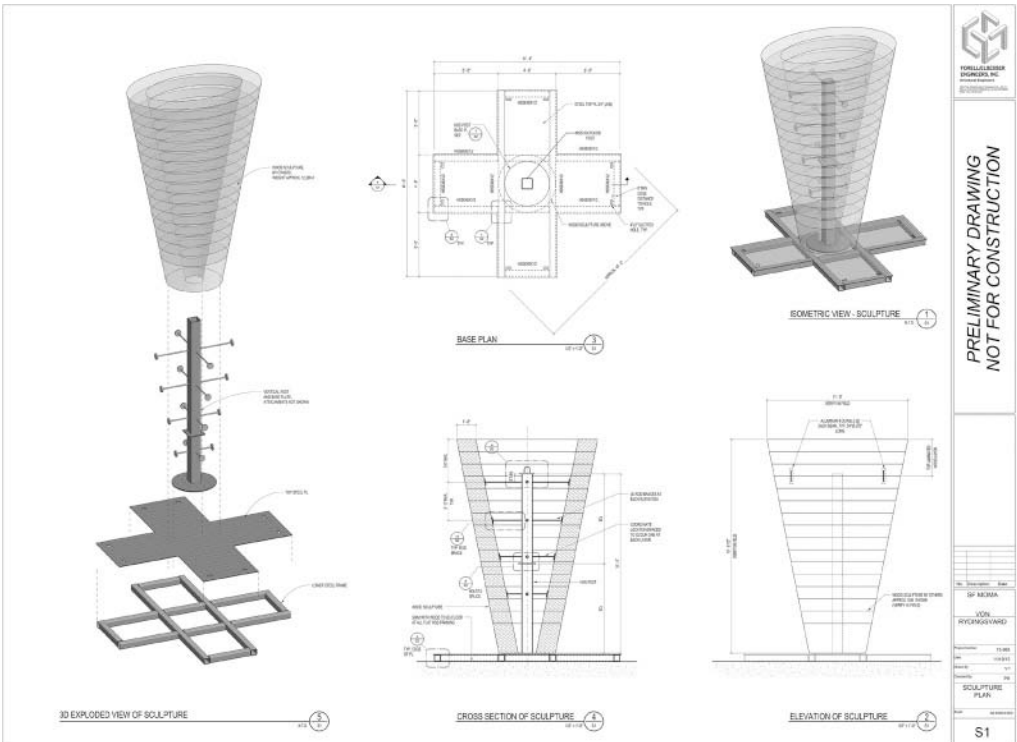

Fig. 11. Rendering of the mount design (Courtesy of Forell/Elsesser Engineers, Inc.)

Fig. 12. The pressure-fit posts as installed (Courtesy of Ursula von Rydingsvard, photograph by AJ Bucknall)

Fig. 13. Assembly of sections onto new mount, lifting the sections from steel beams that were temporarily attached (Courtesy of Ursula von Rydingsvard, photograph by Emily Hamilton)

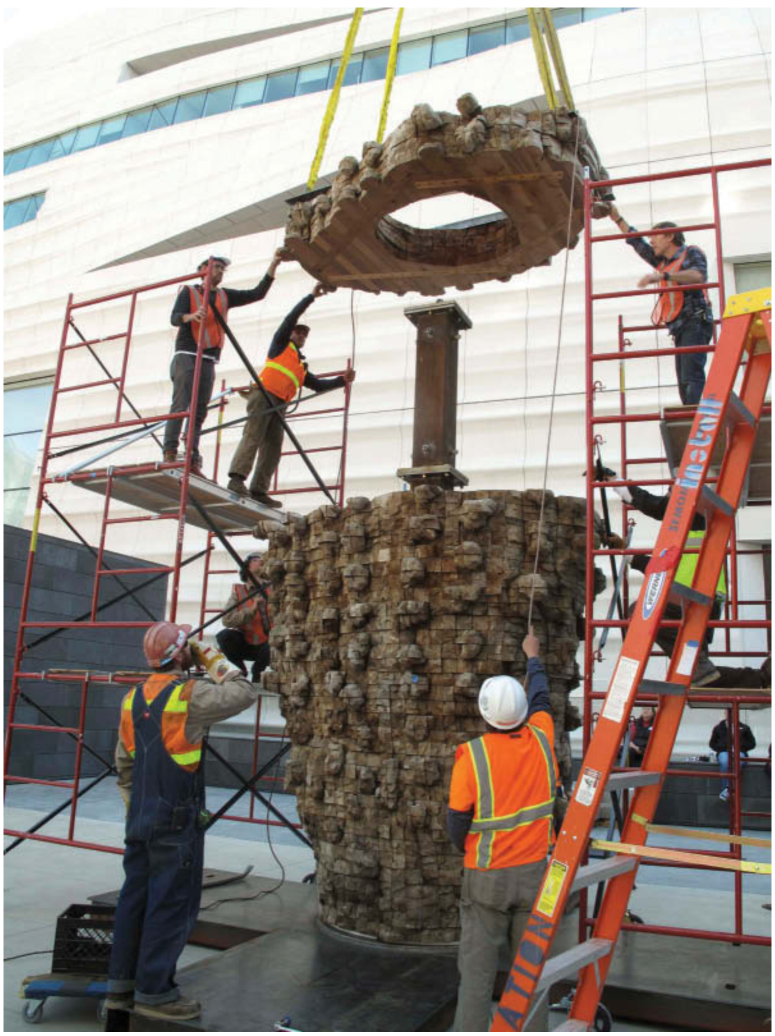

Fig. 14. Assembly of the upper portion of the sculpture on the terrace (Courtesy of Ursula von Rydingsvard, photograph by Emily Hamilton)

Fig. 15. Ursula von Rydingsvard with *Czara z Babelkami,* 2016 (Courtesy of Ursula von Rydingsvard, photograph by Katherine Du Tiel)

We added plastic snakes to the interior of the sculpture as a bird deterrent and also placed a screen between the top two sections to catch debris. The base of the mount was covered with gravel and up-lighting from the base was added at the studio's suggestion.

8. CONCLUSION

Working with artists is at the very core of our practice at SFMOMA, and in this instance, the involvement of the studio was absolutely essential to identify and manage condition issues. Ursula von Rydingsvard was recently able to visit the museum and see the work installed, creating the opportunity for further dialogue about the sculpture and how it is installed. She was pleased with the current appearance of the work and the installation overall, though she suggested recessing the lighting so that the fixtures are less visible. She also suggested changing the rocks that cover the mount to a darker material that would have greater contrast with the sculpture. We look forward to building upon the relationship that this project initiated, which we know will enrich our understanding as we care for this work over time.

ACKNOWLEDGMENTS

This was a richly collaborative project, made possible by contributions from numerous individuals. Many thanks to Ursula von Rydingsvard, Sean Weeks-Earp, Braden Weeks-Earp, the von Rydingsvard studio, and Galerie Lelong for supporting the treatment of the work and generously providing their expertise to care for the sculpture.

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Thanks to Elizabeth Saetta, Kari Dodson, Tracy Power, Molly Lambert, John Childs, Beth Edelstein, and Corina Rogge for talking through the finer points of the treatment and sharing their expertise.

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Phillips, P. C. 2011. *Ursula von Rydingsvard: Working*. New York: Prestel Publishing.

SOURCES OF MATERIALS

ART Flex-tec HV and Prime-A-Trate
Advanced Repair Technology, Inc.
PO Box 510
Cherry Valley, NY 13320
866-859-ARTS
http://www.advancedrepair.com/

Boracare
Do My Own Pest Control
4260 Communications Dr.
Norcross, GA 30093
866-581-7378
http://www.domyownpestcontrol.com/

Bor-8 rods, ½ in. x 2 in.
System Three Resins, Inc.
3500 West Valley Highway North, Suite 105
Auburn, WA 98001-2436
253-333-8118
https://www.systemthree.com/

LiquidWood and WoodEpox
Abatron, Inc.
5501 95th Ave.
Kenosha, WI 53144
262-653-2000
http://www.abatron.com/

X-100 Natural Seal Wood Preservative, clear
Western Log Home Supply
2501 S. Louis Ave.
Sioux Falls, SD 57109
970-315-2660
http://www.westernloghomesupply.com

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THE STUDY OF BOXWOOD PRAYER BEADS AND MINIATURE ALTARS FROM THE THOMSON COLLECTION AT THE ART GALLERY OF ONTARIO AND THE METROPOLITAN MUSEUM OF ART

LISA ELLIS AND PETE DANDRIDGE

The Thomson Collection of European Art at the Art Gallery of Ontario (AGO) and the Metropolitan Museum of Art (MMA) jointly hold an impressive number of early 16th century miniature boxwood carvings known as prayer beads and miniature altars. These intricate objects have fascinated collectors and now museum visitors with their diminutive scale, intricacy, and somewhat mysterious methods of construction.

A technical research project exploring these objects is under way at the AGO and MMA: findings will be shared in an exhibition at the AGO, the MMA, and the Rijksmuseum. The study of carving techniques and strategies of joining tiny, interlocking pieces will help group the objects into clusters of makers and/or workshops, and perhaps even determine a chronology of manufacture.

Conservators and curators at the AGO and MMA have profited from different institutional collection strategies and staff expertise for the benefit of the project. The AGO's investigation relies on high-resolution x-ray tomography, called *micro-computed tomography* (micro-CT), a noninvasive tool that reveals the carvings' internal structures and features. Imaging software allows three-dimensional virtual models to be created from the high-resolution x-ray scans, which can then be examined and manipulated in a so-called virtual deconstruction. With the information provided by the micro-CT scans of their objects, the MMA took the additional step of deconstructing their boxwood objects to the extent possible. With greater access to their interiors, specifics of tooling and fabrication could be documented microscopically, intrusive restorations reduced, broken elements readhered, and accumulated dirt and insect casings reduced.

The AGO has also embarked on an ambitious program to photograph the entire opus of prayer beads and miniature altars found internationally (about 130 objects) using high-resolution, focus stacking software. This will allow the comparison of objects and examination of detail impossible to date with the constraints of traditional photography, which was only able to produce hazy images of these tiny works.

To more thoroughly understand original manufacture and subsequent repairs and restorations, minute samples of the AGO works' adhesives, coatings, and polychromy are being analyzed at the Canadian Conservation Institute with Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy–energy dispersive spectrometry (SEM-EDS), and pyrolysis–gas chromatography–mass spectrometry (Py-GC-MS), as well as a Bruker Senterra dispersive Raman microscope. Similar analytical work is being undertaken at the MMA.

The employment of new technologies such as micro-CT scanning and focus stacking software, along with the analytical work carried out at CCI and MMA, is providing previously inconceivable access to the prayer beads and miniature altars. The resulting data, including high-quality images and previously hidden construction details, will allow conservators to posit credible theories about makers and chronologies of manufacture. The collaboration between institutions is yielding greater results than would otherwise be possible: there is access to a greater number of works for research purposes, as well as the benefit of a collegial environment in which to share findings and deliberate their meaning.

These artifacts and findings about them will be presented in an exhibition entitled *Small Wonders: Gothic Boxwood Miniatures* opening in Toronto on November 5, 2016. Featuring more than 60 rare boxwood carvings from institutions and private collections across Europe and North America, following its debut at the AGO, the exhibition will open at the Met Cloisters at the MMA on February 21, 2017, before traveling to the Rijksmuseum on June 15, 2017.

The study's results will be published in two publications available late in November 2016: a guide to boxwood miniature carving and an exhibition catalog entitled *Small Wonders*: *Late-Gothic Boxwood Micro-carvings from the Low Countries*.

FURTHER READING

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LISA ELLIS has been the Conservator of Sculpture and Decorative Arts at the AGO since 2007, where she is responsible for the AGO's permanent collection of sculpture and decorative arts, as well as the objects in the renowned Thomson Collection of European Art, and the sculpture in the Henry Moore Collection, the largest public collection of the artist's works in the world. She is presently the technical lead on an upcoming exhibition about boxwood carvings from the Thomson Collection at the AGO. She has master's degrees in Art Conservation from Queen's University, Kingston, Canada (1998) and in Art History from the University of Toronto (2000). She has published conservation articles in *Studies in Conservation*, *JAIC*, *Material Research Society Symposium Proceedings*, and *ICOM Proceedings*. E-mail: lisa_ellis@ago.net

PETE DANDRIDGE, Conservator and Administrator, came to the MMA in 1979 after receiving his MA in Conservation and Certificate of Advanced Study from the Cooperstown Graduate Program in the Conservation of Historic and Artistic Works of Art. Since 1984, he has had primary responsibility for the conservation of the ivories, enamels, and metalwork in the collection of the Department of Medieval Art and The Cloisters. His published work and lectures have focused principally on elucidating the technical history of these same materials and the capacities of the artists manipulating them.

DECOYS X-RAYED: WHAT VOLUME RAD TOMOSYNTHESIS AND COMPUTED TOMOGRAPHY CONTRIBUTE TO TECHNICAL STUDY

NANCIE RAVENEL

This article will examine some of the issues of adapting medical radiography to the examination of wooden artifacts, and explore and compare the usefulness of two three-dimensional radiological techniques, VolumeRAD tomosynthesis and computed tomography, for revealing tool marks and marks within joints on wildfowl decoys in Shelburne Museum's collection. While digital radiography equipment has become more affordable for museums, the price tag still is out of reach for smaller labs. The conservators at Shelburne Museum turn to the radiological technologists at the University of Vermont Medical Center Hospital to assist with non-destructive examination of composite objects and paintings. Because of their size, decoys are well suited for transport from the museum to the hospital for study. At the hospital, the equipment used by the technologists to take standard radiographs for the conservators also can be used for VolumeRAD tomosynthesis, rendering the technique more accessible and convenient than computed tomography, which requires separate scheduling. The advantages and disadvantages of each technique will be explored.

KEYWORDS: Radiography, Computed tomography, Digital x-ray tomosynthesis, Wildfowl decoy

1. INTRODUCTION

The craft of making wildfowl decoys in North America has a rich and varied history. As demand for feathers for fashion and wild game for restaurants increased in the mid-19th century, decoy carving went from being the individual pursuit of hunters working to feed themselves or a small community to one that was also undertaken by professional woodworkers and commercial factories supplying professional wildfowl hunters serving a growing commercial market. Professional wildfowl hunters were referred to as "market gunners." It is said that in the 1870s, it was not uncommon that 15,000 ducks were taken by market gunners in a single day on the Chesapeake Bay (Grinnell 1901). Market gunners used hundreds of decoys in order to create the illusion of tranquility within their hunting blinds (Barber 1954).

The Migratory Bird Act of 1913, enacted to stem the rate at which wildfowl were being killed, brought the market-gunning industry to a screeching halt in the United States. While decoys were and continue to be produced for sport, professional decoy makers responded to the change by making decorative carvings. This industry was bolstered beginning in the 1920s thanks to collectors like Joel D. Barber and William J. Mackey, who arranged exhibitions and decoy carving competitions and wrote books and articles, and through increased interest in American folk art from museums and initiatives such as the Index of American Design.

Collectors of wildfowl decoys have been using x-radiography to learn more about the objects in their own collections for decades. Most often, collectors look for evidence of past repairs, especially replacement heads. Since not all makers marked their work, collectors take note of patterns and choices of fasteners within the decoys and, occasionally, marks hidden within joins to attribute decoys to specific makers. Working with medical or veterinary systems, radiographs of decoys can be found in exhibition pamphlets and catalogs at least since the mid-1980s (James 1988; Andresen and Dudley 2011).

The shape and manner in which these sculptures were assembled is regional, relating to available materials and the water conditions in a given hunting area. Decoys used for hunting show evidence of being set out on the waters, being shot over, and the manner of storage. Rigs of working decoys are commonly repainted and repaired in response to damage incurred in the field. Wooden keels and lead weights attached to the underside of the birds may be moved or exchanged in response to water conditions in a different region.

In 1981, a group of collectors and dealers was invited to Shelburne Museum to help assess the collection of 1,400 wildfowl decoys. Occasionally, the attribution of decoys to specific makers was questioned by the group, and they offered suggestions as to what to look for in the way of internal marks or features of construction. In other instances, the group had questions about the degree to which the decoy had been restored—specifically, whether heads had been replaced. In concert with a renovation of the exhibition building that houses the collection, I began to work with Shelburne Museum's decoy collection in 2014. In addition to wanting to resolve questions about the collection raised in 1981, other questions emerged about tools used to construct specific decoy and history of repair.

I solicited the assistance of radiological technologists at the University of Vermont Medical Center Hospital (UVMMCH), formerly Fletcher Allen Hospital, to radiograph selected decoys from the collection. While most questions could be answered through standard radiography, occasionally we found that when the feature we wanted to see was obscured by surrounding radiopaque material, clearer images could be achieved through a three-dimensional radiographic technique, VolumeRAD digital tomosynthesis (VolumeRAD). Because the instrument we were using for standard radiography was a VolumeRAD machine, digital tomosynthesis sweeps were undertaken on all decoys following a quick examination of the standard radiograph on the technologist's monitor. Computed tomography (CT) is a more common 3D radiographic technique that has been used to examine works of art and artifacts. In order to understand the value of information gleaned from images produced using the VolumeRAD technique, two decoys were examined using CT and VolumeRAD. This article will describe the advantages and disadvantages of each technique for examining painted three-dimensional wooden artifacts with metal fasteners using wildfowl decoys from Shelburne Museum's collection as illustrations.

2. OVERVIEW OF COMPUTED TOMOGRAPHY

In CT, the x-ray source and detector rotate completely around the object to create a series of two-dimensional cross section images. These series can be taken along any one of three planes. The coronal plane divides the front from the back; the sagittal plane divides the body laterally down the middle; and the transverse or axial plane divides the top from the bottom as it rests on the table.

The images in any one plane can then combined to create a three-dimensional image (fig. 2) or reconstructed to create two-dimensional orthogonal multiplanar reconstructions (2DMPR). Using the data from a single series of images in a specific plane such as the coronal view, the computer reconstructs the images in the transverse and sagittal views at a specific point and places the two resulting 2D images side by side with the initial 2D view. This allows the researcher to look at any single point within the object in all three dimensions simultaneously, as shown in figure 3.

Initially developed in the 1970s for medical applications, high-resolution CT scanning has been used to image human remains, natural history specimens, archeological artifacts within soil blocks, and rolled papyrus scrolls (Payne 2013). Previously, with the help of radiological technologists at the UVMMCH, I've used CT to examine dolls in Shelburne Museum's collection (Ravenel 2004; Ravenel 2011).

Due to constraints posed by the design of CT scanners used in the medical field, most CT studies within cultural heritage have involved examination of objects no larger than a prone adult human. That said, a technique to perform CT on large-scale works of art, specifically an inlaid fall-front desk made by Pietro Piffetti (Italy, 1701–1777), has been developed using a prototype scanner (Re et al. 2014). The scanner was redesigned so that the object was placed on a turntable and the x-ray source and detector moved vertically in a synchronized fashion to acquire the images. While decoys are smaller than adult humans overall (fig. 4), they do not always fit within a medical scanner due to their height or width. This kind of redesigned scanner could be as applicable to larger decoys if it were available.

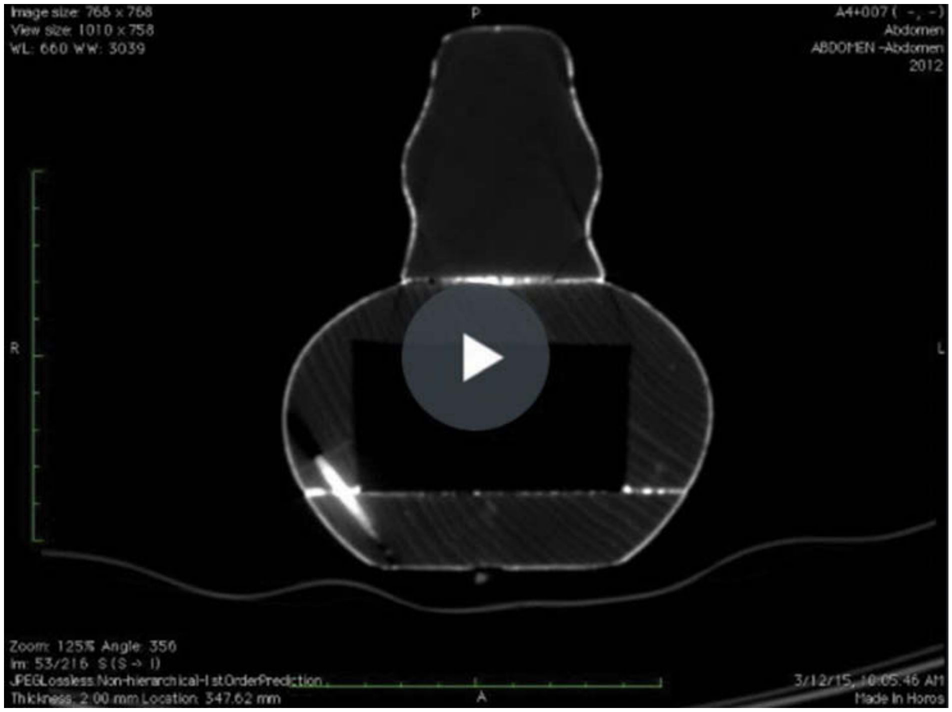

Fig. 1. Coronal view CT. Benjamin Holmes, *Black duck decoy*, ca. 1880, painted wood, iron, lead, leather, 16.2 x 16.2 x 41.9 cm, Shelburne Museum, 1952-192.57. Gift of J. Watson, Jr., Harry H., and Samuel B. Webb (Courtesy of Shelburne Museum and UVMMCH). Video available here: https://youtu.be/KlLPT44HhVg

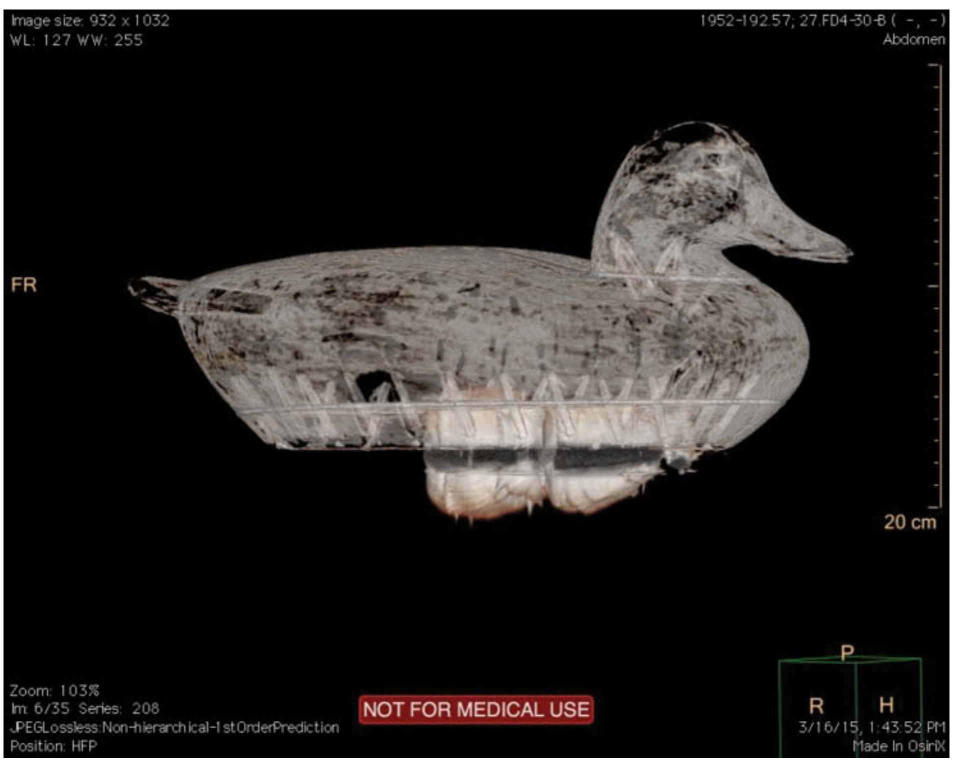

Fig. 2. Three-dimensional reconstruction of CT of Holmes *Black duck decoy*, three-quarter view, from the coronal data (Courtesy of Shelburne Museum and UVMMCH)

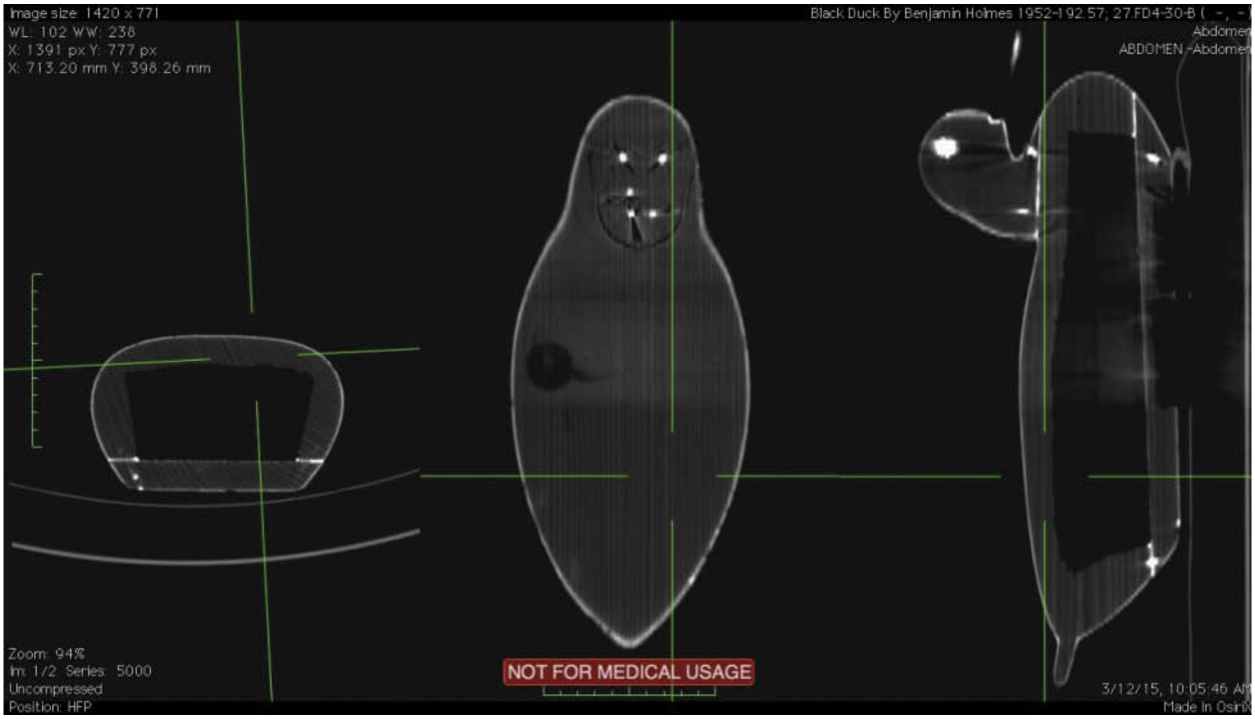

Fig. 3. An example of a two-dimensional orthogonal multiplanar reconstruction (2DMPR) view of Holmes *Black duck decoy*. Screen grab from OsiriX Lite DICOM viewing software. The coronal view is on the left, the transverse or axial view is in the center, and the sagittal view is on the right. Drill tip marks are circled in pink on the transverse view. Two marks made by a center drill bit are enclosed by a blue rectangle. The full circle surrounding the dot is a full turn by the bit, while the arc around the dot is a partial sweep created by the sharpened "tooth" on the outer edge of the bit. (Courtesy of Nancie Ravenel, Shelburne Museum, and UVMMCH)

Time on hospital CT scanners can be difficult to schedule as they are in high demand clinically. Of the 18 wildfowl decoys radiographed in the last two years, we've looked at two using CT, but commonly use VolumeRAD because of its convenience.

2.1 ISSUES CAUSED BY METAL COMPONENTS IN CT

Imaging objects containing metal fasteners or covered in lead-based paints using CT can be challenging. Medical radiographic literature documents efforts to improve digital x-ray CT images of bodies containing metal-based inclusions such as dental fillings, prosthetics, or ballistic damage by altering the conditions under which the CT is taken or the algorithm used to analyze the data that produces the images. While there have been examples of successful studies of pattern welding in medieval swords undertaken using medical and industrial x-ray CT (Stelzner et al. 2016), beam hardening resulting from metal content, whereby the x-ray photons are scattered by the dense material and create obscuring or distorting errors in the resulting images, limits their usefulness.

Distortions, flares, and voids are evident in the images around the metal weights on the underside of decoys, around the eyes due to metallic content in the glass, around the fasteners in necks, and the radiopaque fills in the back of the Albert Laing black duck decoy (fig. 5). The images show voids around these metallic parts where none exist, and in the cases of the lead weights, create light or dark flares that obscure features in other parts of the image.

In the coronal view CT images, the wood grain is clearly evident in Holmes *Black duck's* body (fig. 1), but artifacts from the metal fasteners, lead-containing adhesive, and eyes make it difficult to tell

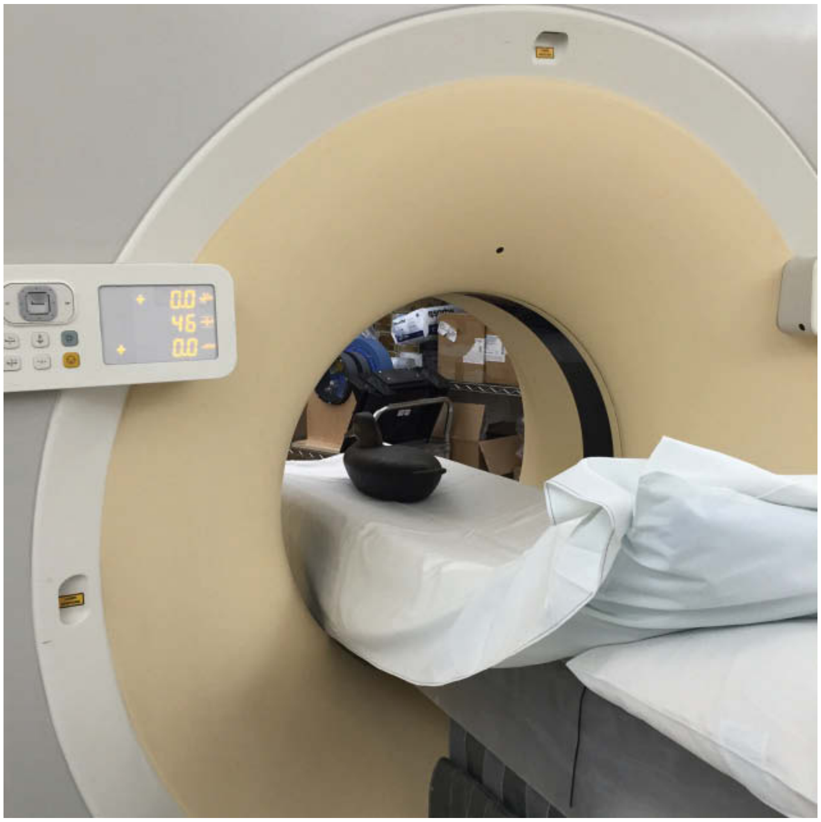

Fig. 4. Holmes *Black duck* in the Phillips Ingenuity CT scanner at UVMMCH (Courtesy of Nancie Ravenel, Shelburne Museum, and UVMMCH)

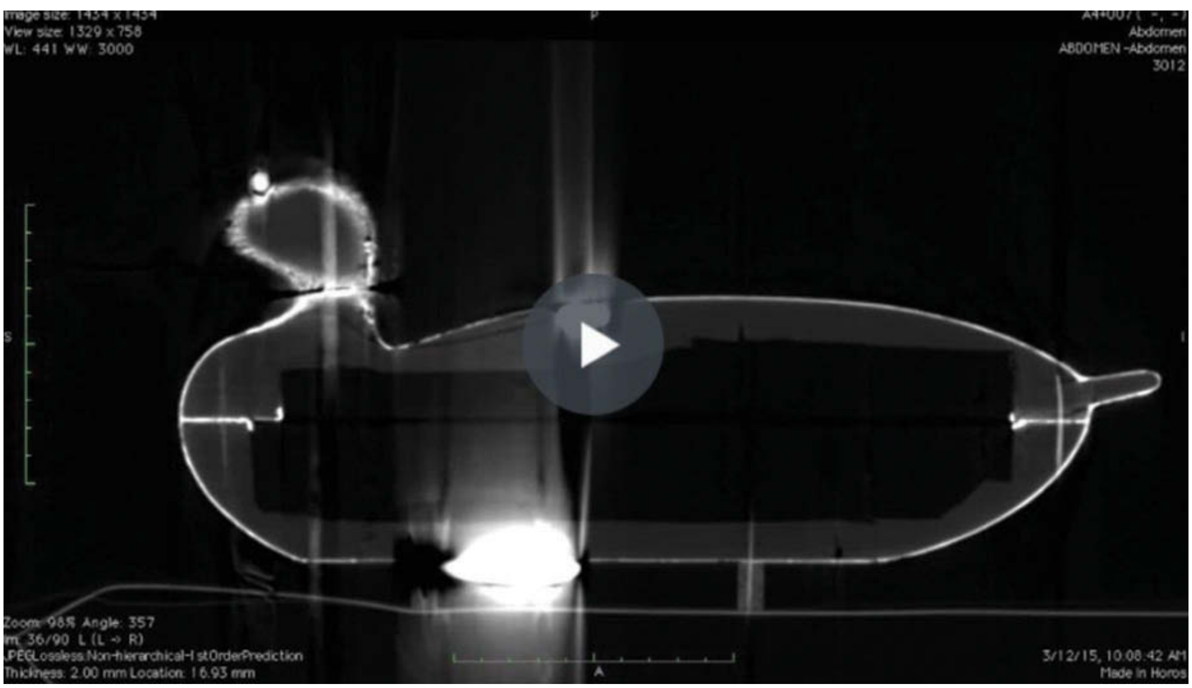

Fig. 5. Sagittal view CT. Albert Laing, *Black duck decoy*, date unknown, painted wood, iron, lead, leather, 17.8 x 16.2 x 40.6 cm, Shelburne Museum, 1952-192.46. Gift of J. Watson, Jr., Harry H., and Samuel B. Webb (Courtesy of Shelburne Museum and UVMMCH). Video available here: https://youtu.be/I2-cmE4PoIs

whether the lines through the head are wood grain or simply flares caused by the paint or other metallic features. However, by viewing the data as a 2DMPR (fig. 3), one can find areas within the structure that are not as affected by distortions, and features of the wood and clues about how it was shaped become more apparent. Especially notable in both the Holmes and Laing *Black ducks* are the marks of drill bits arranged in rows in the top of the hollow within the decoys' bodies as viewed in the axial plane. By moving up through that plane, the cylindrical shape formed by the bits terminate in points at the centers of the circles, and a single cutting point located at the outer perimeter of each mark. The form of these tool marks suggests that a center bit was used to hollow the bodies. This is notable in that the variety of drill bit used can be discerned by following the manner in which the tool bites into the wood by moving through the transverse plane in the 2DMPR.

3. OVERVIEW OF DIGITAL X-RAY TOMOSYNTHESIS AND VOLUME RAD TOMOSYNTHESIS

Conventional medical x-ray tomography was developed in the first half of the 20th century to view consecutive sections of a body in order to separate an area of interest from competing structures. It was a precursor to CT (Littleton and Durizch Littleton 1996). In conventional medical x-ray tomography, the object of study remains stationary while the x-ray tube and film move simultaneously in opposite directions on opposite sides of the object. As a result, the fulcrum of that motion located within the object being studied is in focus in the radiographic image while the surrounding out-of-plane material appears blurry and thus less visible (Farlex Partner Medical Dictionary 2012). Digital x-ray tomography, a relatively recent refinement of conventional tomography, acquires multiple in-focus planes from a sequence of radiographic images taken in one sweep of the x-ray tube while the detector and the object of study remain in fixed positions. The raw data from the detector is then reconstructed and resliced to optimize the resulting images (Dobbins and Godfrey 2003). The individual images can then be viewed in sequence to get a sense of the object's volume.

VolumeRAD tomosynthesis is a digital x-ray tomosynthesis application produced by GE Healthcare. In the 10 years that VolumeRAD has been available to the medical community, it has been used to assess and monitor bone fractures and to detect nodules in the lungs (GE Healthcare 2016). Other companies including CanonUSA and Shimadzu either have produced or are producing competing devices (Iversen et al. 2015).

In VolumeRAD, the x-ray tube moves in a 40° arc over the object, taking as many as 60 images in a single sweep, depending on what protocol is applied (GE Healthcare 2016). The minimum thickness of an image is 1 mm. VolumeRAD typically uses a fraction of the radiation used to run a CT scan. Because the radiologists at UVMMCH use the GE Healthcare Discovery XR656, the machine that runs VolumeRAD, to create standard radiographic images of works of art and artifacts from Shelburne Museum, performing VolumeRAD sweeps is convenient; no separate scheduling is required. Because the design of the apparatus is more open than a CT machine, the size of the object is less of an issue (fig. 6). Larger objects can be repositioned for scanning. Since less radiation is required, metal fasteners and lead-containing coatings and adhesives do not create flares to the same degree they do in CT.

The resulting slices are linear with unfocused edges. Because the arc is not a complete 360°, the resulting slices cannot be reconstructed in three dimensions or reconfigured into other reconstructions in the same way CT slices can be. While the raw data volume can be resliced to further enhance the images, this cannot be undertaken after the images have been processed. Depending on the location of an internal feature, the object may need to be repositioned so that the desired feature will be in focus during a sweep.

Although metal or other high-contrast components within a structure may still cause unwanted ripples or blurs in VolumeRAD images, especially when the high-contrast element is oriented perpendicular to the sweep direction, the effect can be reduced by altering the angle of the object relative to the sweep or increasing the number of images acquired during a sweep (Machida et al. 2010).

Despite these drawbacks, VolumeRAD has proven its value for imaging internal marks that could not be imaged in CT either due to the size of the decoy or to the confounding influence of metal fasteners or lead weights. VolumeRAD also elucidates details of metal fasteners, such as the shape of a slot in a screw head, that might be obscured by other features within the object in a standard radiograph or would be indistinct in a medical CT.

3.1 VOLUME RAD TOMOSYNTHESIS IN PRACTICE: *SWAN DECOY* BY SAMUEL BARNES

Collector and author Joel Barber recounted the story of how he acquired the swan made ca. 1890 by Havre-de-Grace, Maryland carver Samuel Barnes (1857–1926) in his book *Wild fowl decoys* (1954), the first work to consider decoys as works of art. Despite Barber's account, in the 1980s, two decoy scholars questioned the attribution of the swan to Barnes, suggesting that it could be the work of another Havre-de-Grace carver, James Holly (1855–1935). A minimally repaired swan decoy unquestionably attributed to Samuel Barnes features a neck attached to the body with a dowel so that the head could be removed, and an incised Roman numeral "II" on the neck shelf, the join surface on the body with the neck (Johnsgard 1976). The scholars wanted to know if Shelburne's decoy had a similar mark.

Because of numerous metal fasteners added as repairs to secure the joins between the neck and head and in the join between the neck and body, the standard posterior-anterior view radiograph taken from above the neck shelf was fairly inconclusive as far as identifying a mark (fig. 8). The posterior-anterior view is created when the object is laid on the examination table such that the x-ray generator is located above and the digital x-ray detector, taking the place of film, is located within the table or directly under the object. The swan was too large to fit in the medical CT scanner at the UVMMCH, so VolumeRAD tomosynthesis was used to determine whether or not a maker's mark was present on the neck shelf.

By choosing appropriate starting and stopping points within the scan, an image of an incised mark was located. The technologist undertook a sweep of 24 projections around the join between the neck and body in the axial or transverse plane (fig. 7). Within the sweep, one projection provided a good view of the mark, a Roman numeral "III," on the neck shelf and a view of the top of the dowel that originally secured the neck to the body. This is more visible than it was in the 2D radiographic image (fig. 8). Another projection provides an image of the metal pin, which appears to be a headless rod that stops short of either side of the neck, that secures the neck through the dowel (fig. 9). Because the fastener is in plane with the x-ray source, there is no ripple or other distortion in the image.

3.2 VOLUME RAD TOMOSYNTHESIS IN PRACTICE: WHISTLER DRAKE DECOY BY THE MASON DECOY FACTORY

Using CT, it had been possible to capture tool marks in the hollows of the Holmes and Laing black ducks. We chose the hollow Mason Decoy Factory *Whistler drake decoy* (fig. 10) as a test subject to see if the same was possible with VolumeRAD, primarily because it had few complicating factors. The paint on the decoy was original and thinly applied but worn, exposing the wood grain on the surface of the body. The continuous nature of the wood grain across the seam in the decoy's body suggested that the body had been shaped before it was cut in half and hollowed. There was no indication of wood fasteners holding the neck to the body, and the ballast had had been removed from the underside. Thus, the only metal components expected within the decoy were nails securing the upper half of the body to the lower half, x-ray opaque adhesives, and the metal trace elements in the glass eyes.

Fig. 6. Swan decoy sitting on the GE Healthcare Discovery XR656 at the UVMMCH. Samuel Barnes, *Swan decoy*, ca. 1890, painted wood and iron, 48.6 x 24.1 x 97.2 cm, Shelburne Museum, 1952-192.4. Gift of J. Watson, Jr., Harry H., and Samuel B. Webb (Courtesy of Shelburne Museum and UVMMCH)

Fig. 7. VolumeRAD sweep, axial plane, of the neck shelf from the Barnes *Swan*
(Courtesy of Shelburne Museum and UVMMCH). Video available here: https://youtu.be/I2-cmE4PoIs

Fig. 8. Projection 7/24 of the axial VolumeRAD sweep of the neck shelf on the Barnes Swan (left) and the posterior-anterior view two-dimensional radiograph of the same area. Pink rectangles indicate the location of the maker's mark on each image (Courtesy of Shelburne Museum and UVMMCH)

The standard radiograph in the lateral view (figure 11) indeed showed a drill mark in the upper back of the decoy, and the cone shape of the hollow suggested that the drill bit may have been rocked to create the hollow's slanted walls. One could also see that the head was attached to the body by means of a wooden dowel through the neck, secured with a metal pin. The posterior-anterior view radiograph also

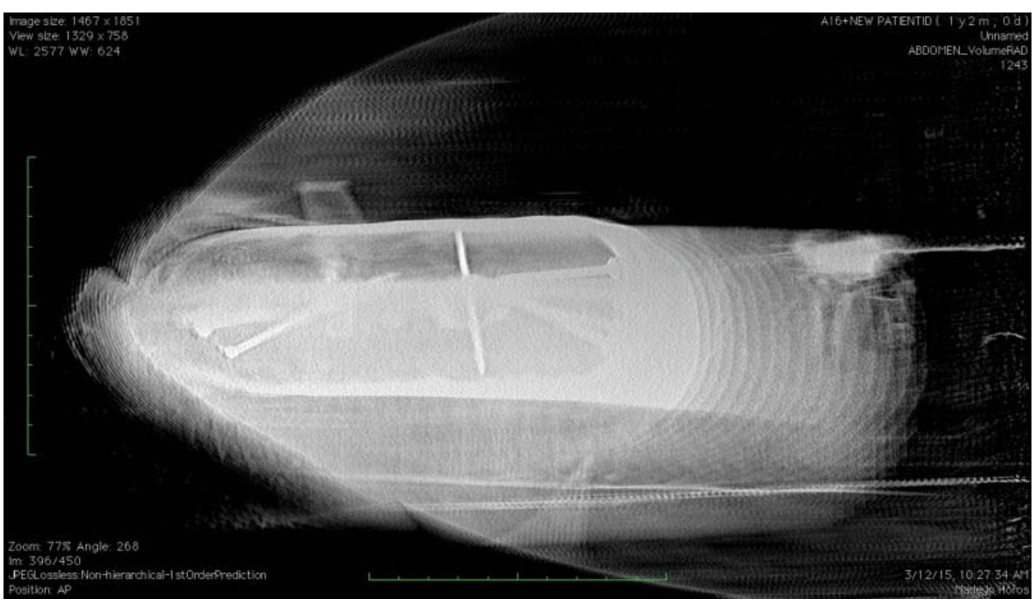

Fig. 9. Projection 13/24 of the axial VolumeRAD sweep of the neck shelf on the Barnes Swan. A pink rectangle indicates the area showing the metal pin securing a metal dowel (Courtesy of Shelburne Museum and UVMMCH

Fig. 10. Mason Decoy Factory, *Whistler drake decoy,* ca. 1900, painted wood, glass, and iron, 16.2 x 14 x 36.2 cm, Shelburne Museum, 1956-707.118. Museum purchase, acquired from Richard H. Moeller, 1956 (Courtesy of Shelburne Museum)

clearly showed the trace of the drill bit in the upper back and that the body had been split at the join line using a band saw, but was inconclusive as to how the bottom section was hollowed out.

Using a variant on a wrist protocol, the technologist performed a VolumeRAD scan with 33 projections in the sagittal or lateral view, with each projection measuring approximately 2 mm in thickness. In the 24th projection of the scan, one can see a more defined mark in the top of the back, but the centers of the drill tips were also clearly visible in the bottom of the hollow, a feature that could not

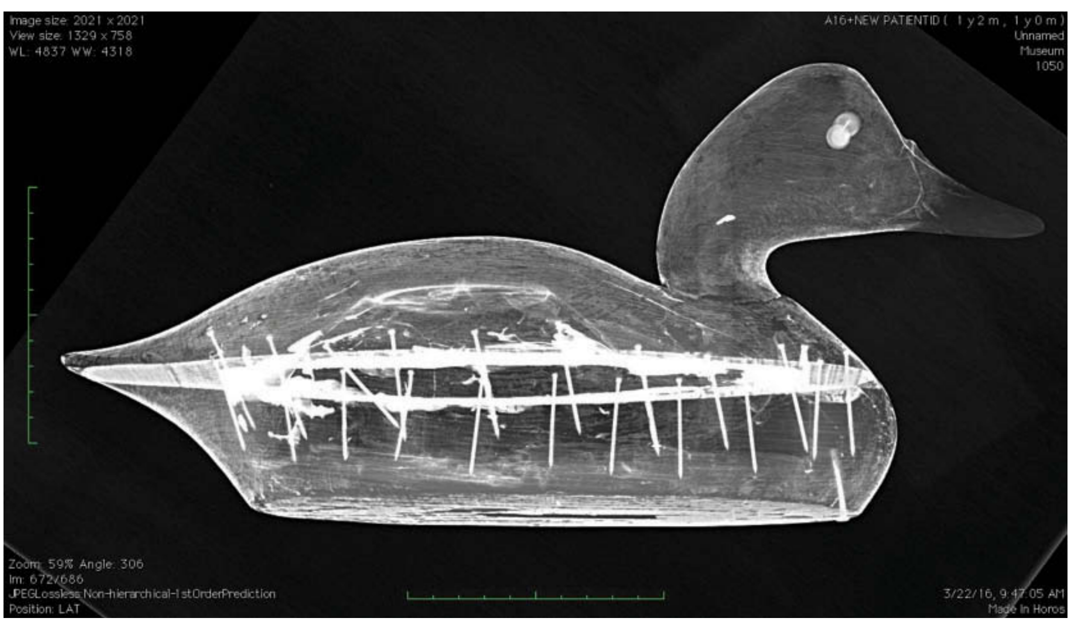

Fig. 11. Lateral view radiograph of the Mason Decoy Factory *Whistler drake decoy* (Courtesy of Shelburne Museum and UVMMCH)

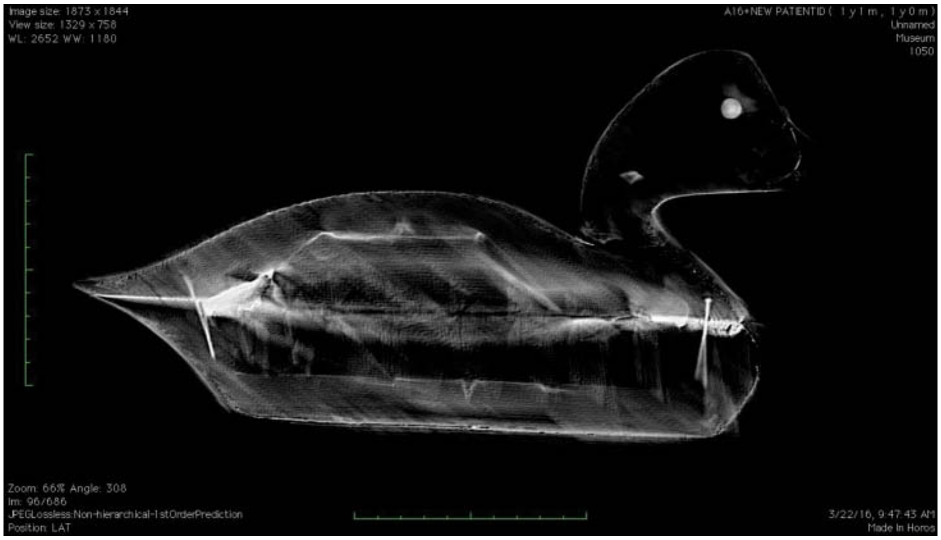

Fig. 12. Projection 24/33 sagittal view VolumeRAD scan of Mason Decoy Factory *Whistler drake decoy* (Courtesy of Shelburne Museum and UVMMCH)

be seen in the two-dimensional lateral view (fig. 12). For the axial or transverse view, using the same variant on the wrist protocol, the technologist performed a sweep with 23 projections, each measuring about 2 mm in thickness. In projection number 9 of the scan, approximately 18 mm from the underside of the decoy, one can see five rotations of what appear to be marks from Forstner bits (fig. 13). The centers of the marks are different sizes, which could suggest that the drill bits were run at various angles at each location as the hollow was being cleared.

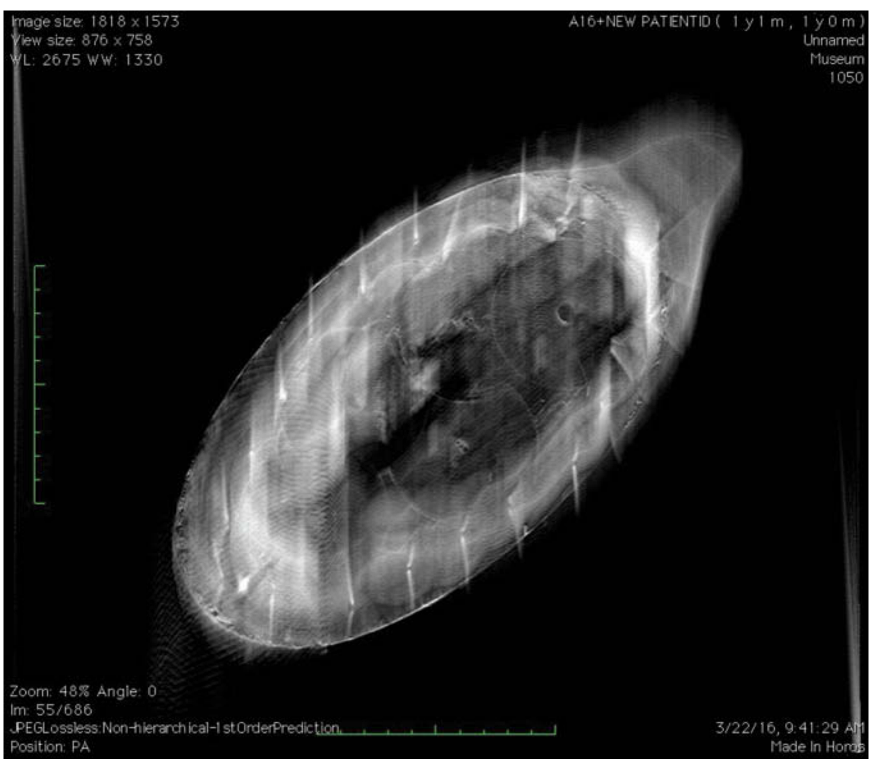

Fig. 13. Projection 9/23 axial view VolumeRAD scan of Mason Decoy Factory *Whistler drake decoy* (Courtesy of Shelburne Museum and UVMMCH)

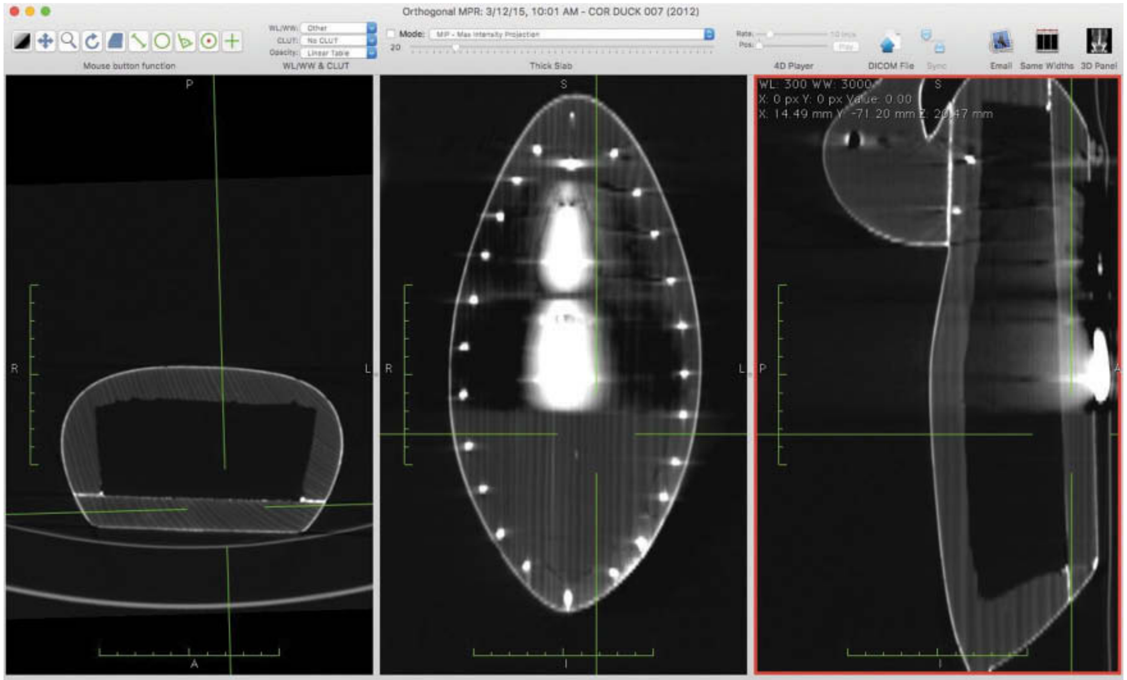

Fig. 14. 2DMPR from coronal view CT series from *Black duck decoy* by Benjamin Holmes (Courtesy of Nancie Ravenel, Shelburne Museum and UVMMCH)

4. CT AND VOLUME RAD HEAD TO HEAD: *BLACK DUCK DECOY* BY BENJAMIN HOLMES

In the interest of clarifying the relative utility of CT and VolumeRAD, let's return to the Holmes *Black duck decoy*. Looking at the individual 2D slices within the CT in figure 1 and in the 2D MPR of the CT data in figure 14, not only is the wood grain apparent in the CT slices, but we can also see that the wood grain in the bottom board is continuous with the rest of the body, indicating that maker, Benjamin Holmes, produced the body from a single block of wood, slicing a piece off the bottom to make the bottom board before hollowing out the upper part. This may place the decoy earlier in Holmes's career (Chitwood 1997). The wood grain structure is not evident in the standard radiograph or VolumeRAD images, possibly obscured by the priming layer of paint. However, the texture of the painted surfaces on the bottom board are clearly evident and discernible from one another in the VolumeRAD projections (fig. 15) while that interior painted surface is not easily identified within the CT images. Figure 15 also shows the position of the screw holding the rigging loop to the underside of the decoy relative to the lead weights, a feature obscured by the head in the standard radiograph.

Thus, both techniques, CT and VolumeRAD have the potential to reveal aspects of the manner in which decoys are constructed that the other one might not.

5. CONCLUSIONS

Three-dimensional radiographic techniques allow the conservator to view features within polychrome objects that may be obscured or hidden in two-dimensional radiographic images. Computed tomography provides full 360-degree data which can be reconstructed in a number of ways. However, the amount of radiation involved in scanning an object with CT can result in beam hardening when the radiation

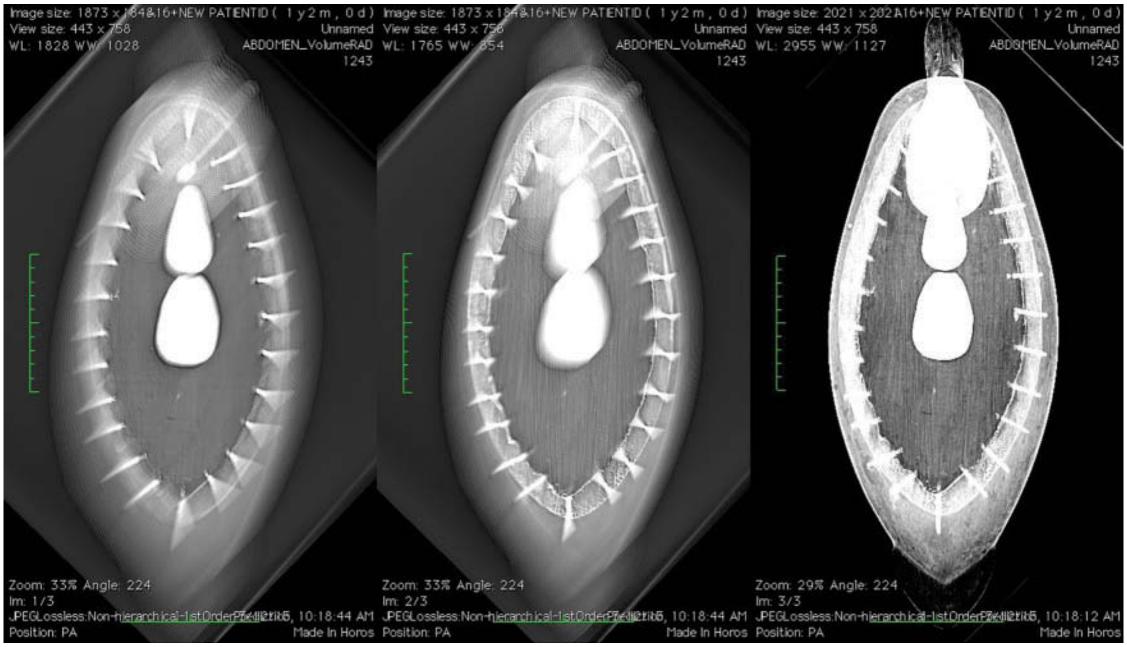

Fig. 15. VolumeRAD projection 5/23, axial view, from the bottom of the Holmes *Black duck decoy* (left), VolumeRAD projection 15/23, axial view, from the bottom of the Holmes *Black duck decoy* (center), and posterior-anterior view radiograph of the Holmes *Black duck decoy* (right) (Courtesy of Nancie Ravenel, Shelburne Museum, and UVMMCH Diagnostic Radiology Department)

encounters radiopaque materials such as paint, metal fasteners, or glass-containing parts. The resulting image artifacts may obscure, obliterate, or distort features of interest within the image.

While figures 1-3 reveal some of the value of looking at painted wooden objects with CT, they also touch on some of the challenges. Chief among these is the manner in which radiation bounces off of metal fasteners and lead-containing fills, adhesives, and paint. Metal objects within the decoys are distorted in appearance. The resulting flares can obscure or even obliterate structural features. For instance, the nails holding the bottom board to the body are indistinct; from the CT image we can't see if they are cut nails or finishing nails, and the lead weights appear pulled out of shape.

VolumeRAD tomosynthesis uses less radiation to complete a scan, but the data represents only a fraction of that which is collected in a CT. Although there are currently fewer options to reconstruct the resulting data for viewing, metal fasteners will be clearly visible and minimally distorted if they are in plane with the scan because less radiation is required for the scan. Because the scan is an arc rather than a full 360-degree sweep, patience is required in making the scan, and the object may need to be repositioned relative to the detector so that features of interest are in the proper plane. VolumeRAD projections are thicker than CT slices, so there is a chance that details such as interior tool marks could be missed in reviewing images.

Depending on the location of metal fasteners and components and the thickness of paint coatings, medical CT and VolumeRAD are capable of revealing marks and other aspects of construction that are not visible in standard two dimensional radiographs.

ACKNOWLEDGMENTS

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Hospital (UVMMCH, Burlington, Vermont). The two-dimensional radiographs and VolumeRAD images in this paper were taken by Carol Kittredge, R.T (R), QA Technologist in the Department of Diagnostic Radiology at UVMMCH using a GE Healthcare Discovery XR656 machine. Without Michael and Carol's curiosity and enthusiasm, this work would not be possible. The CT images were produced on a Phillips Ingenuity CT at UVMMCH by Heidi Streeter. Images taken at UVMMCH were further processed and exported from DICOM images to JPG images using either OsirX Lite, a free, open-source 32-bit DICOM image processing software, or Horus, a free, open-source 64-bit medical image viewer based on OsiriX and other medical imaging software.

At GE Healthcare, Karin Hazlitt, XR Clinical Applications Specialist–Northeast Zone Clinical Education and IT Solutions, and Katelyn Nye, Product Strategist for Xray Detection & Guidance Solutions, patiently answered my questions to further my understanding of VolumeRAD and provided me with some of the literature cited in this paper. Thanks are also extended to members of the Collections Department at Shelburne Museum who helped me pack and transport the decoys to UVMMCH for radiography.

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THE AFTERMATH OF MENDS: REMOVING HISTORIC FABRIC TAPE FROM TLINGIT BASKETRY

CAITLIN MAHONY AND TERI ROFKAR

Disasters strike items of cultural heritage in many forms. Though natural and human disasters cause large-scale destruction in a matter of minutes, the slow deterioration of our collections by misguided interventions can also bring damage of notable impact to institutions. A campaign of undocumented museum mending in the early 20th century left in its wake widespread instability for 130 Tlingit baskets in the collection of the National Museum of the American Indian. The repairs are oversized strips of linen fabric tape attached with excessive amounts of hide glue or cellulose nitrate, covered with imprecisely applied and chromatically unmatched lead-based paints. These well-intended but unsuitable interventions took the existing damage of minor rips, tears, and losses and escalated it in magnitude to include warped structures, areas of embrittlement, and visually distracting repair material that obscures the structure and inhibits exhibition and scholarship.

Guided by modern conservation and the expertise of Dr. Teri Rofkar, a Tlingit master weaver, we undertook a two-year project to reconcile the damage. We investigated the optimal method of removing these mends and designed an appropriate treatment for the baskets that reinstates their integrity, function, and potential for use for the Tlingit community and the museum.

KEYWORDS: Tlingit, Spruce root, Basket, Twined, Treatment, Collaboration, Hide glue, Agarose gel

1. OVERVIEW OF TLINGIT BASKETRY OF SOUTHEAST ALASKA

The origin story of Tlingit basketry is documented in the beginning of Frances Paul's 1944 book on Tlingit basketry.[1] According to legend, the first basket was woven by a woman who was married to the sun. The basket was so great in size that the sun could lower his wife and their eight children back to earth in it. The term "mother basket" now refers to oversized, undecorated baskets that were treasured heirlooms and are rare today. According to the archaeological record, the earliest known twined basket attributed to the Tlingit dates back 4,500 years. It is twined of hemlock branches and roots (museum label text, permanent exhibit, Andrew P. Kashevaroff State Library, Archives and Museum in Juneau, Alaska, June 10, 2016).

Prior to contact, baskets were integral to everyday Tlingit life. They were used to gather, collect, and store food and other items, to strain oils or berries, and to hold water for drinking or cooking. In many cases, the basket's form or weaving technique indicates its primary use. For example, baskets used as strainers are woven with an eye hole technique to allow liquids through.

1.1 PROCESSING OF MATERIAL

All work associated with baskets, from gathering and processing the material to the weaving itself, is done by women. Baskets are almost exclusively woven in spruce root (*Picea sitchensis*). The gathering of these roots usually takes place in early spring. The aim is to gather the root before it is actively moving sap along the pitch line, because the more active the flow of pitch, the more tannin-rich the roots will be, which will have negative effects on the longevity of the roots. A spruce tree that is 1–2 feet in diameter is an ideal source, because its roots have more uniformity of texture and greater lengths free of shoots. Roots are gathered in a sustainable manner to ensure that the weaver can return to the same location and collect year after year.

Once gathered, the roots are roasted in a fire to remove their outer bark and to kill off mold and fungus. The roots are coiled prior to roasting and are flipped repeatedly so that they are evenly heated. They are removed from the fire when the steam leaving the root creates a high-pitched hissing sound. Immediately after removal, they are run through a pronged wooden stake in the ground called an *ena* to remove the bark. Then, they are placed in water to cool them and arrest further cooking. The roots must be split within a four-day period or they may grow moldy. They are split along their length following the

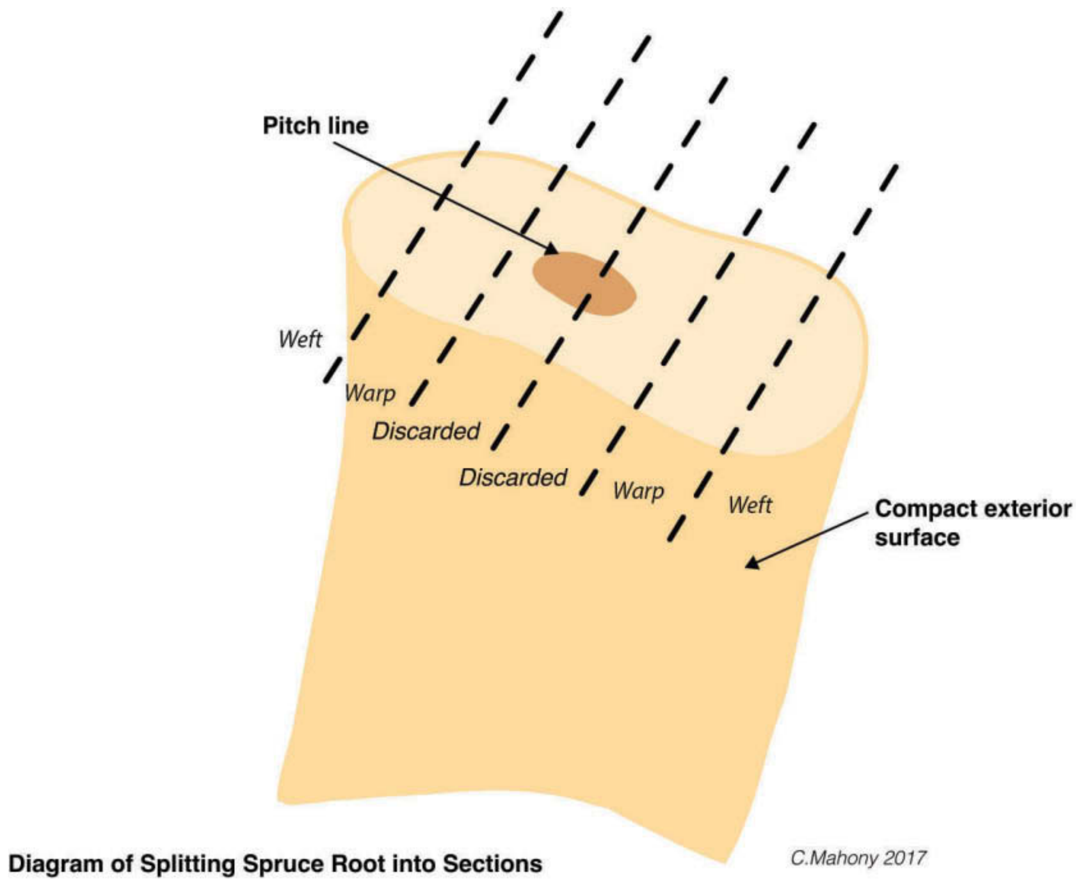

Fig. 1. Diagram of splitting spruce root into sections (Courtesy of Caitlin Mahony)

cellular structure (fig. 1). The first split is along the visible pitch line down the center. The innermost section on either side of the split is discarded because it contains the pitch line. From there, each piece is divided again, creating a weft element with a compact and rounded surface, and a warp element with two flat sides. The split roots are dried in bundles and can be stored for years and later remoistened when ready to use.

Most the roots are left undyed for twining in the basket unless they are part of a design or pattern. Early dyes were vegetal- or mineral-based and the color pallet was limited to blacks, greens, and various shades of red and orange. In the latter half of the 19th century, aniline dyes were introduced by traders and become instantly popular. These dyes were brighter and provided more color variety including blue, purple, yellow, and stronger greens.

1.2 WEAVING

The principle technique in Tlingit basketry is a simple two-strand twining. In twining, the passive elements, or warps, are vertical and the active elements, or wefts, are horizontal. Other techniques such as in-between or chase weaving, skip stitch, and openwork or eye hole twining are used in combination with two-strand twining. Tlingit baskets are woven right side up with the courses progressing counterclockwise from left to right. This weaving direction produces an effect where the next stitch is slightly below the one before it and at the terminus of the basket it will "jog-down" at finished rim. This is an easy method for distinguishing between Tlingit and Haida baskets, because Haida baskets are woven inverted and each stitch "jogs up" (Busby 2003, 47). When the basket weaving is complete, the interior and exterior is burnished with a bone tool to even out the weave and create a lustrous surface.

The baskets are typically decorated on the exterior by introducing a third element of either maidenhair fern (*Adiantum pedatum*), spruce root, or a grass stem, dyed or undyed, during the twining process that wraps over and under a weft strand but never reaches the inner basket surface. This technique is often referred to as "false embroidery," which is imprecise and unclear because it does not reach the interior or because it is added during weaving. "Wrapped weft" is the preferred term. There are several species of grasses traditionally used, including blue joint (*Calamagrosti canadensis*), dunegrass (*Elymus mollis*) and wood reedgrass (*Cinna latifolia*) (Pojar and Mackinnon 1994). Reed canary grass (*Phalaris arundinacea*) is used by contemporary weavers. It is important to note that bear grass, rye grass, Timothy grass, and squaw grass were not used on Tlingit baskets though they are often cited in catalog information.

Aside from its aesthetic qualities, the wrapped weft decoration also is also functional. When the grass wraps around the weft, it forms two additional layers, which add structural integrity. When the basket is filled with water, the roots soften, causing the basket to lose some of its shape. However, the cuticle layer on the grasses and ferns wrapped around them prevents them from swelling, which provides stability and strength. This characteristic explains why baskets used for cooking or drinking are heavily decorated along the walls.

Designs made from wrapped weft are typically created within the rows of dyed rather than undyed roots, creating visually complex layers of patterning. They often consist of two thick bands separated by a thinner band in the center. This thin band allows the weaver to accomplish symmetry in the design. Additionally, there are sometimes series of triangles and rhomboids created above and below the banded designs that are referred to as ascenders and descenders. These are more typically seen in older baskets. Standard designs are described at length in Paul 1991 (44–79). In addition to their aesthetic beauty, the designs reference cultural metaphor, features in nature, and stories. There are no familial or clan restrictions on the use of designs.

1.3 TOURIST MARKET

By the turn of the 20th century, non-native traders brought significant changes to the production of spruce root baskets. They introduced weavers to aniline dyes, which were favored due to their bright colors and thus began to replace natural dyes. They also brought with them items such as metal pots, pans, and kettles, which replaced the baskets themselves, causing some forms of basketry to die out. Finally, and perhaps most notably, traders and other non-native travelers began purchasing baskets and encouraging weavers to make baskets for sale. This created a significant shift in the size, form, and designs of baskets produced.

The so-called "berry baskets"[2] and rattle lid forms became the mainstay of trade, but other novelty forms such as basketry-covered bottles or flat basket trays were also popular. These forms flourished because they appealed to the buyer and were faster to produce. New designs were generated that were pictorial and sometimes mimicked patterns on dishware or Chinese porcelain. The buying public preferred a finer weave, which often came at the expense of strength and integrity (Busby 2003, 94).

2. TLINGIT BASKETRY AT THE NATIONAL MUSEUM OF THE AMERICAN INDIAN

There are over 700 Tlingit spruce root baskets in the collection of the National Museum of the American Indian (NMAI). The majority of the baskets entered the collection in the early 20th century from various private collectors who either sold or donated them to the museum. There is a variety of forms and designs, ranging from large undecorated baskets to ornately decorated tourist market creations; however, the most common is a cylindrical basket with slightly flared walls and no lid, often referred to as a "berry basket."

Irrespective of form or collector, there is extensive ripping, tearing, and loss throughout our Tlingit basketry concentrated on the rims, at the joining of the base and walls, along fold lines, and along rows of dyed spruce root. The damage exhibited is notable compared to those from other cultural groups.

2.1 UNDOCUMENTED MENDING CAMPAIGN

In response to the structural damage exhibited on the baskets, there appears to have been a historic in-house mending campaign. A recent survey conducted of the Tlingit baskets revealed that 130 of the 580 examined had oversized strips of fabric with excessive amounts of adhesive applied to rips, tears, and losses in the structure. Twenty-four baskets had "major repairs," which was defined as having more than 20 pieces of adhered fabric, or a repair that obscured a sizable area of the walls or base (fig. 2a). In each instance, the adhered fabric strips were painted with imprecisely applied and chromatically unmatched paints (fig. 2b).

Fig. 2a. Interior view of basket showing mends around the entire base. Tlingit, *Basket*, 1906, spruce root and grass, 28.5 x 29 cm, National Museum of the American Indian, 009552.000 (Courtesy of Caitlin Mahony); 2b. Detail image of fabric mend showing oil paint on adjacent wefts. Tlingit, *Basket*, 1923, spruce root and grass, 27.5 x 25 cm, National Museum of the American Indian, 116656.000 (Courtesy of Caitlin Mahony)

Though the mending activity was undocumented, the repairs are very standardized in their application and are present on baskets from different collectors. Therefore, it seems likely that they were carried out within the museum and by a very limited group of people. The NMAI, formerly the Museum of the American Indian in New York City, has a history of "menders" and restorers on staff in the early 20th century who worked with the collections and made undocumented repairs.

During the basketry survey, observations on the appearance of mends were noted. In most cases, the adhesive was characterized as yellow and slightly opaque, but there was obvious variation. Further testing with ultraviolet-induced visible fluorescence spectroscopy (UV-Vis) and Fourier transform infrared spectroscopy (FTIR) revealed that hide glue was present on 10 out of 11 baskets analyzed, as well as cellulose nitrate.

The fabric was painted in various shades of brown and about 37% of the baskets surveyed exhibit excess paint on adjacent wefts. FTIR was conducted on a paint sample from the fabric and the results identified it as a lead white oil paint.

These well-intended but misguided mends escalated the damage and instability. In some cases, the greater strength of the adhesive as compared to the substrate created tears directly adjacent. In many instances, the break areas show misaligned warps likely caused by distortion from the shrinkage of the adhesive as the solvent evaporated. In every instance, the water from the hide glue embrittled the spruce root through the movement of tannins, dirt, and other residues.

Additionally, the mends are visually dis uring. Due to their size, the mends obscure substantial areas. The "disturbed" state of the baskets keeps them from exhibition, study, and handling. They have become inactive objects—no longer performing their original function within the museum.

3. CURRENT PROJECT

This project aims to establish an integrated protocol for the future care and treatment of Tlingit baskets within museum collections and expand on research that has been done on these baskets by a previous NMAI Mellon Fellow, Luba Dogvan-Nurse. Like the previous phase, this project is being done in partnership with Dr. Teri Rofkar, a renowned Tlingit weaver. To broaden the conversation around the care of Tlingit basketry within museums, a three-day workshop was organized in April 2017 at the NMAI Cultural Resources Center, to which conservators from institutions with significant Tlingit baskets collections were invited. Conservators from the Winterthur/University of Delaware Program in Art Conservation, the University of Pennsylvania Museum of Archaeology and Anthropology, the American Museum of Natural History, and the NMAI participated. The outcomes of this workshop contributed greatly to the outlined protocol.

3.1 WORKSHOP ON THE CARE AND TREATMENT OF TLINGIT BASKETRY

The workshop began in a round-table format with approximately 30 baskets selected for discussion placed around a table. The baskets included those that had been historically mended, those that had been treated more recently, and historic and contemporary baskets that were unrepaired. This showed a range of conditions and treatments to provide inspiration for the discussions.

The morning of the first day began with introductions and a discussion of the Tlingit baskets in each institution's collection. Each participant contributed institutional knowledge on the treatment and condition of Tlingit baskets, and from this a list of treatments was compiled and divided into native repairs, historic museum treatments, and current or contemporary treatments. It was acknowledged that many of the historic and native repairs aimed to reestablish function, whereas the goal of current conservation practice, and specifically for these damaged baskets, was different. Many of the repairs were found to be overly invasive or damaging in some way, though it was acknowledged that each repair was

Fig. 3a. Detail image showing adjacent rip and tear caused by the strength and shrinkage of the hide glue. Tlingit, *Basket*, undated, spruce root, dyes, and grass, National Museum of the American Indian, 208585.000 (Courtesy of Caitlin Mahony); 3b. Detail of mend that is painted to resemble the weave pattern of the basket. Tlingit, *Tray*, undated, spruce root and dyes, National Museum of the American Indian, 156630.000 (Courtesy of Caitlin Mahony)

likely done with the best intentions, and participants reflected on how they would be judged in the future for their actions.

Goals were established for the workshop: to set a new paradigm for the care and treatment of Tlingit baskets, to activate the broken baskets that have been static in collections, to collect and diffuse information for the Tlingit and conservation communities, and to establish relationships between all parties rather than merely use each other as resources.

The afternoon was spent learning about the harvesting and processing of spruce roots with a hands-on basket twining session. This highlighted scientific and mechanical aspects and allowed the participants to comprehend the skill and time investment of the weavers. It helped them improve their understanding of the basket's structure, the choices the weaver made, and why certain elements looked the way they did.

The second day was dedicated to science. At the outset, the focus was on a technical review of the baskets to investigate what these damaged baskets offer that complete baskets do not. Areas of interest for the conservator and community were discussed. It is of special interest for the Tlingit weavers to know the age of the baskets and where they came from. Samples of archaeological or very old ethnographic spruce root baskets can be carbon dated. Conducting dye analysis on baskets may also be of interest to document the change from natural to synthetic dyes. While sampling is often restricted within museums due to historic oversampling, Teri's perspective was that the fragments from these baskets may be "volunteers" for sampling. The most important question to ask when sampling is what information the analysis is going to give back to the community. The importance and benefit of integrating the native and museum knowledge systems became apparent throughout all the discussions.

The topic then shifted into investigating how technology can be used to document, collect, and disseminate information. After learning from Teri that raw materials for basketry were not traded, the question arose as to whether the spruce roots can be sourced if their elemental profile is compared to those that were collected from a known site. An honest conversation ensued about whether a reliable elemental profile could be achieved with a portable x-ray fluorescence spectrometer (pXRF), an instrument available to Teri in her home community. Foreseen issues with using this instrument in this way were discussed, including: the inherent variability in organic material; the effects that age, dirt, residues, and preparation of the materials would have on the resultant spectra; the skepticism around quantification; and the strict protocols required to create reproducibility. However, it was acknowledged that the question was valid and there was value in creating a comparative database that could be combined with other analytical techniques such as scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS).

Additionally, spectrophotometry and colorimetry were discussed as possible methods of measurement of the darkness of the roots. This would effectively record the extent of tannin oxidation and the preservation or loss of dye vibrancy. In conjunction with this data, there is the possibility of using photogrammetry techniques to document the shape and surface texture of the basket and then possibly 3D-print baskets or digitally reconstruct them to appear as they would have originally.

Finally, the aspect of dissemination or diffusion of knowledge came to the forefront of the science discussion. Workshop participants came up with the idea of gathering the information about the baskets (i.e., the scans, the reconstructions, the images, and the technical information) and loading them onto tablets so they can be accessible to communities that are far removed from them.

4. ESTABLISHING THE PROTOCOL

The final day of the workshop brought together all the concepts produced over the three days. A path forward was set, creating a protocol for the care of these baskets that also established access to these

Fig. 4a. Image of a basket in its current condition with darkened spruce root, painted fabric mends, and faded dyes. Tlingit *Basket* (NMAI 208585.000) (Courtesy of Caitlin Mahony); 4b. Digital reconstruction of the basket in figure 4a as it may have originally appeared before the roots darkened, the historic mends were applied, and the dyes faded (Courtesy of Laurie Stepp)

baskets for the Tlingit weaving community. A select group of baskets has already been used to test and demonstrate the protocol of care, which is described in the following sections.

4.1 DOCUMENTATION

As with every conservation treatment, the treatment of these baskets begins with extensive documentation. The materials, manufacturing techniques, and condition are documented. If necessary, the condition is annotated in images to show locations of rips, tears, and historic fabric mends.

4.2 ANALYSIS

As part of the overall investigation, analysis is being used to identify the historic repair materials and supplement catalog information. UV-Vis was successful in identifying the historic adhesive on the baskets (fig. 5). Thus far, 10 out of 11 analyzed baskets were found to have hide glue. FTIR has been conducted to confirm these identifications. It also identified the paint on one basket as a mixture of linseed oil and lead white.

4.3 CONSULTATION

The treatment undertaken for each of these baskets aims to establish structural stability and to remove inappropriate repairs to prevent further damage. It is tailored on a case-by-case basis taking into consideration what will be gained vs. what will be lost. Prior to treatment, a member of the community is consulted to provide information that will guide the treatment approach and enhance object interpretation. This information will confirm or correct documentation for each object. For example, the catalog information for these baskets lists bear grass as the material used for the wrapped wefts. However,

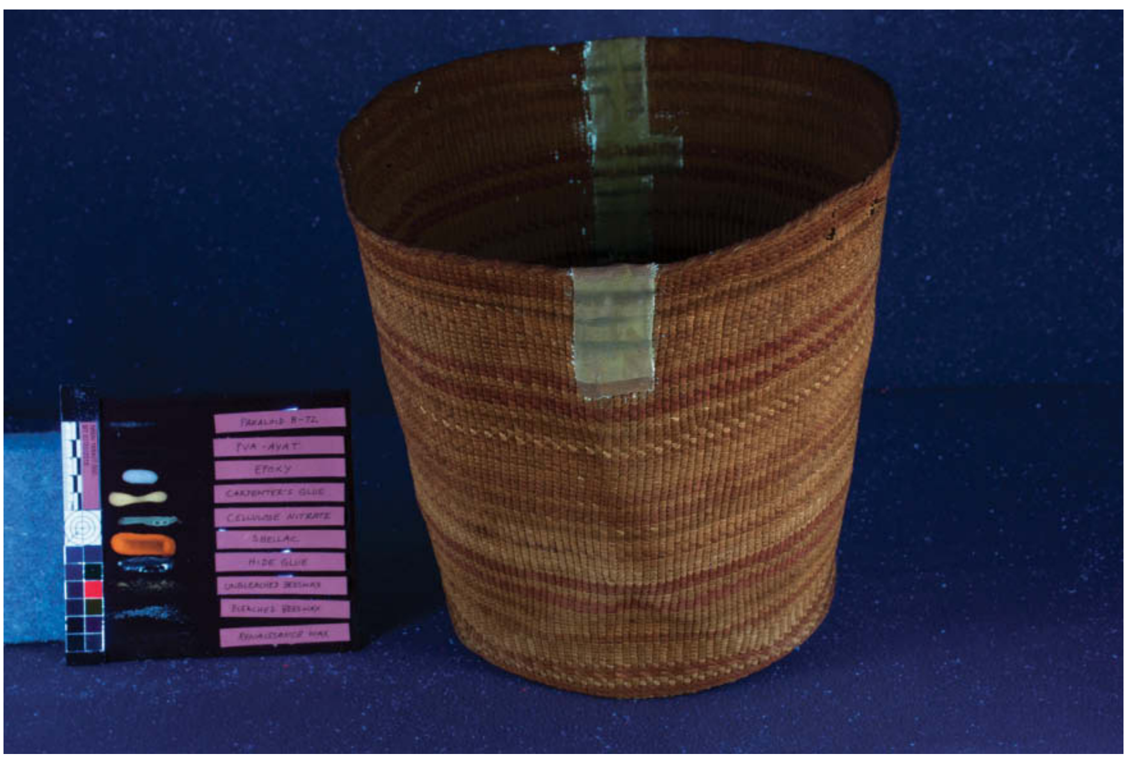

Fig. 5. Image of basket under longwave ultraviolet radiation showing visible fluorescence of the hide glue under the fabric. Tlingit, *Basket*, undated, spruce root, embroidery thread, and dyes, 28.5 x 34.1 x 24.1 cm, National Museum of the American Indian, 168407.000 (Courtesy of Caitlin Mahony)

bear grass is not available in that part of Alaska and would not have been used for any of these baskets. Consultation has altered the proposed course of treatment for one of the selected baskets thus far. This basket had a hole in the structure due to lost warps and weft. In consultation, it was suggested that the damage was providing a portal into the structure that would be otherwise concealed; thus, information about the weaving process was revealed. This information could be used by Native weavers viewing the basket. With this insight in mind, the area was stabilized through a treatment that addressed the adjacent warps and wefts without filling the area, which would have been a likely treatment. In this project, it is recognized that cultural values may be more important than physical integrity in some cases.

4.4 EXPERIMENTATION

Each stage of these treatments is designed and tested prior to application. For the taking down of the hide glue mends, there has already been success. Thanks to the UCLA/Getty Conservation Program that donated deaccessioned fragments from their study collection to this project, hide glue mends were recreated on aged Tlingit basketry.

Over the years, individual baskets have been treated at the NMAI with varied success. Water is the clear choice to solubilize the hide glue, but in each instance, brush application caused tide lines or blanching. The idea came about to use a gel to slowly introduce water to a specific location to soften the hide glue instead of solubilizing the glue and driving it into the structure.

Agarose gel was already available in the lab, having been used in stain removal treatments on textiles. Agarose is the nonionic, natural polymer component of agar, which is extracted from red sea algae. It is non-proprietary and is readily available in powder form from chemical suppliers (Warda et al. 2007). The gel is formed by adding to boiling water or by adding the powder to water and then heating, making sure the solution exceeds 85°C, the temperature required to achieve gelation. The water-based solution can have calcium or sodium hydroxide added to adjust the pH. Other solvents such as acetone or ethanol can be added, as can surfactants, bleaching agents, and enzymes. Agarose gel, or the less pure agar (also known as agar-agar), has gained recent popularity in multiple aspects of conservation as a way to slowly introduce solvents for cleaning, bleaching, removing old repair material and stains, and for humidification (Warda et al. 2007; Scott 2012).

During initial testing, the agarose gel achieved the qualities required; i.e., it effectively softened the adhesive enough for mechanical removal without creating tidelines. Furthermore, it did not have negative effects on the dyes, and it was easy to apply and control. With these encouraging results, it was selected for the treatment.

4.5 TREATMENT

The treatment that has been most successful on the baskets thus far is as follows: after dry-cleaning the surface with polyurethane cosmetic sponges, soft-bristle brushes, and low-suction HEPA vacuuming, agarose gel is applied to the mends that are approved to be taken down. A 2 % (w/v) solution of agarose gel is made in small batches to avoid molding. Each week a new batch is made by adding the powder to room-temperature deionized water and heating it on a hot plate until it reaches a temperature just above 85°C. It has been found that too high a temperature dries the gel out significantly and too low a temperature creates problems with cohesion. A rigid plastic tray is used as a gel mold; it is wiped with ethanol immediately before the gel is added to inhibit mold growth. Once the solution is heated to proper temperature, it is poured into a tray until it is about 3 mm thick, because at this thickness, the gel was flexible yet sturdy enough for handling and adjusting. The tray with the gel is kept in a polyethylene bag to help the gel keep its moisture content. When placed in the refrigerator at the end of the day, the gel tends to last through the week before it shows signs of mold.

Once set and cooled, the gel is placed directly on the fabric strip of the historic mend, or when it has been removed, directly on the adhesive residues. The area is covered with plastic and weighted enough for the gel to achieve even contact with the surface. The setup is left in place for approximately 45 minutes. The cohesive quality of the gel allows the setup to be repeatedly lifted to access the area and monitor the wetting process.

The gels require no special disposal procedures and can be reused if they are moist and free of adhesive residues. After the glue has softened, the adhesive residues are mechanically removed using wooden skewers, cotton swabs, and Japanese tissue. These are all soft tools so as not to damage the spruce root, which was also softened during the treatment. When using the tools, the direction of the stitches is followed to minimize the risk of damage.

Thus far in the project, five baskets have been cleaned and the fabric mends have been removed. The treatment has been time-intensive and it has proved difficult to reach the inner mends placed around the base. However, as there have been no adverse effects observed, it has been deemed successful.

4.6 ASSESS AESTHETIC REINTEGRATION

Aesthetic reintegration is being highlighted as a separate aspect of the treatment because for each basket, it will be determined through further consultation whether aesthetic reintegration is a necessary or appropriate step. For this group of baskets, the goal is not to prepare them for exhibit; therefore, it is being discussed on an individual basis whether reintegrating the basket visually compromises information about the technology, its use, or another aspect valuable to the community. This decision will consider what will be gained versus lost. For example, upon the removal of a fabric mend on the basket in figure 6a, a dramatic color difference was revealed between the area under the mend that was protected from light and the roots elsewhere on the basket, because the tannins did not oxidize in the protected area to the extent that they did on other areas of the basket. While this is visually distracting, it is valuable information. Likewise in figure 6b, the removal of the mend showed the intense colors of the dyes in the break edges, especially the green and purple. The treatments applied will be tailored so that this revealed information is on view rather than concealed.

4.7 HOUSING AND PREVENTIVE CARE

Preventive care is being addressed through different mounting solutions and evaluations of housing for the long term. Housing and mounts should allow visual access to areas that may contribute technical or decorative information, facilitate safe handling, and utilize areas that are inherently the strongest on the basket. Special considerations are being made for exceptionally flared baskets and baskets with weaker bases. They may benefit from storage upside down so that pressure is relocated from the weakened areas to the side walls where bands of wrapped weft decoration reinforce the structure of the basket due to the added layers and the rigidity of the grass and fern material.

4.8 MENTORSHIP

Providing access to these baskets for the Tlingit community is one of the main concerns of the project. To address this goal, the idea was generated during the workshop to start a pilot mentorship program that will use tablets to disseminate information to the community. The idea arose to seek external funding or crowdsourcing for tablets to be loaded with information gathered through this project and left in the community for continued use. The tablets would feature information that would be useful for weavers, including comprehensive images of the baskets and details about size, gauge, scale, materials, and any catalog information.

Taking the aspects of mentorship one step further, Teri has suggested pairing a member of the community with one of these damaged baskets, not to replicate the basket but to draw inspiration from it to create something new. There is precedence for this type of mentorship already. Teri was mentored by a basket in the collection of the University of Pennsylvania Museum of Archaeology and Anthropology that

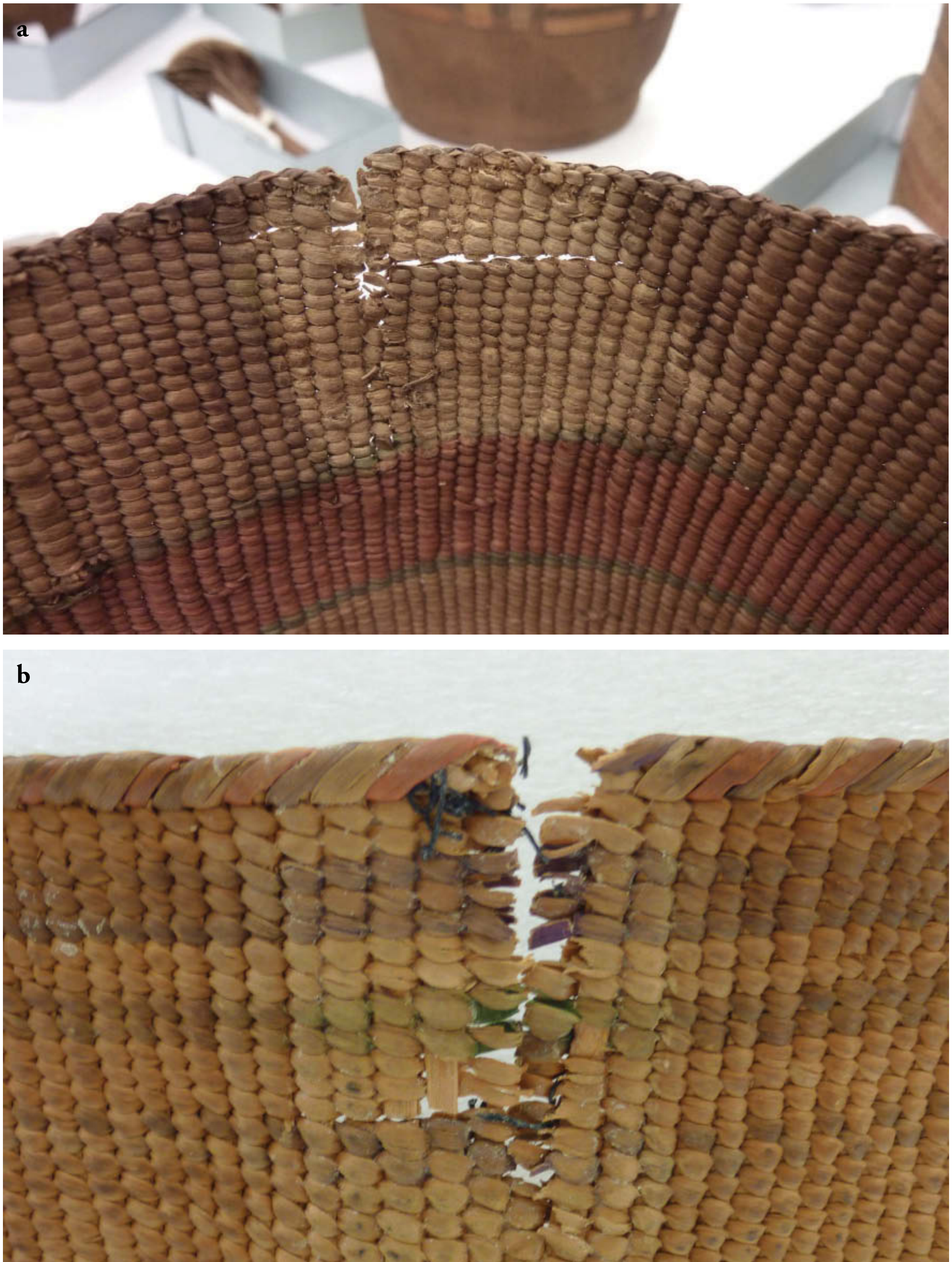

Fig. 6a. Detail of basket where removal of fabric mend showed the extent of tannin oxidation on the basket. Tlingit, *Basket*, undated, spruce root, dyes, and grass, 22.7 x 22.0 x 17.2 cm, National Museum of the American Indian, 218838.000 (Courtesy of Caitlin Mahony); 6b. Detail of basket where intense dyes were preserved within the break edge. Tlingit, *Basket*, undated, spruce root, embroidery thread, and dyes, 28.5 x 34.1 x 24.1 cm, National Museum of the American Indian, 168407.000 (Courtesy of Caitlin Mahony)

was collected in 1905. She made a similar replica based on the technique and patterning. While this aspect has not yet been implemented, it is a priority for the future of this project.

5. FUTURE ASPECTS

This project is part of a two-year Mellon Fellowship research project. Due to time constraints, one of the goals was to outline actions that participants in the workshop and the next NMAI Andrew W. Mellon fellow may take up this project can take in the future. These include:

- Continued collaboration between participants of the workshop and opening it to other institutions
- Shared database and information
- Dye analysis by students at Winterthur/University of Delaware Program in Art Conservation
- Mentorship possibilities at University of Pennsylvania Museum of Archaeology and Anthropology and American Museum of Natural History
- Connecting communities with baskets in these institutions and supporting weavers through commissions

6. CONCLUSION

There are several distinct aspects of this project to highlight.

- **Resource vs. relationship**

This project has made a conscious effort to acknowledge the relationships built during the process. Relationships have formed between conservators, between conservator and basket, between the museum and the native community, and between the baskets and the community. At the base of this acknowledgement comes the distinction between resources and relationship that needs to be considered in interactions with communities.

- **Reactivating collections**

Due to their poor condition, these baskets have been passively sitting on the shelves in storage. The collection of Tlingit baskets is large enough that these damaged baskets would not typically be selected for exhibition over those that are more stable. Through this collaboration, the role of these baskets has been redefined. Their damaged state has been viewed as an opportunity to discover aspects about the structure, material, and technique that would not be available in whole baskets. By connecting the baskets to the Tlingit community, they become active again as mentors. This idea can be applied to material in a variety of institutions.

- **Integrating knowledge systems**

The success of this project was due to the seamless integration of knowledge systems between native and non-native expertise. As a Tlingit weaver, Teri's knowledge of the science and art embodied by these baskets provides vital insights into the function and aesthetic of many of the basket features. When this information is combined with the contributions of a conservator on analysis, condition, and acute observation, the full picture of the basket—the tangible and non-tangible aspects—are fully developed and acknowledged.

- **Support continuance of culture through commissions**

One aim of this project is to stabilize and preserve the baskets for the future; however, an equally important aspect is to contribute to the preservation of the weaving tradition in the Tlingit community.

In addition to connecting the community to the baskets, institutions can also support weavers through the commission of new baskets inspired by damaged baskets that are their mentors.

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NOTES

1. Frances Paul wrote Spruce Root Basketry of the Alaska Tlingit in 1944. She was the wife of a Tlingit man, William Paul, a lawyer from Tongass who fought for the voting rights of the Tlingit people. She wrote a few books on Tlingit culture and cultural material. According to Paul (1991), the Legend of the Origin of Basketry is as follows:

   "In those days a certain woman who lived in a cloud village had a beautiful daughter of marriageable age. She was greatly desired by all mortals and many came seeking to mate with her. But their wooing was in vain. At last it chanced that the eyes of the Sun rested with desire upon the maiden and at the end of his day's travel across the sky he took upon himself the form of a man and sought her for his wife.

   "Long years they lived together in the Sky-land and many children came to them. But these children were of the Earth-world like their mother and not of the Spirit-world of their father, Ga-gahn. One day as the mother sat watching her children frolicking in the fields of the Sun-land, her mind filled with anxiety over their future, she plucked some roots and began idly to plait them together in the shape of a basket. Her husband, the Sun, had divined her fears and perplexities. So he took the basket which she had unknowingly made and increased its size until it was large enough to hold the mother and her eight children. In it they were lowered to their homeland, the Earth. Their great basket settled near Yakutat on the Alsek River, and that is the reason that the first baskets in southeastern Alaska were made by Yakutat women. (9)"

2. There is not one type of basket that is solely for berries. When the berries were ripe, all baskets were berry baskets.

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SOURCE OF MATERIAL

Agarose LE

Benchmark Scientific, Inc.
PO Box 709
Edison, NJ 08818
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TERI ROFKAR was a Tlingit daughter of Raven from the Snail House (T'akdeintaan), a clan originating in Lituya Bay (Ltu.a`a), related closely to the Coho (L'uknax.a`di) clan. She was the daughter of an Englishman from California and granddaughter of the Kaagwaantaan Wolf of Ground Hogs Bay, Alaska. She was introduced to Tlingit weaving by her grandmother when she was a child. During her art career she received numerous awards—the NEA Heritage Fellowship, the highest honor for Traditional arts; recognized as a "Living Cultural Treasure" in 2009; membership in the United States Artists Fellowship Inaugural class in 2006; the Buffet Indigenous Leadership award in 2004; the Alaska Governors Award for Alaska Native Art in 2004; and the Rasmuson Distinguished Artist Award for 2013. Teri passed away in late 2016. In 2017, her legacy was honored through the Special Recognition for Allied Professionals Award given posthumously by the American Institute for Conservation of Historic and Artistic Works.

ENCOUNTERING THE UNEXPECTED IN SOUTHEAST ASIAN LACQUER: TREATING THE DORIS DUKE COLLECTION AT THE WALTERS ART MUSEUM

STEPHANIE HULMAN, MEG LOEW CRAFT, GLENN GATES, HERANT P. KHANJIAN, AND MICHAEL R. SCHILLING

In 2002, the Walters Art Museum received a gift of 150 objects of Southeast Asian Art. Many of the objects originated from Thailand and Myanmar (formerly Burma) and were created in the 19th century. In 2014, the Department of Conservation and Technical Research embarked on a three-year grant from the Institute of Museum and Library Services to treat the objects that were previously identified as conservation priorities. These objects exhibited varying degrees of deterioration due to age, flood damage, and prior intervention. Many of the lacquered and gilded surfaces were actively flaking, and a majority of the objects were covered in an unusual sticky brown coating that was eventually identified as modern. Additional information was collected about the decorative surfaces with a variety of analytical techniques. Once treatment work began, it was readily apparent that Southeast Asian lacquer behaves differently than East Asian lacquer. The largest issues involved solvent sensitivity as it relates to consolidation and cleaning. Questions regarding the visual reintegration of loss were addressed through research travel to Thailand and Myanmar and collaboration with curators. It is hoped that the information gained from this project will be a catalyst for future research and study regarding the treatment of Southeast Asian lacquered objects.

KEYWORDS: Southeast Asia, Lacquer, Cross section, Py-GC/MS, XRF, FTIR, Gel

1. INTRODUCTION

Doris Duke (1912-1993) was the American heiress of a large tobacco and energy fortune. During her lifetime, she had numerous estates and amassed a large collection of antiques and fine art from all over the world. On her around-the-world honeymoon in 1935, she traveled to Bangkok and other parts of Asia and started to collect Southeast Asian antiques. From the 1950s through the 1970s, she made the bulk of her purchases through an antiques dealer named François Duhau de Bérenx. At the time, she was the only active Western collector outside of Thailand with an interest in objects of this type and caliber (Tingley 2003). Much of her Southeast Asian art collection was stored at Shangri La, her estate in Hawaii where she planned to build a Thai Village to display the objects and paintings. She was unable to find an appropriate location for the Thai Village in Hawaii, however, and her collection was eventually moved to her estate in New Jersey, called *Duke Farms*. She started construction of the Thai Village in New Jersey, but it was not completed before she passed away in 1993. In 1999, Hurricane Floyd struck the East Coast of the United States, causing significant flooding at Duke Farms that damaged many of the objects, especially those that were stored on her indoor tennis court.

In 2002, the Walters Art Museum received a significant portion of her Southeast Asian collection as a gift from the Doris Duke Charitable Foundation. Other pieces were given to the Asian Art Museum in San Francisco, and some were sold at auction (Christie's New York 2004). Following the completion of an Institute of Museum and Library Services (IMLS)-funded survey of the collection in 2012, objects that were ranked as both conservation and curatorial priorities were brought from off-site storage to the Walters for treatment. Many of these objects were decorated with Southeast Asian lacquer and gold leaf that was actively flaking and had also been covered with a sticky orange-brown coating.

Given the large size of many of the objects and the limited space within the conservation laboratories, it was decided that the conservation treatment would be completed in the galleries in view of the public. Although this location would provide the unique opportunity for visitors to view the work of conservators, it also created challenges in terms of the selection of materials for cleaning and consolidation. Ventilation was limited to portable fume extractors, and the noise of the extractors made it

Fig. 1. Public conservation space with objects from the Doris Duke Collection of Southeast Asian Art (Courtesy of Ariel O'Connor)

difficult for the conservators to speak to visitors. The extended use of solvents was therefore limited to days and times when the conservation space was not open to the public. Due to these restrictions, as well as the needs of the objects, water-based treatment systems were favored for cleaning and coating removal when possible. Similarly, consolidation with solvent-based adhesives was not completed in view of the public. To date, more than 6500 visitors have watched the Doris Duke Collection conservation project and have responded very positively to the opportunity to view conservation work in progress (fig. 1).

2. SOUTHEAST ASIAN LACQUER

In recent years, researchers at the Getty Conservation Institute and the J. Paul Getty Museum have made significant contributions to the study and analysis of Asian lacquer. An expert system developed for interpreting test results of Asian lacquers from thermally assisted hydrolysis and methylation with pyrolysis-gas chromatography/mass spectrometry (THM-Py-GC/MS) makes it possible to identify a wide range of raw materials and additives. The system relies on AMDIS (Automated Mass Spectral Deconvolution and Identification System), a freeware program developed by the National Institute of Standards and Technology (NIST), to identify marker compounds in pyrograms using a library compiled from in-house and published studies of reference samples. A custom Excel workbook organizes the marker compound results in the AMDIS report and displays sorted information in diagnostic graphs that aid in artists' material identification (Schilling et al. 2016). A procedure developed for microexcavation of lacquer cross sections makes it possible to analyze the materials in individual layers. Their studies have drawn attention to the fact that although there are three main species of lacquer trees with different growing regions, commercial trading of raw materials to other regions broadened the range of availability (Heginbotham and Schilling 2011).

Fig. 2. Drying cellar at Mya Thit Sar Lacquerware Shop in Bagan, Myanmar (Courtesy of Stephanie Hulman)

Southeast Asian lacquer trees grow in Thailand and Myanmar, although the main source of lacquer today is the Shan State of Myanmar (Fraser-Lu 2000). Southeast Asian lacquer comes from the *Melanorrhoea usitata* tree and is known as *thitsi*. The lacquer is harvested by cutting "v"-shaped notches into the bark of the tree, and the sap drips out of a bamboo spout. When the lacquer sap first comes out of the tree, it is milky white in color, but it turns black upon exposure to the air and sunlight (Journal of the Royal Society of Arts 1919). Therefore, Southeast Asian lacquer is naturally black without the addition of pigment, and the richness of the black color is noted as a unique characteristic of Southeast Asian lacquer (Honda et al. 2007).

Lacquer that is being used in Southeast Asia today has numerous other additives because the raw lacquer sap is so expensive (Simatrang 2002). There are some references to historic lacquerware techniques in Southeast Asia from the British Colonial period, but there is also confusion about how closely modern and historic methods relate. Consequently, part of this project involved visiting the region and making connections with people familiar with the industry. There are some general principles of Southeast Asian lacquerware production that are consistent with both historic and modern descriptions, the first of which is the manufacture of *thayo*, or bulked lacquer (referred to as *smook* in Thailand). Bone ash, teak wood sawdust, or burnt organic material such as rice husk and cow dung are added to raw lacquer to create a thick putty. This thicker lacquer layer is applied on top of a substrate (usually wood or bamboo) to create a smooth surface (Yoe 1896). It is applied by hand and allowed to dry in an underground cellar for five to seven days depending on the weather, as high RH is required (fig. 2).

Multiple bulked lacquer layers are sometimes applied, and the layers are polished in between applications with a variety of abrasive materials. Some round objects are turned on a wheel for this smoothing process (Fraser-Lu 2000). The drying time for the preparatory layers alone can take months, which is much longer than Japanese and Chinese lacquer and has been noted as one of the main disadvantages of Southeast Asian lacquer (Honda et al. 2007). Multiple recent studies focus on methods for altering thitsi lacquer to reduce the drying time. These studies also clarify the chemical differences between the various types of lacquer (Tun and Lwin 2001). It remains uncertain as to whether these alteration methods will be adopted by craftspeople in the near future or how the changes would affect the aging properties of Southeast Asian lacquer.

While current practice includes the application of multiple finishing layers of lacquer for fine pieces, cross section analysis of samples from the Walters' 19th century objects does not indicate more than one or two. It is unclear whether this discrepancy is the result of a change in working methods or the inability to distinguish the number of layers because of the polishing steps. Cross section analysis of modern lacquerware samples with a known production method would help to answer these questions. There is also conflicting information regarding the inclusion of diluents in the upper lacquer layers. Some accounts of modern lacquer production do not mention any additives in the final layers (Isaacs and Blurton 2000). Other modern descriptions indicate that it can be difficult to create smooth coatings with Southeast Asian lacquer, which necessitates the addition of other ingredients like wood oil and drying oil (Heginbotham and Schilling 2011). Historic descriptions of Burmese lacquerware production also mention the addition of *wood oil*, but this term is also sometimes used to refer to the lacquer itself. In both modern and historic accounts, lacquer is also sometimes referred to as varnish, and *shansi* (tung oil) is sometimes described as wood oil. Additional scientific analysis of historic samples and modern reference materials would help to answer many of these questions. There is also the possibility that artists were using whatever materials were on hand, which could account for the differences within historic and contemporary descriptions.

The application of gold decoration on lacquer appears to be fairly well understood historically, and the practice does not significantly differ today. The technique is referred to as *lai rot nam* in Thailand and *shwe-zawa* in Myanmar. For patterned gilded designs, areas that are to remain black are painted with a water-soluble pigmented gum resist, then gold leaf is applied over the entire surface while the exposed lacquer design is still tacky (fig. 3).

Once the gold is applied and the lacquer dries, the entire surface is washed with water, which removes the water-soluble gum along with the gold leaf on top (Isaacs and Blurton 2000). Some

Fig. 3. Shwe-zawa process demonstrated at the Lacquerware Museum in Bagan, Myanmar (Courtesy of Stephanie Hulman)

historic accounts describe the application of a varnish over the decorative surface, but that was not described by current artisans. Examination of objects in the Walters collection indicates that the patterned gilded surfaces were originally uncoated. The significant abrasion of the gilding on many pieces in other Southeast Asian collections also indicates that no protective coating was applied. There are descriptions of the addition of sesame oil or shansi (tung oil) to ungilded lacquered surfaces for added sheen, but there was no mention of a final surface coating application in modern workshops (Journal of the Royal Society of Arts 1919). There also seems to be some confusion about whether or not it is possible to achieve a clear coating of Southeast Asian lacquer, or if the clear coating would have been made of another material. Unlike Japanese lacquer that is processed to create a clear coating, current and historic accounts of the industry do not mention the purification of raw Southeast Asian lacquer sap other than straining out debris. Henry Burney's historic account of lacquerware production in Ava (Burney 1834) says that there is no form of clear Burmese lacquer, only a semitransparent mixture of 3:10 shansi (tung oil) to thitsi. Conversely, a modern interview of a Thai lacquer craftsman reported that the pieces were finished with a final clear coat of lacquer (Nilvilai 2000). It is uncertain if this confusion is the result of the translations of words like clear, lacquer, and varnish, or if a clear coating was achieved by the mixture of lacquer with another material. Modern workshops use a small amount of lacquer mixed with tung oil for the application of pigmented lacquer, which could perhaps be used as a clear coating (Fraser-Lu 2000). There are also descriptions of tung oil mixed with sesame oil in a ratio of 1:3 to protect the carved and colored lacquer surfaces and provide added sheen (Htun 2013).

Once Southeast Asian lacquer dries, it has slightly different properties than other types of lacquer, including greater flexibility. Interestingly, the composition of the Burmese lacquer sap is not very different from Japanese lacquer sap in terms of the proportions of water, plant gum, glycoprotein, laccase enzyme, and polyphenol (Wang et al. 2014). The main differences lie in the chemical structures of the polyphenols (specifically catechols). Thitsiol contains significant amounts of alkylphenyl catechols, which are absent in urushiol and laccol and affect the polymerization of the lacquer. Prolonged exposure to polar solvents such as ethanol and acetone during consolidation tests at the Walters caused the lacquer layers to deform upon drying. Some sensitivity to xylene was also noted. The differences in the behavior of the dried lacquer layer in terms of increased flexibility and sensitivity to a wide range of solvents could also be related to the additives that are sometimes described as part of the production process.

3. ANALYSIS

A variety of analytical methods were used to examine these objects with the help of the conservation science departments at both the Walters Art Museum and the Getty Conservation Institute. In general, the materials that were identified were consistent with those described in period accounts of lacquer production in Southeast Asia with the exception of the surface coating, which is likely a mid-20th century addition.

3.1 UV EXAMINATION

The most important aspect of the examination in longwave (365 nm) ultraviolet radiation (UV) was the appearance of the surface coating before and after cleaning. The surfaces were constantly examined in UV during cleaning to assess how much of the coating was removed, and also to identify areas where multiple coatings were present. The autofluorescence color of the surface coating ranged from yellow to green, and in some areas fluorescence was suppressed due to dirt that was trapped in the coating (fig. 4).

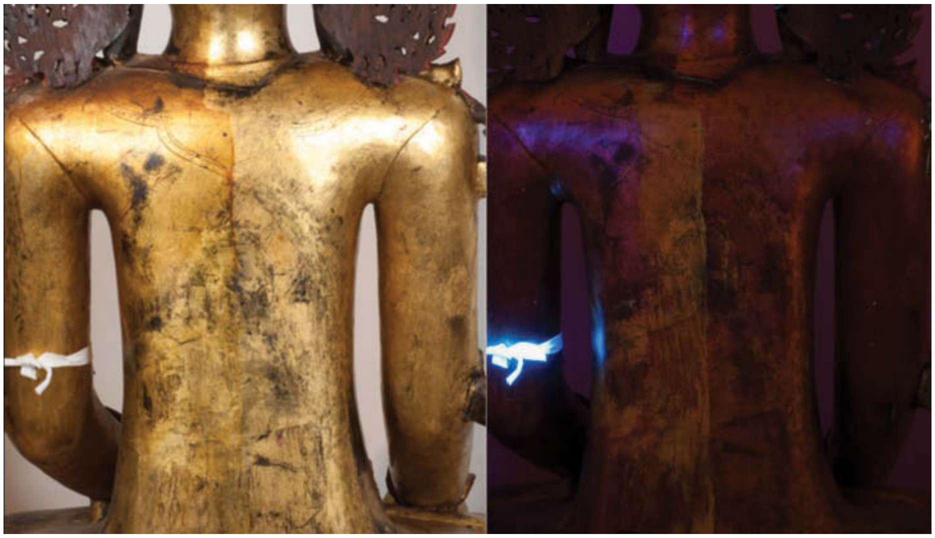

Fig. 4. During cleaning comparison of normal light versus longwave UV-induced visible fluorescence of the modern surface coating. *Seated Buddha*, 19th century, dry lacquer, wood, gold leaf, mirrored glass, red and black lacquer, 181.5 × 120 × 60 cm, The Walters Art Museum, 25.232 (Courtesy of Gregory Bailey)

3.2 CROSS SECTION ANALYSIS

In general, the objects were found to have multiple thick layers of bulked lacquer, followed by thinner layers of fine lacquer. In some instances, red pigments were added to these underlying fine lacquer layers, while others were unpigmented. Gold leaf was applied directly to the lacquer while still tacky, and there were some samples with multiple layers of gold leaf that may have been applied during a restoration campaign or possibly by practicing Buddhists who wished to earn merit (fig. 5).

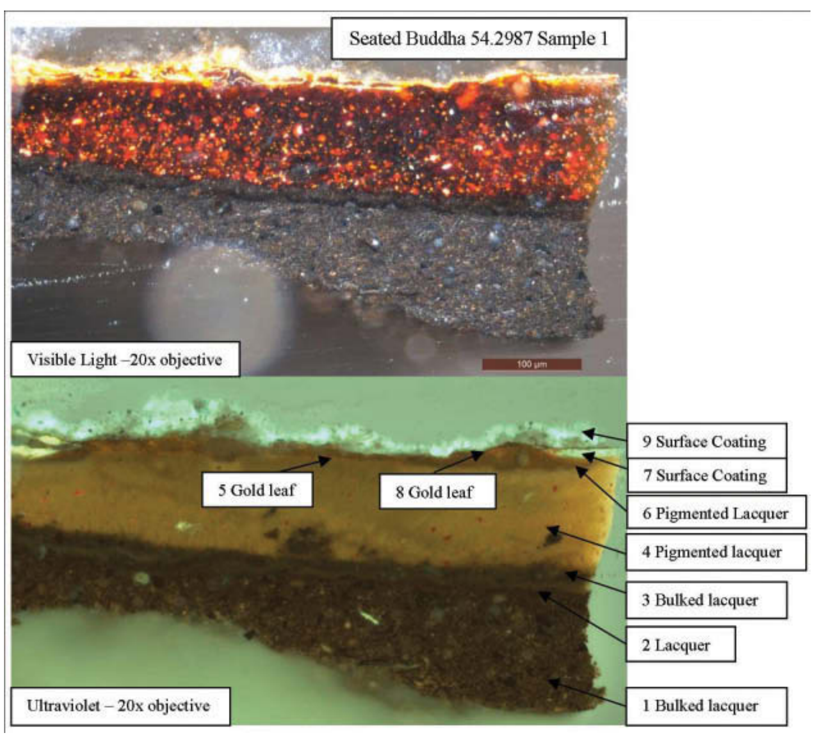

Fig. 5. Sample from the seated Buddha (54.2987). Multiple gilding layers are visible, as well as fluorescent surface coatings (Courtesy of Stephanie Hulman)

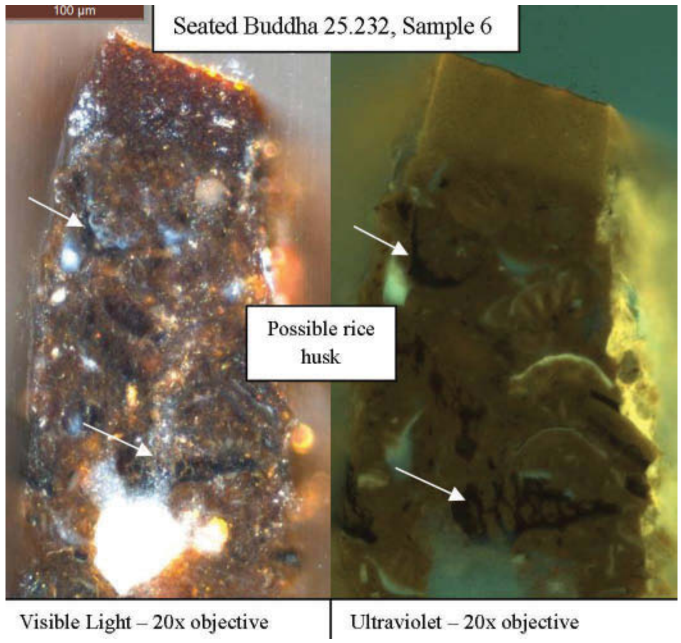

Fig. 6. Sample from the dry lacquer seated Buddha (25.232), multiple bulked lacquer layers with coarse filler materials (Courtesy of Stephanie Hulman)

The cross section samples also show the presence of surface coatings, sometimes more than one. In some of the bulked lacquer layers, the filler appeared similar to plant material, such as rice husks (fig. 6).

3.3 ELEMENTAL INFORMATION

The primary use of XRF was to confirm the presence of gold in the metallic leaf and identify the metal substrate on some of the objects. The two metal Buddha sculptures were found to have copper and zinc components, indicating brass. The metal leaf on these surfaces was found to contain mostly gold with some copper. In addition, the metallic backing on the mirror pieces for the standing Buddha (54.3000) was found to contain lead and tin, and the red pigment on the seated Buddha (54.2987) contained mercury (associated with vermilion—HgS). (See the appendix for equipment and collection information.)

3.4 LACQUER ANALYSIS

Tests at the Getty Conservation Institute revealed the presence of thitsi lacquer and a drying oil in samples of the upper lacquer layers from the seated Buddha (54.2987). The presence of characteristic phenyl catechols confirmed thitsi lacquer, which comes from the *Melanorrhoea usitata* tree of the Anacardiaceae family. Perilla oil was also identified in these layers, which has a palmitic/stearic acid ratio of about 2.4. The bulked lacquer layer contains thitsi with a small amount of drying oil and a material with high saturated fatty acid content like a nondrying fat or lipid. Period recipes call for the addition of vegetable oils to later lacquer layers and pigmented layers, but the addition of nondrying oils to bulked lacquer is not mentioned (Burney 1834). It remains uncertain as to which oil was used in this instance and why it was used.

3.5 SURFACE COATING ANALYSIS

Since so many of the objects in the Duke Collection were covered in the sticky brown surface coating, it was important to determine its composition. The composition of the coating would affect decisions about its possible removal, as well as ways to remove it safely. Samples of the coating were

Fig. 7. Surface coating sample location from the seated Buddha (54.2987) (Courtesy of Ariel O'Connor)

removed from six objects in the collection and analyzed by GC/MS at the Walters following derivatization with MethPrep II using the method devised by the Getty Conservation Institute (Schilling and Keeney 2003) (fig. 7).

The results showed a drying oil and also a phthalate—likely dioctyl phthalate. Although dioctyl phthalate was commonly used as a plasticizer in the 20th century, there is also information regarding the inclusion of dioctyl phthalate in agarwood (or eaglewood):

> Agarwood is a known aromatic from Southeast Asia that is used in culturally significant practices. Agarwood exudes a sap rich in dioctyl phthalate when the tree is tapped; the tapped tree exudates also contain sesquiterpenes (aristolene). No sesquiterpenes have yet to be identified in the coating samples from the objects. However, agarwood essential oil is expensive and imitations or counterfeits can contain up to 100% dioctyl phthalate. (Gates 2015, 19)

In addition to the results of the coating analysis indicating a modern plasticizer, numerous objects in the Duke Collection were covered in this coating, including objects that were not used as part of religious ceremonies. It is likely that the coating was applied to either protect the surfaces or act as a consolidant, and it is unlikely that the coating was added for ritual purposes while the objects were in use in Southeast Asia, justifying its removal.

4. CASE STUDIES

Although many objects were treated during the course of the IMLS grant, the five that are highlighted here represent different substrates and decoration techniques and also illustrate the various approaches to treatment and object interpretation.

4.1 LARGE SEATED BUDDHA (25.232)

This dry lacquer seated Buddha was likely made in the Shan State of Myanmar and may date to the 18th or 19th century (fig. 8).

Fig. 8. Dry lacquer seated Buddha before treatment (25.232) (Courtesy of Gregory Bailey)

The figure is just under 1.8 m tall and 1.2 m wide. The main body of the figure was made by applying multiple layers of lacquer on top of a clay core. The first lacquer layers were bulked with fill materials, and progressively finer layers of lacquer were applied to create a smooth surface. Once the lacquer was dry, the clay core was removed, leaving a hollow sculpture (Isaacs and Blurton 2000). The raised ornament on the Buddha is made of bulked lacquer. While the lacquer surface was still tacky, a very thin layer of gold leaf was applied to much of the surface. Some areas, such as the base, are highlighted with red lacquer as well. The garments are ornamented with pieces of colored and mirrored glass, and fibrous material is visible behind the glass pieces. These fibers may be remnants of the paper backing that is described as part of the production method for the glass pieces (Tilly 1901). The flames that adorn the ears, shoulders, elbows, and knees are made of wood, and some are visually obvious replacement pieces. The Buddha's finial is made of a solid piece of wood and may have been replaced as well.

The Buddha figure was significantly damaged in the past and has undergone multiple restorations. At one point, the Buddha was broken into many pieces and reassembled using traditional materials including lacquer, thayo, and gold leaf, and some of those repairs had failed. The replacement pieces were also made using traditional materials, although the wood carving is not as fine and many of the glass pieces are highly reflective and do not appear to be backed with the same material as the original. The thin gilded surface was significantly abraded on the face, hands, and feet. New cracks had formed at the base, especially around nails that went into an interior wooden support that was added later. Similar cracks were noted on a dry lacquer Buddha at the British Museum that had completely

Fig. 9. *Thai Seated Buddha*, 19th century, copper alloy, clay core, gold leaf, mirrored glass, red and black lacquer, 70.5 × 53.5 × 48 cm, The Walters Art Museum, 54.2987 (Courtesy of Susan Tobin)

Fig. 10. *Thai Standing Buddha*, late 19th century, copper alloy, gold leaf, mirrored glass, lacquer, 110 × 28.5 × 16 cm, The Walters Art Museum, 54.3000 (Courtesy of Susan Tobin)

broken early in its tenure at the museum (Minney 1994). A dark orange sticky coating had been applied to the majority of the surface and extended over areas of loss and abrasion. Since the coating was still sticky, a significant accumulation of surface dirt within the coating could not be removed by dusting alone. There were also scattered drips of white glue from previous repairs.

4.2 THAI SEATED BUDDHA (54.2987)

The smaller seated Buddha statue from Thailand illustrates the defeat of Mara's army (fig. 9).

Phra Mae Thorani is depicted with water coming from her flowing hair, and heads of soldiers float in the water below. Given the style of ornament and dress, this Buddha may date to the 19th century. The heavily patterned robes would have been covered with mirrored glass pieces. The brass sculpture was created using the lost-wax casting method, and the clay core remains inside to support the very thin casting (0.44 mm in some areas). The metal surface was covered with multiple layers of lacquer, the last of which was used to adhere a thin layer of gold leaf. Although obscured by a heavy layer of dirt and surface coating, horizontal surfaces on the tiered throne are accentuated in red lacquer. This Buddha also shows evidence of previous repair, as areas of lacquer loss were covered in gold leaf without leveling the surface. Like the large seated Buddha (25.232), the Thai Buddha was covered in a visually similar orange-brown sticky coating. A heavy accumulation of dirt was also trapped in the coating. Previous areas of restoration with brass paint had darkened.

4.3 THAI STANDING BUDDHA (54.3000)

Although likely from the same time period as the Thai seated Buddha (54.2987), the standing Buddha is shown in royal attire with his upraised left hand in the *Abhâya mudrâ* position (fig. 10).

The Buddha was also made using the lost-wax casting method, and the finial was cast as a separate piece. The exposed metal surface in areas of loss is very rough, and deep scratch marks are visible from finishing. The scratch marks would have helped lacquer adhere to the metal surface, and a bulked lacquer layer was necessary to create a smooth surface for gilding. The Buddha retains many of its mirrored glass inserts that were attached with bulked lacquer.

The most significant condition issue was flaking lacquer on both the front and back. The back had already suffered a significant amount of lacquer loss, and only about 10% of the remaining lacquer was well adhered to the metal surface. The gilded surface had suffered from abrasion, especially on the proper right arm and on the back. The surface was unevenly covered with the same dark sticky coating found on both seated Buddha figures (25.232 and 54.2987). Drip marks were visible, and the largest accumulation of the coating was on the top of the crown and the bottom of the jeweled neckline.

4.4 BURMESE MANUSCRIPT CHEST (65.142)

Doris Duke also collected furnishings that were used as part of Buddhist practice, and this manuscript chest is a wonderful example of the special housings that were created for sacred Buddhist texts. The piece was likely made in Myanmar during the 19th century and is constructed of six large single planks of wood, probably teak (fig. 11).

The front three sides of the chest feature an elaborate scene of the *Bhûridatta Jâtaka*, number 543 in the Pâli-language collection and number six among the last 10 Jâtaka (Woodward 2015). The scene is illustrated in bulked lacquer that was pressed into a mold to form the ornamental patterns and figures, and many of the figures on this chest are repeated. The raised lacquer designs are gilded. Portions of the interior of the chest and trim elements are coated with red lacquer.

Like many of the other objects in the collection, the manuscript chest was covered in the dark orange-brown sticky coating. The coating was especially fluid on this object and could reform and level after a sample was removed. A significant accumulation of dirt was also embedded in the coating on the bottom trim piece. The lid of the chest was covered in dirt and had suffered from water damage. The lid would have originally been covered with red lacquer, but the surface was entirely stripped or sanded at one point in its history. In addition, much of the gilding on the raised ornament was abraded, which created a black and gold color scheme that distracted from the narrative scenes depicted in thayo.

Fig. 11. *Burmese Manuscript Chest*, 19th century, wood, bulked lacquer, red and black lacquer, gold leaf, 63 × 98.5 × 62.5 cm, The Walters Art Museum, 65.142 (Courtesy of Susan Tobin)

4.5 THAI MINIATURE SHRINE (64.183)

The miniature shrine would have been used as part of Buddhist practice in the home of a wealthy individual (fig. 12).

Typically, a small Buddha statue would be placed in the center of the shrine with vases of flowers on either side. The shrine is architecturally similar to many of the temples in Thailand in terms of the roof ornamentation but has a slightly different floor plan and proportion than an actual temple. This piece was created with a different series of surface layers, showing a white filler material, multiple fluorescent coatings, a chrome yellow pigmented layer, and gold leaf on top (fig. 13).

The presence of this yellow layer is unusual, as all of the other gilded objects have dark brown, black, or red surfaces underneath. The hand-carved wooden structure is likely teak. The miniature shrine was also covered in the sticky brown coating, which was exceptionally dirty on the horizontal surfaces. There were numerous broken and missing roof ornaments, some of which had been saved and stored with the object. Although very dirty and heavily coated, the majority of the gilding underneath was intact.

5. TREATMENT

5.1 CONSOLIDATION

The most challenging consolidation treatment was on the Thai standing Buddha (54.3000). Only approximately 10% of the lacquer on the back of the figure was securely attached to the metal surface. Lifting areas projected as far as 0.5 cm from the surface. To further complicate the situation, initial consolidation tests showed that the lacquer was extremely sensitive to polar solvents and even xylene, which was particularly challenging given the extended drying times associated with a metal substrate. The chosen consolidant needed to be soluble in mostly nonpolar solvents, and it needed to have tack so that it could adhere the flakes to the surface quickly due to the vertical orientation of the object. Lascaux

Fig. 12. *Thai Miniature Shrine*, late 19th century, wood, gold leaf, white and yellow ground, 181.5 × 47 × 68.5 cm, The Walters Art Museum, 64.183 (Courtesy of Susan Tobin)

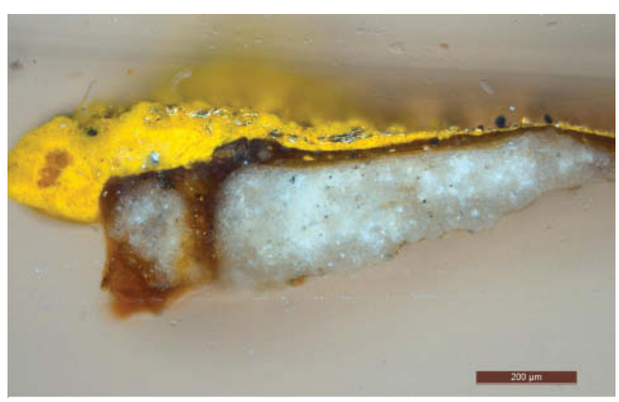

Fig. 13. Cross section sample of miniature shrine decorative surface showing a yellow pigmented layer underneath the gilding (Courtesy of Stephanie Hulman)

P550-40TB (butyl methacrylate resin) was selected for testing in a 10% v/v mixture of xylene in mineral spirits because a slight aromatic component was found to be necessary to dissolve the adhesive. Initial tests in dilute liquid form were unsuccessful because the consolidant ran down the vertical surface and took more than 24 hours to dry completely. To address this issue, sheets of Lascaux P550-40TB were cast and allowed to dry on silicone release Mylar. The thin sheets of cast adhesive were placed behind the flaking lacquer and then reactivated with solvent and some dilute adhesive. The lacquer was still rather flexible, but thicker flakes needed to be relaxed with a heated spatula and pressed into place (no color change was observed due to the introduction of heat). Once the adhesive residues were removed, B-72 Retouching Gels were applied around the thick break edges to avoid snagging and future loss, as the curator did not want the losses completely filled. Adhesive sheets were not necessary on objects with less severe flaking, and the xylene-mineral spirits solvent mixture for the adhesive worked well without causing cockling and distortion of the lacquer surface upon drying (fig. 14).

5.2 SURFACE COATING REMOVAL

The next phase of treatment was removal of the dark and sticky surface coating from the gilded surfaces on many of the objects. On some objects, a water gel was found to remove the majority of the coating in a timely fashion without disturbing the gilded surface. The gel used xanthan gum as the thickener and was adjusted with acetic acid to a pH of 5.0, which is slightly acidic and safer for the lacquered surface underneath the gilding. On surfaces where the gilding layer was thicker and intact like the miniature shrine (64.183), a pH of 6.5 was safe to use. Citric acid was added as a chelator (1%-2% w/v), and Surfonic JL-80X was used as the surfactant (0.4% w/v). In some instances, a small amount of isopropanol was mixed into the gel where the coating was thicker and more difficult to remove. In general, the gel was allowed to sit on the surface for two-and-a-half minutes before clearing with a cotton swab dipped in pH-adjusted water (fig. 15).

Recently, the coating has been safely removed on additional objects by first flooding the surface with octamethylcyclotetrasiloxane (Cyclo-2244 D4 cyclomethicone fluid) and then applying a water gel at a pH of 5.5 with diethylenetriaminepentaacetic acid (DTPA) as a chelating agent (2% w/v) and 2-(*N*-morpholino)ethanesulfonic acid (MES) as a buffer. Benzyl alcohol was added to the gel at roughly

Fig. 14. Standing Buddha (54.3000); view of the back before and after consolidation with Lascaux P550-40TB (Courtesy of Susan Tobin)

Fig. 15. Surface coating removal from the roof of the miniature shrine (64.183) (Courtesy of Stephanie Hulman)

7% w/w until an emulsion forms. The surface was then cleared with a pH 5.5 solution adjusted with acetic acid and ammonium hydroxide. It is important to note that this gel was not safe to use on the red lacquer surfaces and that the use of a silicone solvent as a barrier layer was necessary on the gilded surfaces.

On some objects, such as the small seated Buddha figure (54.2987), a gel was inappropriate given the detailed ornamentation and inability to properly clear the surface. In those instances, a variety of solvents were tested in numerous areas on the object. Acetone was found to be the most effective at removing the coating from gilded surfaces and required the least amount of rubbing. The red lacquer was solvent sensitive, so the entire coating could not be safely removed and a thin layer was left behind. In some areas where the coating was very thick, acetone was applied on a cotton pad and placed on the surface for 30 seconds to one minute. Much of the coating soaked into the cotton pad, which required less use of abrasive swabs. Following solvent cleaning, 2% w/v citric acid in distilled water (pH of 2.0-3.0) was mixed 1:1 with acetone and applied with a swab or cotton pad to remove remaining surface dirt that was trapped underneath the coating. The surface was rinsed with 1:1 ethanol/distilled water to remove the citrate and any additional dirt or coating.

5.3 INPAINTING

Once the surfaces were clean and the lacquer was consolidated, the curator was consulted to determine the extent to which losses would be inpainted. The Thai seated Buddha (54.2987) provided inspiration for the chosen inpainting method, since there were already visible regilding campaigns that were lower than the other surfaces. The curator decided to continue with this aesthetic and not level the areas of loss with fill material. Only the most distracting losses on the objects were addressed, which was consistent with the approach to inpainting that was observed at museums in Thailand and Myanmar. Conversely, religious objects at active temple sites are regularly refinished or completely replaced when new objects are donated. For this project, losses were inpainted with metallic watercolors (fig. 16).

The metallic watercolors are comprised of mica pigments (natural mica particles coated with interference layers of titanium dioxide and/or iron oxide) in a gum arabic binder. Schmincke watercolors were selected because the paint adhered well to the metal surface without easily rubbing off. One benefit of the use of watercolors is that inpainting can be easily removed with water if it ever needs to be redone without disturbing consolidated areas.

5.4 STRUCTURAL LOSS COMPENSATION

The only object that required significant loss compensation was the miniature shrine (64.183). Many of the roof ornaments were missing and needed to be replaced to restore symmetry in some of the more prominent areas. Molds for the replacement pieces were made by forming the shapes out of Plasticine

Fig. 16. Thai standing Buddha (54.3000) losses inpainted with metallic watercolors without filling (Courtesy of Susan Tobin)

Fig. 17. Roof of miniature shrine (64.183) before and after loss compensation (Courtesy of Susan Tobin)

in the area of loss overtop of an isolating piece of plastic wrap. This technique helped to ensure a tight fit given the irregularity of the break edges. Silicone molds were made of the Plasticine pieces, and the actual replacement pieces were cast in dental plaster. The pieces of plaster were soaked in 3% to 5% w/v Paraloid B-72 in acetone for greater strength. Golden acrylic paint was used to match the chrome yellow underlying surface on the object, and Regalrez 1094 varnish was used as a size for the gilding layer. After the majority of the decoration was complete, the pieces were attached to the object with 30% w/v B-72 in 1:1 ethanol/acetone over an isolation layer of Regalrez 1094. The remaining gaps were filled with Modostuc calcium carbonate putty (PVA binder) and inpainted with Schmincke metallic watercolors (fig. 17).

5.5 DIGITAL RECONSTRUCTIONS

A few of the objects in the Duke Collection have significantly abraded gilded surfaces that make the objects difficult to visually understand, most notably the manuscript chest (65.142). The use of a black layer under the gold creates a strong contrast wherever abrasion occurs, which distracts the viewer from the detailed designs of raised lacquer or facial features of the Buddha figures. For some objects, the amount of missing gold would mean a complete regilding campaign, which was not appropriate from a curatorial or conservation perspective. The gilded surfaces on these objects are exceptionally susceptible to abrasion, especially where little gold remains, so it is unlikely that a later gilding layer could ever be removed from the surface without losing more of the original gilding below. To strike a compromise for the manuscript chest and to give visitors a better sense of how the object would have originally appeared, a rendering was created in Photoshop with overlays of red and gold in the appropriate locations (fig. 18).

Fig. 18. Digital reconstruction of the decoration on the manuscript chest (65.142) (Courtesy of Stephanie Hulman)

6. CONCLUSIONS

The information that was collected during the analysis and conservation treatment of these objects has shown that the properties of Southeast Asian (thitsi) lacquered objects vary from their East Asian (urushi) lacquer counterparts. The issues of solvent sensitivity are related to the composition of the lacquer, both in terms of the thitsi and the additives. The methods that were developed to treat these objects worked well, but there may be other adhesives and cleaning methods that work better. It is also important to note that although general trends were observed, each object had a varying range of pH and solvent sensitivity, and extensive testing was necessary. Hopefully, further research will be completed and shared about other Southeast Asian lacquered objects to add to these findings.

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Appendix 1: EQUIPMENT SETTINGS

54.3000 metal surface analyzed with an Elio Device SN605 with a rhodium tube (40 kV, 80µA, 240 s, 12000 cps, no filter). 54.2987 metal surface analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 s, 46412 cps, collimator 1.500, no filter, helium purge). Major elements for both: Cu, Zn. Minor elements for both: Fe, Si, Pb, Sn, Ca, Mn, Ni.

54.3000 gilded surface analyzed with Bruker AXS ARTAX system with a rhodium tube and polycapillary lens (50 kV, 252 µA, 120 seconds, 4128 cps, no filter, helium purge). Major elements: Au, Cu, Fe. Minor elements: Hg, Zn, Ca, Mn, K, Ni, Ba. 54.2987 gilded surface on top of metal surface analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 seconds, 43633 cps, collimator 1.500, no filter, helium purge). Major elements: Au, Cu, Zn. Minor elements: Fe, Mn, Pb, Sn, Ca.

54.3000 metallic backing and glass piece analyzed with an Elio Device SN605 with a rhodium tube (40 kV, 80 µA, 120 seconds, 12,000 cps, no filter). Major elements: Pb, Sn (possibly from glass). Minor elements: Cu, Ca, Zn, Fe, Si, Sr, Ti, Cl, Zn.

54.2987 red lacquer analyzed with a Bruker AXS ARTAX system with a rhodium tube (50 kV, 200 µA, 120 seconds, 20876 cps, collimator 1.500, no filter, helium purge). Major elements: Hg, Cu, Zn. Minor elements: Pb, Fe, Ni, Ti, Ca, Sn, Ba, Mn, Cl, K.

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SOURCES OF MATERIALS

2-(*N*-morpholino)ethanesulfonic acid (MES) hydrate, 99+% for biochemistry
ACROS Organics
500 American Rd.
Morris Plains, NJ 07950-2462
800-ACROS-01
http://www.acros.com

Acetic acid 80% reagent grade
Fisher Scientific
1 Reagent Ln.
Fair Lawn, NJ 07410
201-796-7100
https://www.fishersci.com

Benzyl alcohol
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com

Citric acid monohydrate
Sigma
PO Box 14508
St. Louis, MO 63178
800-325-3010
http://www.sigmaaldrich.com

Diethylenetriaminepentaacetic acid (DTPA)
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Golden Acrylic Paint
Golden Artist Colors Inc.
188 Bell Rd.
New Berlin, NY 13411
607-847-6154
http://www.goldenpaints.com

Lascaux P550-40TB
Alois K. Diethalm
AG, OH 8360
Brüttisellen
Switzerland
+41 1 833 0786
http://lascaux.ch/en/produkte/restauro/index.php

Modostuc
Plasveroi International
Via Camussone 38
27010 Vellezzo Bellini (PV)
Italy
+39 038 292 6896
http://www.plasveroi.it

Octamethylcyclotetrasiloxane (Cyclo-2244 D4 cyclomethicone fluid)
Clearco Products Co. Inc.
3430 G. Progress Dr.
Bensalem, PA 19020
800-533-5823
http://www.clearcoproducts.com

Paraloid B-72
Conservation Resources International LLC
5532 Port Royal Rd.
Springfield, VA 22151
703-321-7730
http://www.conservationresources.com

Plaster-Hydrastone Merlin's Magic
Garreco LLC
P.O. Box 1258
Herber Springs, AR 72543
800-334-1443
http://www.garreco.com

Plasticine Modeling Clay
Flair Leisure Products PLC
Anne Boleyn House
Ewell Rd.
Cheam, Surrey SM3 8BZ
England
+44 0845 456 1775
http://www.flairplc.co.uk

Regalrez 1094
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Silicone Mold Material—Elite Double 8 (vinylpolysiloxane)
Zhermack Technical
Via Bovazecchino
100 45021 Badia Polesine (RO)
Italy
+39 042 559 7611
http://www.zhermack.com

Surfonic JL-80X
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
805-682-9843
http://www.conservationsupportsystems.com

Xanthan gum
The Personal Formulator
97 South Red Willow Rd.
Evanston, WY 82930
307-264-0367
https://www.personalformulator.com

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LOOKING AT GUILLOCHÉ IN CONSERVATION

BRITTANY NICOLE COX AND DAVID LINDOW

Guilloché, also referred to as engine turning, is work produced on a rose engine or straight-line engine. The rose engine was developed in the 16th century but found wide-scale popularity in the early 19th century when Breguet applied the craft to augment his watch dials, cases, and movements; many believe it reached its apex with Fabergé. Conservation methodology for guilloché work appears to be a relatively new subject, and understanding the processes by which an object was made or decorated may be the first stage in development. Little information is widely available on the rose engine, and even less is available on the process by which its patterns are created. In this article, we briefly explore the history of these machines and their various uses through examining the steps required for accomplishing distinct patterns and looking at some of the diverse objects that employ them. The rose engine was employed not only in horology to decorate metal objects of art but also in other media, such as pottery by Josiah Wedgwood and modern plastic injection molding patterns. As these machines were used from the early 16th century into the present, many conservators are likely to encounter objects that were either made or decorated by them.

A link is provided to an additional resource in which the reflective quality of guilloché work along with the effects of oxidation on this property is examined, and through this the various pitfalls in the practice of cleaning and repair are identified. Further, 60 common guilloché patterns are cataloged.

KEYWORDS: Guilloché, Engine turning, Rose engine lathe

1. INTRODUCTION

The rose engine lathe is an enigma to all but a small group of artisans who use it, despite being employed in a broad scope of work from decorative ivories to pottery, clocks, watches, and snuff boxes, as well as glass molds, the printing of stamps and stock certificates, and plastic injection moldings. Although the practice has been so widely used, the techniques employed by these machines are seldom explained in books or other publications. Often the use of the rose engine to decorate an object is not mentioned, even in instances where the machine was used to decorate the entire piece. In conservation, a working knowledge of how an object was made is not only useful but crucial. Given the scant scholarly work on the subject, we endeavor here to scratch the surface and give a brief account of both the machine's history and how it was used, in the hopes of fostering further study. To this end, we conducted a literature review, produced a catalog of 60 common patterns, and prepared and treated 28 metal samples. These samples consist of composition 353 brass, nickel silver, and fine silver. They were treated with common nonconservation-based approaches to show how patterns can be distorted, and to demonstrate the effects of oxidation on the reflective surface. It is our hope that this will spur discussion about how to better treat these highly reflective metal surfaces, as the characteristic flash of guilloché is arguably its most important tangible property.

Guilloché, or engine turning, is a form of mechanical decorative engraving that is found on a variety of materials, such as metals, clay, glass, bone, and wood. The patterns are produced on a rose engine or straight-line machine and can be applied directly to the surface or transferred by use of a mold or other method.

2. HISTORY

The earliest known printed account of turning in English included a description of the rose engine lathe and was written by Joseph Moxon in his book *Mechanick Exercises: Or, the Doctrine of Handy-Works* (1989), originally published in 1683. Moxon had seen the copper engravings of a rose engine used in Fe'libien's *Des Principes de l'Architecture*, published in 1678 (Maurice 1985; Moxon 1989). In 1701, Charles Plumier, a friar and botanist who had been encouraged to take up turning by his father, published a practical book in French dedicated to turning. Plumier's book superseded Moxon's book in usefulness and reigned as "the classic book on turning for 100 years—until Bergeron" (Maurice 1985, 105−106). This was a watershed period for the rose engine, as by the 18th century the "Engine Turner" was almost exclusively the practitioner of the rose engine producing "fine line" work on metal (Matthews 1984, 9). However, to begin this history with Moxon and Plumier is to leave out roughly a century and a half of the machine's use. A *Box in the form of a rose, with a miniature portrait of Anne of Cleves*, ca. 1539, can be seen in the collection of the Victoria and Albert Museum, as seen in figure 1.

The turned portion of the piece is ivory, which was the choice turning material of craftsmen during this period. By the late 16th century, men like Georg Friedel and Jakob Zeller, both from Dresden, were employing the rose engine lathe to turn highly complex compositions (Maurice 1985; Syndram and Scherner 2004; Syndram 2010). One of the largest collections of this type resides at Pitti Palace in Florence; this group of 27 turnings was taken from Coburg, Germany, as spoils during the Thirty Years' War and has remained intact to this day (Piacenti 1989). Although ivory was an exceedingly popular material at this time, wood objects were also turned on the rose engine lathe. Two examples can be seen in the collections of the Victoria and Albert Museum, as shown in figures 2a and 2b.

By the middle of the 17th century, the use of the rose engine lathe had spread across western Europe, and the avocation of rose engine turning remained common among sovereigns until the late 18th century (Maurice 1985). Bergeron published his treatise on turning, *Manuel du Tourneur*, in 1792 and 1796; the world would not see another such instruction manual for almost 200 years (Maurice 1985).

During the 18th century, the rose engine became the tool of the tradesman, and guilloché work on metal became the primary application (Matthews 1984). Despite this, the rose engine's use broadened; decorated objects made from such materials as agate (see http://collections.vam.ac.uk/item/O156317/snuffbox-unknown/), ceramic, pewter (figs. 3a, 3b), and even buttons can be seen.

Josiah Wedgwood introduced engine turned decoration to his ceramics in 1763. Wedgwood would continue to use the rose engine for decoration, as shown in promotional films from the 20th century (see https://www.youtube.com/watch?v=DDDBQh8YpfA). The diverse use of the rose engine

Fig. 1. Hans Holbein and unknown artist, *Box in the form of a rose with a miniature portrait of Anne of Cleves*, ca. 1539, ivory, card, watercolor, vellum, diameter of box: 6.1 cm, diameter of lid: 5.95 cm, Victoria and Albert Museum, P.153: 1, 2-1910 (Courtesy of Victoria and Albert Museum)

Fig. 2a. A wassail bowl made in England with engine turned decoration. Unknown, *Wassail bowl*, 1640–80, Lignum vitae, ivory, height: 50 cm, Victoria and Albert Museum, W.8A to C-1976; 2b. A cup case made in Denmark with engine turned decoration. Unknown, *Cup case*, 1643, pearwood, height: 205 mm, diameter: 100 mm, Victoria and Albert Museum, W.20:1-1969 (Courtesy of Victoria and Albert Museum)

Fig. 3a. Wedgwood, *Vase*, 1764–65, earthenware, height: 18.4 cm, diameter: 11.4 cm, Victoria and Albert Museum, C.6-2010; 3b. Detail of turned button decorating a coat. Unknown, *Coat*, 1750–59, pewter, dimensions unknown, Victoria and Albert Museum, T.962-1919 (Courtesy of Victoria and Albert Museum)

Fig. 4. An étui made in Paris: "This basse-taille technique first appeared in Parisian goldsmith's work ca. 1768, after the introduction of the rose-engine lathe" from item description. Toussaint-François Pillieux, *Étui*, 1785–86, gold and enamel, dimensions unknown, The Metropolitan Museum of Art, 95.14.42a, b (Courtesy of the Metropolitan Museum of Art)

applied by Wedgwood can be readily understood through examining the company's catalog of work (Reilly 1989).

By the middle of the 18th century, guilloché patterns had become rather elaborate and were often overlain with enamel (see http://collections.vam.ac.uk/item/O156448/snuffbox-unknown/). By 1768, the basse-taille technique of covering engine turned gold and silver with translucent enamel had come to Paris along with the introduction of the rose engine (fig. 4).

Examples of highly elaborate boxes and objects made in the third quarter of the 18th century using this technique are shown in figure 5.

It can be seen in figure 5 that the engine turned cuts do not include more complex designs as seen on later work, where the cuts "cross" each other to create composite patterns. To accomplish this would require a "crossing plate," which lathes such as those shown by Moxon lacked (Daniels 2002; Moxon 1989). However, by ca. 1760–70, crossing plates are seen on rose engines, such as those owned by Louis XVI (Maurice 1985). Additionally, the straight-line engine and a straight-line chuck (an attachment for the rose engine) appear around this time (Matthews 1984). The introduction of elliptical and eccentric chucks also added to the variety of possible patterns, as shown in figures 6a and 6b (Matthews 1984). Guilloché continued gaining popularity with craftsmen, and examples of engine-decorated snuffboxes, musical boxes, singing bird boxes, and many other objects appeared (figs. 6c, 6d).

From about 1790, engine turned objects found their way into popular circulation, likely owing to Abraham-Louis Breguet's influence, which led to a wide use of basse-taille. Breguet's watches "set a standard of thinness, elegance, simplicity, robustness and good timekeeping that make them sought all over Europe, including Russia" (Clinton and Daniels 1965, 79–83). His prominent style is depicted in the example shown in figure 7.

Contemporary watchmakers, such as Roger Smith, still use Breguet's work as a standard of excellence. Breguet's trademark silver dials were often bleached, producing a whitish, matte surface that accentuates the engine turning. However, this finish is susceptible to degradation, and recovery is difficult, if not impossible. Craftsmen contemporary to Breguet manufactured objects with both guilloché and enamel; however, Breguet's work into the 19th century set the bar for watches of this era and the guilloché on them.

In 1819, Joseph Perkins obtained a patent for a machine to engine turn security notes as a means to discourage forgery, and by ca. 1824 engine turning had found its way into the Calico printing industry

Fig. 5a. Nicolas Ménière, *Box*, 1773–75, gold and enamel, 6.99 x 5.59 cm, Victoria and Albert Museum, 915-1882 (Courtesy of Victoria and Albert Museum); 5b. Jean-Joseph Barrière, *Box*, 1771–72, gold, 2.7 x 6 cm, Victoria and Albert Museum, 180:1&:2-1864 (Courtesy of Victoria and Albert Museum); 5c. Bouillerot, Charles Alexandre (maker) and Zincke, Christian Friedrich (painter), *Box*, 1771–74, gold and enamel, 4 x 8.9 x 4.7 cm, Victoria and Albert Museum, 151-1878 (Courtesy of Victoria and Albert Museum); 5d. Charles Le Bastier, *Snuffbox*, 1773–74, gold and enamel, 3.2 x 7.3 cm, The Metropolitan Museum of Art, 17.190.1163a, b (Courtesy of the Metropolitan Museum of Art)

(Matthews 1984). By 1840, the "Penny Black" postage stamp, which featured engine turning for the first time, was introduced to England (fig. 8).

Another notable figure is Peter Carl Fabergé (1846–1920) who, like Breguet, utilized engine turning on his popular works. In 1872, Peter Carl took over his father's workshop and was joined by his brother, who heavily influenced production, in 1882. Fabergé's work took a significant change in direction in 1884–85, when he replaced the head work-master. With this new style came fans, opera glasses, snuffboxes, bon-bonnières, scent bottles, *carnets de bal*, parasol and cane handles, seals, and entire toilet services. These objects, along with the imperial Easter Eggs for which he is most well known, also saw production in 1884. These pieces often incorporated high-quality enamels with engine turning underneath. This set the work apart from that of his contemporaries, and the technique was continued until the dissolution of the firm in 1917, following the Revolution in Russia. In 1918, Fabergé fled to Switzerland, where he died two years later (Bainbridge 1979; Habsburg-Lothringen and Curry 1996).

Wedgwood and others continued to utilize the rose engine, and many notable watch companies employed engine turning on cases (figs. 9a, 9b, 9c), whereas clockmakers used it for dial designs into the 20th century (fig. 9d).

La Chaux-de-Fonds became an important area for engine turning as watches like those depicted earlier gained popularity. This led to companies such as Lienhard to begin production of trade-style rose engine lathes, straight-line machines, and closely related brocading engines (Matthews 1984). In England, George Plant & Son manufactured engine turning machines beginning in 1857. Although Swiss and English machines were likely found in the factories, Charles Field led the way in making

Fig. 6a. Use of the elliptical chuck (Courtesy of Brittany N. Cox); 6b. Elliptical "rope" pattern overlay (Courtesy of Brittany N. Cox); 6c. A mercury gilded birdcage automaton with engine turning, late 18th century (Courtesy of Ken Goldman); 6d. A 19th century gold and enamel box and domino set decorated with engine turning (Courtesy of Ken Goldman)

Fig. 7. A watch by Breguet with an engine turned dial and case. Abraham-Louis Breguet, *Watch*, 1798–1809, gold, 4.7 x 4.2 x 0.8 cm, height with suspension loop: 5.3 cm, Victoria and Albert Museum, M.19-1957 (Courtesy of Victoria and Albert Museum)

Fig. 8. The Penny Black mark and image is a registered trade mark of Royal Mail Group Limited. Reproduced with kind permission of Royal Mail Group Limited

engine turning equipment in America, specializing in rose engines, straight-line engines, and brocading engines (fig. 10).

In a lecture given at the Ornamental Turners International symposium in 2012, Peter Dicristofaro, curator of the Providence Jewelry Museum, presented a paper concerning the American watch and jewelry industries and their approaches in the manufacture of clad metals. This talk remains unpublished, but according to Dicristofaro, American methods significantly reduced costs for tradesmen and also managed to retain the same aesthetic in their products as with precious metals. Looking to further reduce costs and industrialize a luxury market, they explored techniques for imitating engine turning while reducing the amount of precious metals previously used in production. To this end, they developed press tools and operations that achieved a finish often hard to distinguish from authentic engine turning.

Fig. 9a. Waltham, *Riverside Maximus*, 1911; 9b. Hamilton, *950*, 1940; 9c. American Watch Co., *Model 1872*, 1881; 9d. Unknown, *Ebonized Two-column Inverted Swinging Clock*, 1830 (Courtesy of Skinner)

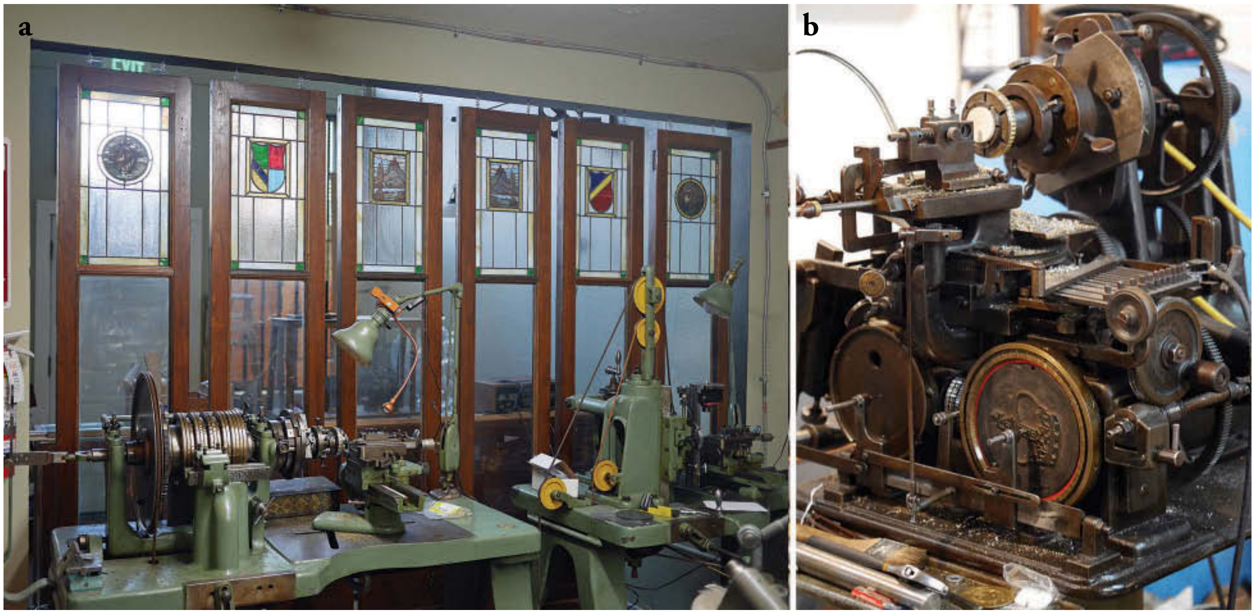

Fig. 10a. Lienhard rose engine (left) and straight-line machine (right); 10b. Brocading machine (Courtesy of Brittany N. Cox)

Sometimes the top layer of metal was cut through to achieve a distinct appearance, as the two metals oxidized differently. Often a method called *chasing* was employed, in which the cutting tip of the tool was dulled so as to impress a shallow line that did not break the surface or remove any metal. Given that engine turned objects were considered fashionable, these developments in fabrication that lowered costs made engine turned objects affordable to the middle class for the first time. Engine turning saw its greatest ubiquity during the American Art Deco period, and its popularity grew well into the 20th century until less expensive techniques and changes in style brought an end to its utility. However, true engine turning and stamped patterns can be found on items ranging from jewelry, money clips, and lighters to mirrors, comb boxes, and makeup cases into the 1970s, although in decreasing numbers (Dicristofaro 2012).

The history of engine turning in America can be traced through machine patents and trade catalogs. In the 19th century, Charles Field was a pioneer and the most prominent manufacturer of engine turning equipment, holding numerous patents on rose engines, brocading machines, watch case dies, and shirt studs. Notably, he is listed on the first American rose engine patent. Despite having enriched the jewelry industry with his innovations, there is but one known mention of his work in a jewelry magazine when he died at age 59. Following his death, Charles Field Jr. took over the business and continued to operate the firm until it

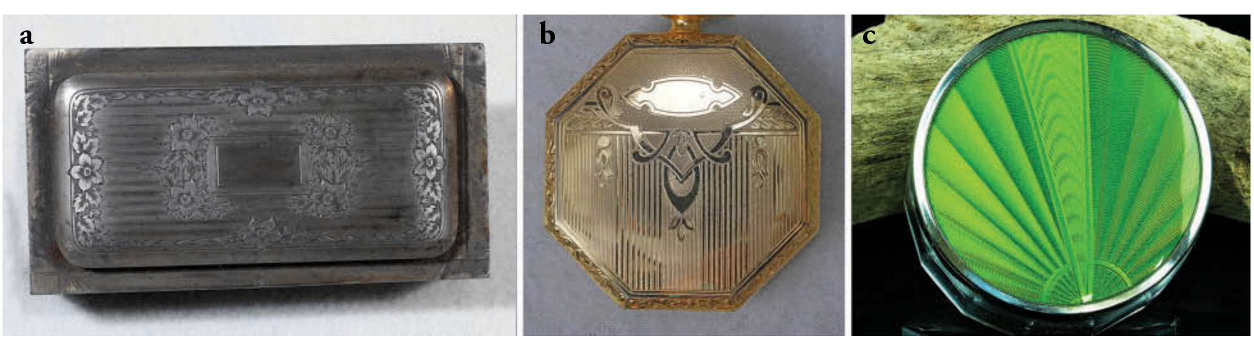

Fig. 11a. Press tool with engine turning (Courtesy of Brittany N. Cox); 11b. Clad metal watchcase with engine turned pressing (Courtesy of Brittany N. Cox); 11c. Celluloid and metal engine turned compact case (Courtesy of Steve White)

closed. He is credited with a patent from 1922 for an engine turning machine capable of decorating multiple pens simultaneously. The firm was not singularly devoted to the making of engine turning equipment, but made other machinery as well and also practiced engine turning for the trade.

By 1910, the F. A. Hall firm began manufacturing a rose engine and straight-line machine similar to those of Charles Field, and in 1920, Linden, another manufacturing firm known for producing textile machines, began fabricating engine turning equipment. Using their background in the design of production machinery, they were successful in developing an efficient production rose engine and straight-line machine; many models were capable of decorating multiple pieces simultaneously. In 1921, the Kenloc firm assumed production of the F. A. Hall straight-line engines, and in 1930, M. J. Brohen from Attleboro, Massachusetts, also entered the market. However, by the end of 1933, the production of American engine turning equipment stopped. During that brief period, the Brohen firm produced both rose and brocading engines.

Despite the decline, engine turning has not completely died out, as it is still practiced by a few devoted shops in Europe, especially around the watch industry, and in the United States. Firms in the United States include the RGM Watch Co. in Mt. Joy, Pennsylvania; Philip Peck, a goldsmith from Huntingdon Valley, Pennsylvania; and Phil Poirier, a goldsmith from Taos, New Mexico. With classes being offered at the Memoria Technica workshop in Seattle and the momentum of a small movement to provide information on the art form, the practice is gradually resurfacing.

3. THE MACHINES

Both the rose engine and straight-line machine are hand operated (figs. 12, 13). When the operator turns the hand crank on the rose engine, the fly wheel rotates, which carries the rosettes and the work piece.

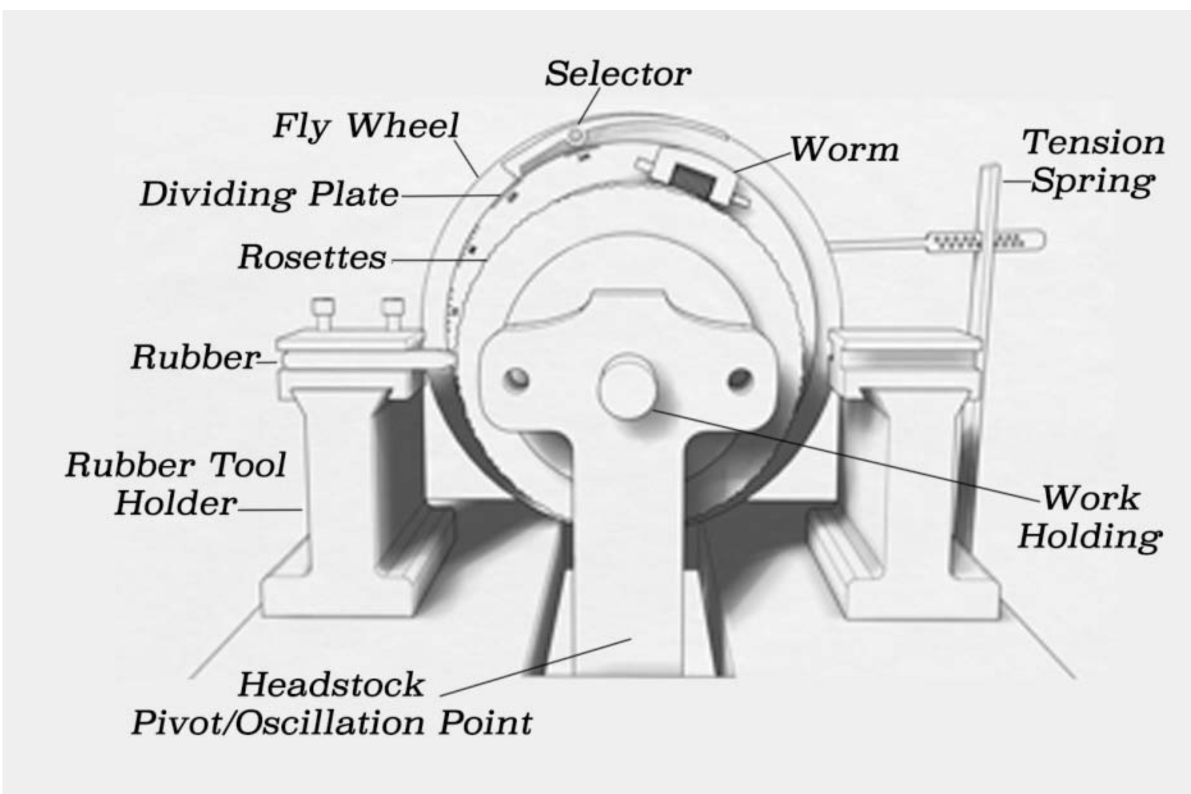

Fig. 12. Diagram of the rose engine (Courtesy of G. Phil Porier)

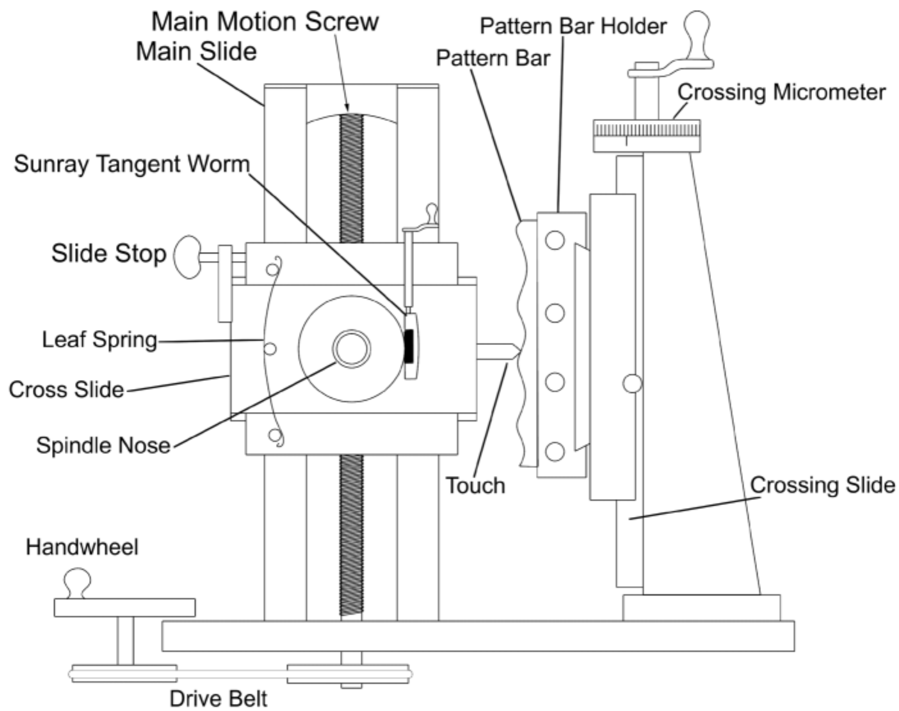

Fig. 13. Diagram of the straight-line machine (Courtesy of G. Phil Porier)

When a rubber is engaged with a rosette, the headstock is forced into oscillation by spring tension against the rubber. The pattern carried by the rosette is then translated to the work surface via a hand-operated stationary cutter that is indexed toward the center as each subsequent cut is made. Similarly, on the straight-line machine, when the operator turns the hand crank, the headstock that carries the work and the rubber is forced via spring tension against a pattern bar. The pattern is placed onto the surface by a hand-operated stationary cutter that can be indexed across the workface or left at a center point. The work piece can then be rotated 360°, creating a radial pattern from the center out.

The invention of the rose engine is certainly earlier than the straight-line machine, although an exact date for the invention of the straight-line machine is unknown.

3.1 ROSE ENGINE

Rose engines, including those made specifically for guilloché work, have not significantly evolved since the 18th century. The machine pictured figure 14 is a 20th century machine made in La Chaux-de-Fonds, Switzerland, by Lienhard, a popular maker of rose and straight-line engines. This was used in the Bulova Watch Co. factory on Long Island, New York, before its closure.

As the spindle rotates carrying the work in the chuck, a "fixed" or nonrotating tool cuts the metal. The depth of cut is set by the "guide" or "geed," which can be seen on the right side of the cutting tool. It is dressed with an obtuse angle of 160°, as shown in figure 15a.

The depth of the geed can be adjusted to give deeper or shallower cuts. The cutting tool slides forward or back by the hand of the operator and is pushed in until the geed rubs against the work, as shown in figure 15b. An adjustable dead stop can also be used in place of the geed, as seen on the right side of the slide in figure 15b.

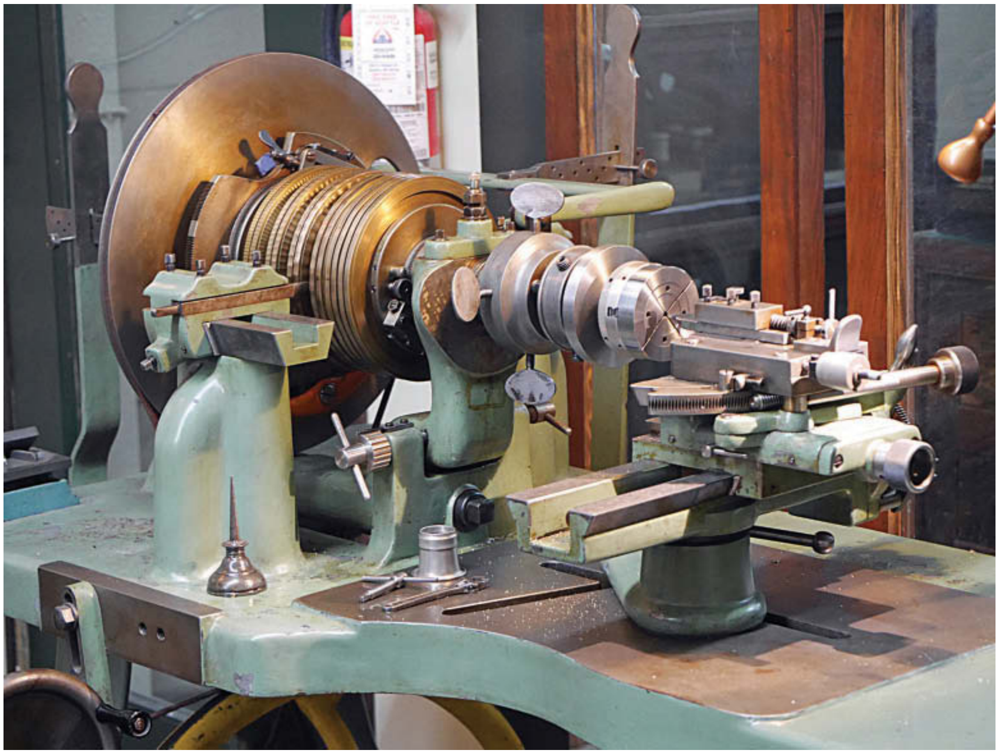

Fig. 14. The rose engine has a headstock that rocks on pivots with a series of cams, called *rosettes*, attached to the spindle and a follower that forces the headstock to rock in accordance to the profile on the rosette (Courtesy of Brittany N. Cox)

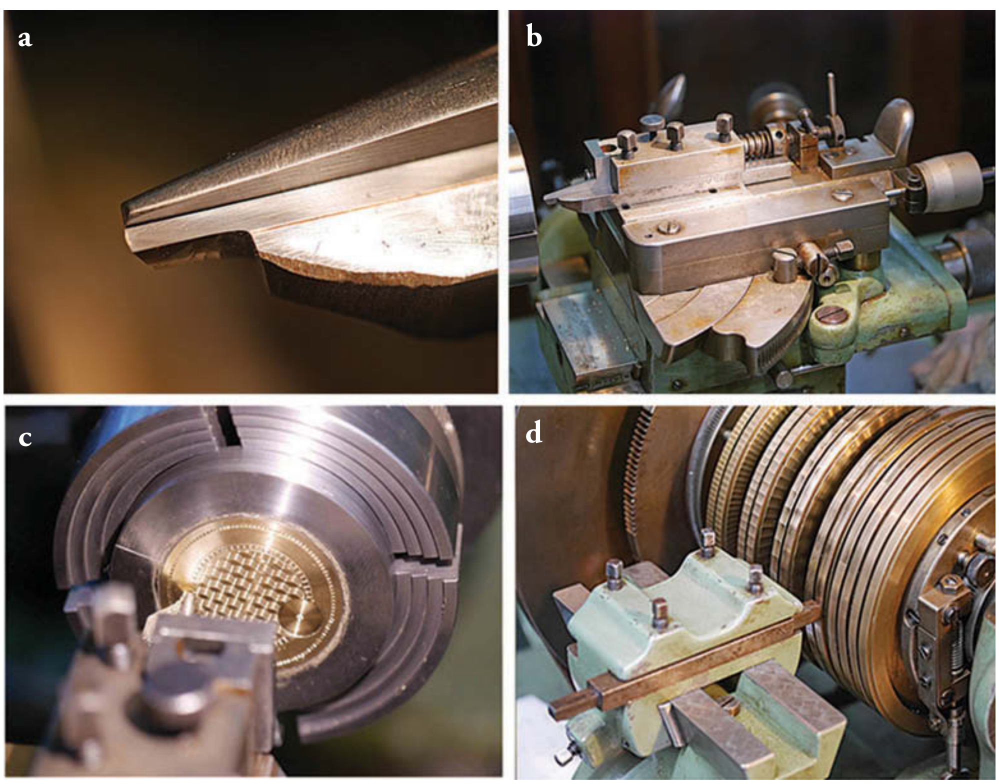

Fig. 15a. The cutting tool and geed; 15b. The slide; 15c. Cutting tool and geed engaged with the work; 15d. Rosette engaged with the rubber (Courtesy of Brittany N. Cox)

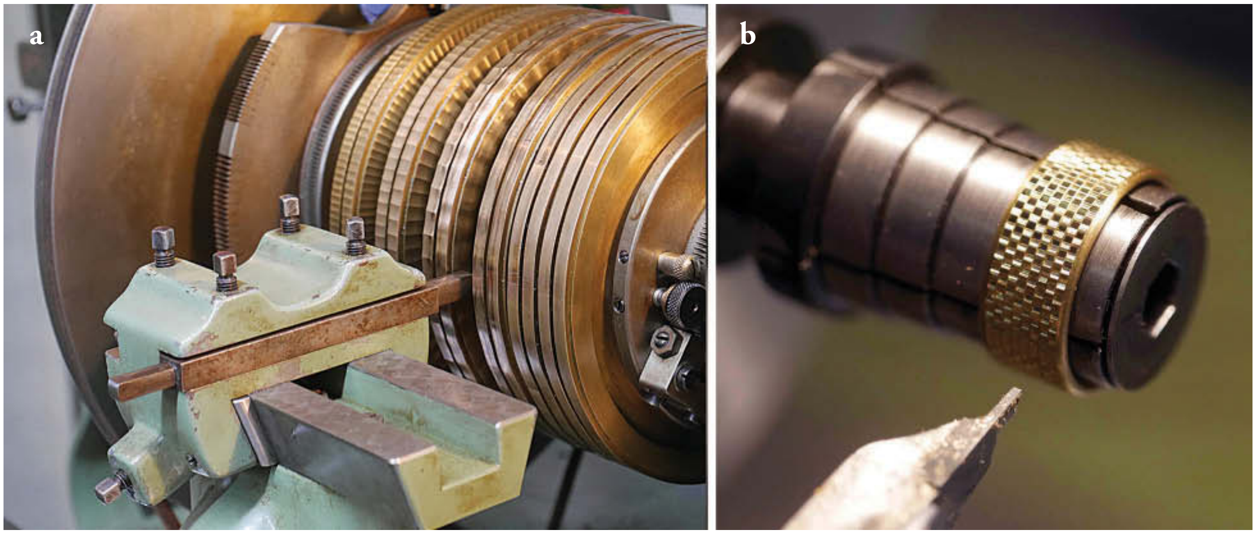

Fig. 16a. Rubber engaged with the rosette; 16b. A ring made using the chisel technique (Courtesy of Brittany N. Cox)

Figure 15c shows both the cutter and geed engaged with the work. The obtuse angle of the cutter ensures that the cut is quite shallow, and the shallow angle, coupled with a slight negative relief on the top of the tool, gives the bright, reflective shine typical of guilloché.

The "rocking" action, produced by the engagement of the rubber with the rosette, is shown in figure 15d. The rosette is basically a cam that carries a pattern or wave but provides only the basis or foundation of a resulting pattern. When combining the wave on the rosette with other aspects of the machine, such as the dividing plate or worm, one can generate several variants from a single rosette. The headstock moves forward and back through spring tension produced by the rubber, also known as a touch, being driven by the outside diameter of the rosette.

A rubber can be seen engaged with the face of the rosette in figure 16a, which causes the spindle to traverse, or slide left and right in the spindle bearings. This action is used for work on the outside of cylinders, such as the ring in figure 16b. It is also used to give what is called the *chisel* effect on watch dials, often to highlight the seconds and chapter rings.

Fig. 17. Rubbers for rose engine (Courtesy of Brittany N. Cox)

Fig. 18a. Crossing plate and detent; 18b. Crossing plate and detent; 18c. A worm and worm wheel (Courtesy of Brittany N. Cox)

Followers, called *rubbers* or *touches*, some for pumping and some for rocking, can be seen in figure 17. Just as any change of rosette renders a different cut pattern, so does any change to the rubber. A wide variety of rubbers are required for diversified work.

The crossing plate and detent are shown in figures 18a and 18b. This is used to "phase" the pattern on the work. This entails shifting the pattern so that the cuts "cross" over each other, creating optical illusions that are often associated with guilloché. Figure 18c shows a worm and worm wheel, which offer alternative means of phasing. The worm is used for patterns such as the "moiré" and "drape." The worm offers more minute adjustments as well as greater variability in phasing.

Many distinct patterns can be cut using a single rosette with the same rubber; four such patterns are illustrated in figure 19. These pattern changes were created through alterations in phasing and by moving the tool toward the center in varying amounts between subsequent cuts. Historically, instances of the same pattern have not carried the same name. Different operators of these machines, from region to region and time to time, have used a variety of the names for the same pattern. The popular pattern

Fig. 19. Four distinct patterns cut with the same rosette and rubber on the rose engine (Courtesy of Brittany N. Cox)

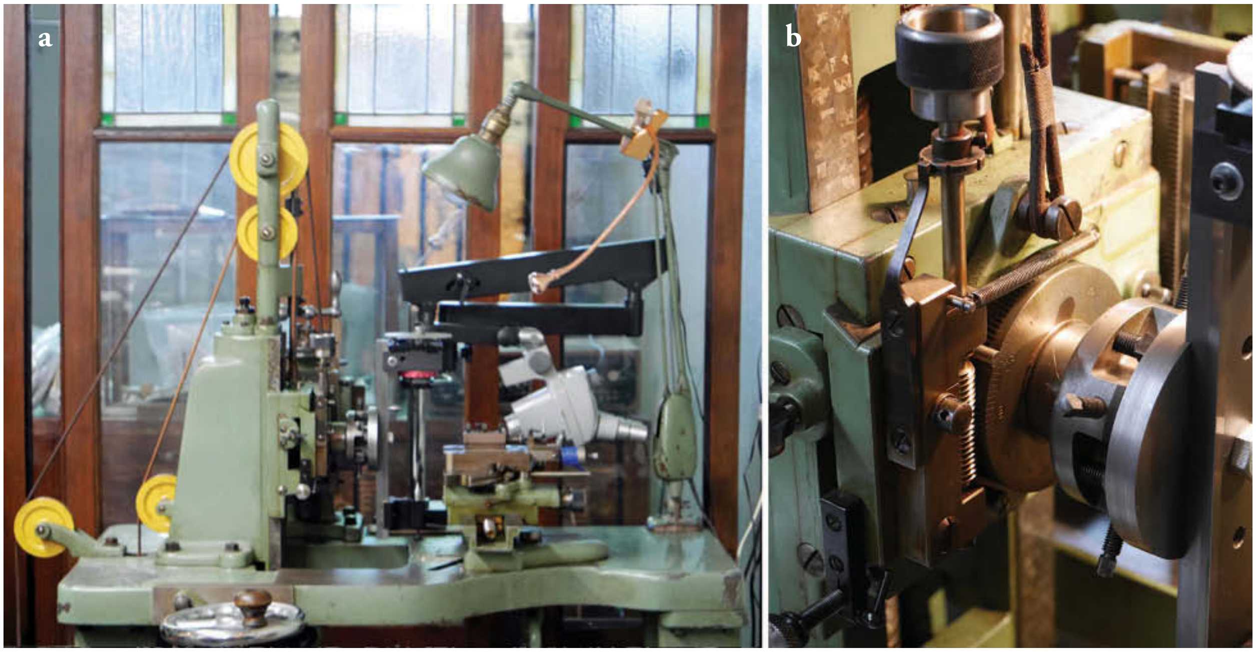

Fig. 20a. Lienhard straight-line machine; 20b. Vertical and horizontal slides (Courtesy of Brittany N. Cox)

known as the moiré or the drape actually applies to a broad number of patterns that look very similar. Technically, the moiré is different from the drape, but the untrained eye may not distinguish the two from one another.

3.2 STRAIGHT-LINE MACHINE

A 20th century Lienhard straight-line machine at the Memoria Technica workshop is shown in figure 20a. The leather belts that connect to the spindle go over the top and come down to the left-hand side, carrying weight to counterbalance the weight of the main slides. The headstock is driven by means of a lead screw, which is protected by the large vertical casting on the left-hand side of the machine. The lead screw is moved by means of a belt, which is turned by the crank on the left. The slide rest sits to the right.

There are two main slides, vertical and horizontal, in figure 20b. As the lead screw drives the headstock vertically, the horizontal slide is forced to move forth and back according to the pattern bar being followed by the rubber or touch.

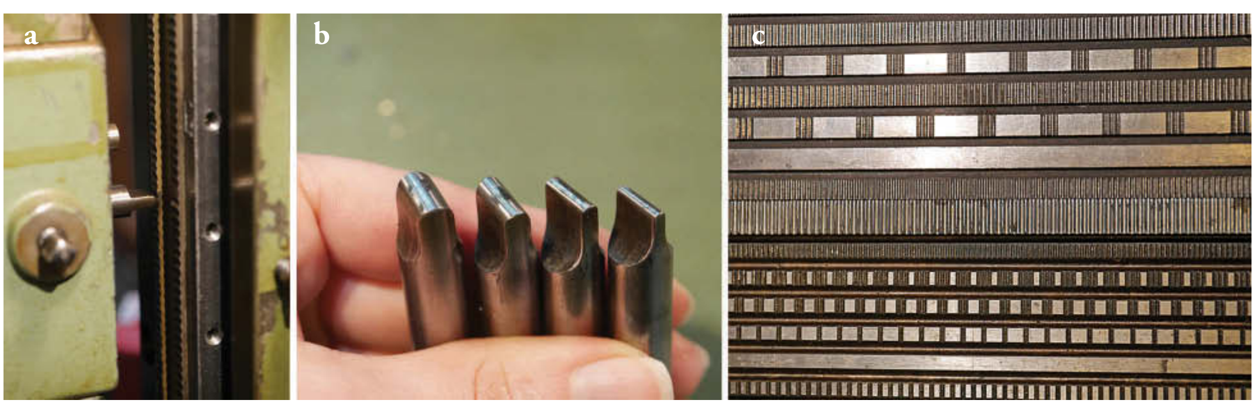

Fig. 21a. Rubber engaged in pattern bar; 21b. A variety of rubbers for pattern bars; 21c. A variety of pattern bars (Courtesy of Brittany N. Cox)

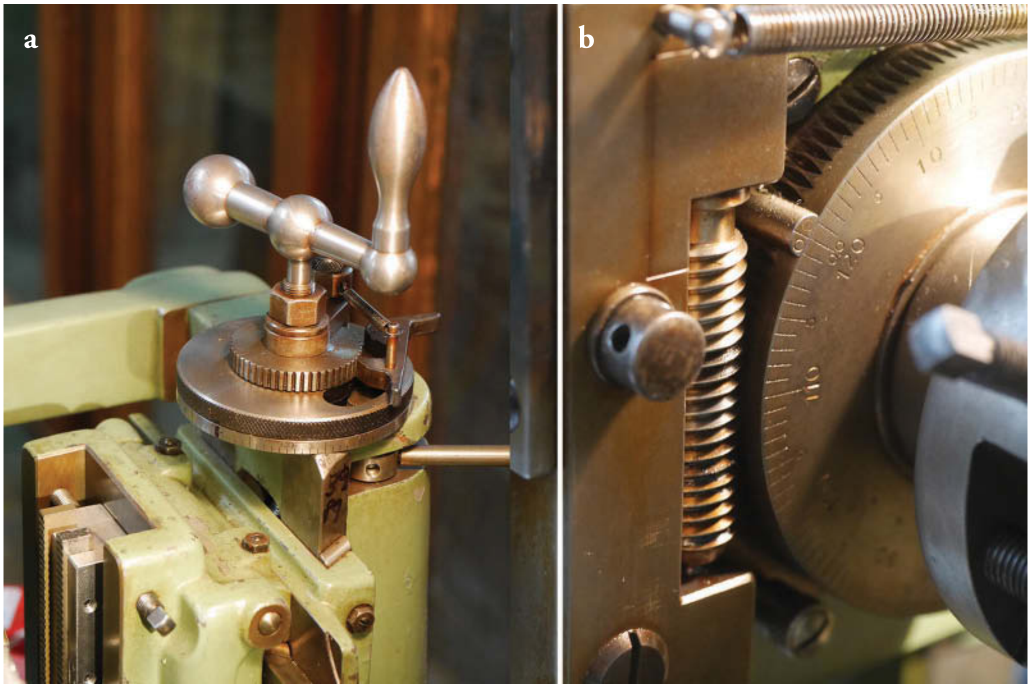

Fig. 22a. The indexing handle and dial, which allows one to change the orientation of the pattern bar between cuts; 22b. The worm and indexing dial for rotating the work between cuts (Courtesy of Brittany N. Cox)

A rubber can be seen engaged with a pattern bar in figure 21a. Figure 21b shows a variety of rubbers, and as with the rose engine, any change to the rubber—even on the same pattern bar—will result in a different cut. Figure 21c shows a variety of pattern bars ranging from low amplitudes to high, allowing a wide variety of work from the same machine.

The pattern bar can be moved with a lead screw, as illustrated in figure 22a. The function of this relates to the "crossing wheel" on the rose engine and is used for "phasing." It allows the pattern bar to be shifted up and down, changing its relationship to the work. This is what creates the various patterns in straight-line work.

The headstock has an "indexer" that allows the work to be rotated a specific amount (fig. 22b). This mechanism allows for patterns such as a sun burst. The indexing on this machine is done by means of a worm, which rotates the work 3° per revolution. It also serves to augment alignment, especially with work-holding devices such as the pen chuck, which attaches to the headstock spindle. The pen chuck allows cylindrical devices to be held vertically and indexed after each subsequent cut.

4. PATTERNS AND TREATMENT METHODOLOGY

In this section, we provide our catalog of 60 common patterns and discuss our results in treating the 28 metal samples of composition 353 brass, nickel silver, and fine silver. The fresh cut samples have been lacquered to help retain the aesthetic properties of new guilloché work, and we have treated our other samples with commonly encountered treatments so that the degradation of these properties is apparent. We cannot emphasize enough that we are *not* recommending these commonly encountered treatments but are rather discouraging the use of them and giving examples so that conservators can more easily identify what has been done to objects in the past. We also hope that it will spark some discussion and research into other viable conservation-based treatments that might prove effective in reclaiming original finishes.

Section 4 of this article is continued at https://mechanicalcurios.com/looking-at-guilloche-in-conservation/.

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SOURCES OF MATERIALS

Fine silver
Rio Grande
7500 Bluewater Rd. NW
Albuquerque, NM 87121
505-839-3000
https://www.riogrande.com

353 brass, Nickel silver
McMurray Metals Co.
3000 Elm St.
Dallas, TX 75226
214-742-5654
http://mcmurraymetals.com

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WHEN IN ROME, DO AS THE ROMANS DO? THE CONSERVATION OF AN ITALIAN MARBLE AND MICROMOSAIC TABLETOP

ELIZABETH La DUC

A 19th-century Italian marble tabletop featuring micromosaic scenes of Rome was the subject of technical study and conservation treatment. The tabletop, part of the collection of Historic New England, is elaborately decorated with two distinct techniques: inlaid colored stones, known as *commesso di pietre dure* or Florentine mosaic, and micromosaics, also known as *mosaici minuti*. The tabletop was broken into four large pieces with areas of loss along the breaks and required extensive treatment before going on display in the recently reinterpreted Josiah Quincy House in Quincy, Massachusetts. The materials and methods of manufacture were investigated using FTIR spectroscopy, photomicrography, and art historical research. Issues concerning best practices for treatment of the tabletop are discussed with regard to the use of traditional methods versus the use of modern replacement materials. Losses to the pietre dure were isolated and then filled with bulked and tinted epoxy, using techniques developed to imitate colored stone as well as to increase reversibility. The losses in the micromosaics were filled and then inpainted using methods to replicate the complex appearance of the originals. Some traditional practices, such as the use of fine abrasives and wax coatings, were determined to be appropriate and satisfactory for the treatment.

KEYWORDS: Mosaic, Micromosaic, Marble, Pietre dure, Loss compensation, Inpainting, Epoxy

1. INTRODUCTION

In 2014, an elaborate Italian tabletop (fig. 1) in the collection of Historic New England was the subject of conservation research and treatment. The tabletop, which dates to the late 19th century, combines two quintessentially Italian art forms: commesso di pietre dure and micromosaics. Its poor condition raised questions about extent and method of treatment, and the relative scarcity of conservation literature necessitated inventive methods of treatment and problem solving.

1.1 PROJECT BACKGROUND

Historic New England, formerly known as the Society for the Preservation of New England Antiquities, is a historic preservation organization that maintains 37 historic house museums over five states in New England. As part of Historic New England's Proactive Preservation Interpretation and Planning (PPIP) Process (Solz et al. 2012), the decision was made to reinterpret the Josiah Quincy House in Quincy, Massachusetts, from 1772, the time of the house's construction by Josiah Quincy, to the 1880s, the time of Eliza Susan Quincy, Josiah's great-granddaughter (Carlisle 2014). This multiyear project required the conservation treatment of over 100 objects performed both in the conservation lab and on site. The Italian tabletop was one of the most significant treatments in terms of time required. Although not original to the Quincy House, the tabletop and its accompanying painted and gilt wood base were chosen for exhibition because they correspond to the time period of the reinstallation. The treatment was also performed as the author's major project required as a component of a post-graduate Mellon Fellowship at Historic New England.

1.2 DESCRIPTION OF THE TABLETOP

The circular black marble tabletop, measuring 56.3 cm in diameter and 1.7 cm in thickness and weighing approximately 12 kg, is inlaid with decorative colored stones (commesso di pietre dure) and

Fig. 1. Before treatment. Unknown maker, *Marble and micromosaic tabletop*, 1870–1890, 56.3 cm (D) x 1.7 cm (H), Historic New England, 1933.1254. Gift of Mrs. George P. (Susan Emily Jewell) Sanger (Courtesy of Historic New England)

micromosaics. The colored stones, separated by thin black marble dividers, are placed in a band around the outer edge of the table with a narrow red stone border on either side. All of the 32 decorative stones are different, with the majority red or yellow in color. The stones include various types of marbles, breccias, lumachellas, fluorite, lapis lazuli, and other unidentified species. The lapis lazuli inlay is uniquely assembled from two pieces, most likely because of the expense and rarity of the material. The fluorite inlay also received special treatment; it is backed by a support of a thin black stone (possibly slate), perhaps intended to provide a solid background for the semi-translucent stone or to reduce its thickness and thus cost.

In the center of the tabletop is a large micromosaic of the Doves of Pliny surrounded by a malachite border. Around this are eight small micromosaics showing scenes of Rome. Alternately oval-shaped and circular, these roundels depict clockwise from top: the Pantheon, Castel Sant'Angelo, the Roman Forum, the Arch of Titus, St. Peter's Basilica, the Capitoline Hill, the Colosseum, and the Tomb of Cecilia Metella. Each of these micromosaics has a narrow border of red *smalti* (glass tesserae). On the back of the tabletop is an illegible inscription in white chalk, now partially abraded. The tabletop is mounted on a three-legged painted and gilded wooden base in the Neo-Grec or Renaissance Revival style dating to the 1870s or 1880s.

It is rare to find a tabletop that combines the techniques of pietre dure and micromosaic. It is the author's opinion that the tabletop was made in Rome, for several reasons. The scenes of Rome suggest local production, as does the fact that micromosaics were almost exclusively a Roman technique. In contrast, while the best pietre dure was produced in Florence, the technique of hard stone intarsia was practiced many places in Europe, including Rome. Also, the usage of the stone inlays differs from that of typical Florentine work: the stones do not form a picture but are instead used decoratively and as mineralogical specimens.

2. PIETRE DURE

2.1 HISTORY OF PIETRE DURE

Commesso di pietre dure (Italian: a placing together of hard stones), often called simply pietre dure or Florentine mosaic, is an ancient technique dating back to the opus sectile mosaics of the ancient Mediterranean. The technique was revived in Rome in the 1500s and was further developed by the establishment of the Galleria dei Lavori, the official court-supported workshop, by Federico I de Medici in 1588. The Galleria flourished for a few centuries, producing elaborate works of art, including pictures, tabletops, and cabinets, as well as large-scale architectural revetments such as the Capella dei Principi at the Church of San Lorenzo. Rival courts, especially in Prague, Dresden, and Madrid, set up their own stone-working factories (Massinelli 2000). With the decline of the Medici family and its patronage in the early 19th century, the workshop was renamed the Opificio delle Pietre Dure (OPD). By the end of the 19th century, commissions and patrons were waning, and the OPD changed its focus to restoration. The OPD is now one of the premier centers for conservation and conservation training in Italy, focusing not just on stone conservation but also on paintings, textiles, and other objects (Koeppe and Giusti 2008).

2.2 TECHNIQUE OF PIETRE DURE

Creating pietre dure objects is an intricate, labor-intensive process. Pietre dure objects are usually made on a black stone substrate. The best pietre dure objects use *paragone*, a black siliceous stone; black Belgian marble and slate are also commonly used. Depending on whether the support material itself is integrated into the design, recesses are chiseled into the support to receive the inlays. On Historic New England's tabletop, the circular nature of the tabletop and the channels suggests the use of a lathe, both to cut the support and to create the recesses. Meanwhile, slabs of stones—either pietre dure (hard stones) or pietre tenere (soft stones, with a Mohs hardness less than 6, including marble)—are cut to an appropriate thickness, usually 2–4 mm but occasionally thinner. The design, drawn on paper, is pasted onto the stone. The stones are then cut into pieces known as *formelle* using a wooden bow saw fitted with an iron wire coated in damp emery powder. The cut pieces of stone are assembled on the substrate using a heated mixture of pine rosin (colophony) and beeswax, in a 4:1 ratio by tradition (fig. 2)

Fig. 2. Break edge of the tabletop illustrating the manufacturing technique of pietre dure. From bottom to top: the black marble substrate, the rosin layer, and the decorative stone slab. Note the thickness of the adhesive layer (Courtesy of Historic New England)

(Chastang 2012). After the adhesive has set, the top of the work is polished with progressively finer abrasives and the object is coated with wax. An important distinction between pietre dure and other forms of mosaics is that in pietre dure, the pieces are cut so they fit tightly together without any adhesive or mortar visible (Acidini 2008).

3. MICROMOSAICS

3.1 HISTORY OF MICROMOSAICS

Micromosaics, also known as mosaici minuti or Roman mosaics, are what their name suggests: mosaics in which the tesserae are very small. Like pietre dure, the history of micromosaics dates to the 16th century in Rome, but the term micromosaic is modern, coined in the late 20th century by the famed collector Sir Arthur Gilbert to describe mosaics that require magnification to see the tesserae. In 1578, the Reverenda Fabbrica di San Pietro (RFSP), also known as the Studio del Mosaico Vaticano, was founded to create mosaics to decorate the interiors of St. Peter's Basilica. Starting in the early 18th century, the studio began to make smaller works using minute glass tesserae. By the end of the 18th century, most commissions were no longer from the Vatican but instead from private clients. In the 19th century, artists such as Michelangelo Barberi created masterworks for wealthy patrons, while dozens of Roman studios mass-produced micromosaic souvenirs for visitors on the Grand Tour (Gonzales-Palacios 1982).

Along with scenes of Rome, the Doves of Pliny is almost certainly the most common image produced in micromosaics. It is found on six different objects in the Gilbert Collection alone (Gabriel 2000). Based on the famous mosaic uncovered at Hadrian's villa in 1737 and now in the Capitoline Museum, the name comes from the description of the subject by Pliny. The image was reproduced in micromosaics on objects ranging in size from tabletops to paperweights to jewelry; the objects vary widely in quality as well.

3.2 TECHNIQUE OF MICROMOSAICS

To make micromosaics, opaque, matte glass tesserae known as smalti are fabricated by drawing out pieces of colored glass cakes into strips (*filati*) of varying thickness by heating with a flame. At the high point of micromosaic production, over 28,000 colors were used in a wide range of shapes (fig. 3). Specialized smalti known as *malmischiato* (badly mixed) are made by fusing multiple colors together with heat. The filati are shaped while still hot and then snipped into small pieces. The cut pieces are placed on a substrate of black stone, copper, or glass using *mastice*, a combination of linseed oil, chalk, and other materials but which confusingly does not contain mastic resin (fig. 4). Once the mastice has hardened, the micromosaic surface is polished using fine abrasives. In order to create a seamless surface, gaps between the smalti are filled with colored wax applied with a spatula. The mosaic is then polished a final time (Rudoe 2000).

The extent of colored wax used is more easily determined with ultraviolet radiation, as seen in the detail of the sky behind the Pantheon (figs. 5, 6). This also reveals how much wax has been lost through use or cleaning. Examination of micromosaics in Historic New England's collection showed this to be a not unusual phenomenon.

4. SCIENTIFIC ANALYSIS

Very little analysis has been published on pietre dure and micromosaic objects, with information about materials used almost entirely based on historical records and craft tradition. Analysis undertaken by

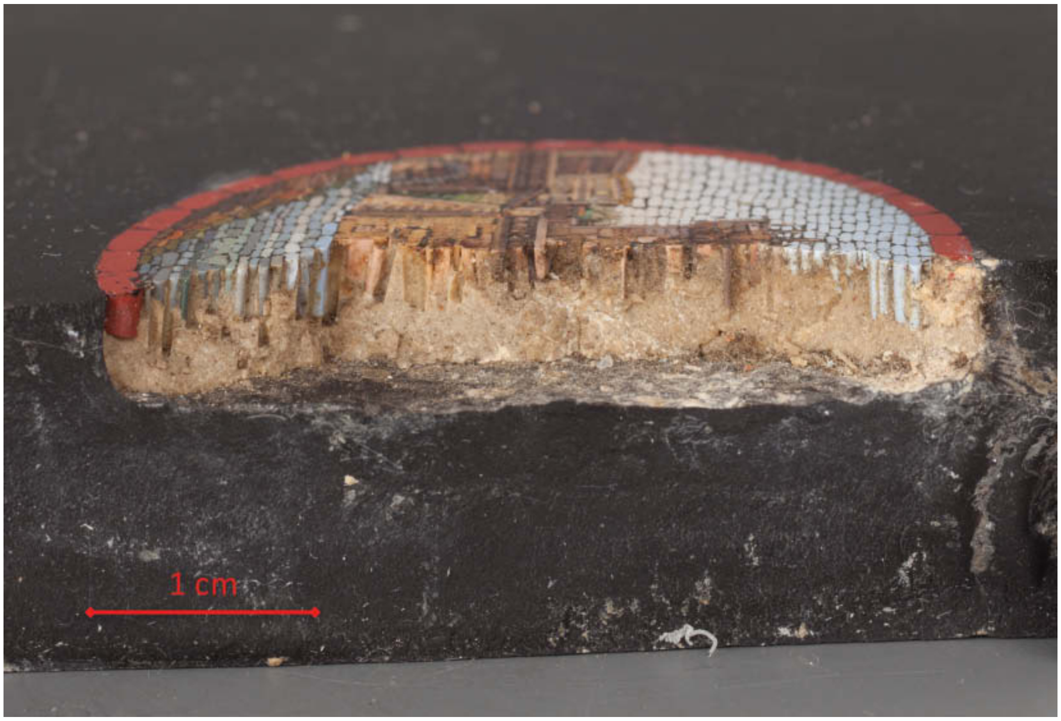

Fig. 3. Detail of the micromosaic of the Doves of Pliny, showing the wide range of colors and shapes of smalti (Courtesy of Historic New England)

Fig. 4. Side view of the break edge of the tabletop, showing manufacture of the micromosaic: the black marble base, the mastice (traditional mixture of linseed oil, lime, and marble dust), and the opaque glass smalti (Courtesy of Historic New England)

Fig. 5 and 6. Micromosaic of the Pantheon under normal and UVA radiation. The remains of colored wax in between smalti show ultraviolet-induced visible fluoresence. Also note the malmischiato smalti used for the columns of the Pantheon and the small figures (Courtesy of Historic New England)

Chastang (2012) of a late 17th-century pietre dure cabinet used gas chromatography-mass spectrometry (GC-MS) to identify the adhesives as pine rosin and beeswax. To learn more about Historic New England's tabletop, samples were taken of the adhesives used for both techniques and of the wax in the micromosaic. Analysis by Fourier transform infrared (FTIR) spectroscopy[1], with results supported by polarized light microscopy (PLM)[2], provided some answers but left some questions.

The adhesive under the pietre dure consisted of a natural resin, most likely pine rosin, and had significant amounts of calcium carbonate, either from contamination from the marble of the tabletop or from chalk used as a bulking agent. Despite references in the literature to the use of a wax-rosin mixture, no wax was detected. The results for the adhesive underneath the micromosaic were less conclusive. The spectrum was dominated by peaks for calcium carbonate, with only traces of an organic material detected. The lack of a carbonyl peak suggested the organic material was neither a drying oil nor a natural resin. Future analysis, either with additional separation and extraction steps or with another technique such as GC-MS, could be performed to identify the material. The sample of red-colored wax used between the smalti was found to be a mixture of a natural wax (most likely unrefined beeswax) and hematite (red ochre), matching expectations.

5. TREATMENT

5.1 CONDITION OF THE TABLETOP

The tabletop was in poor condition, with major structural and surface issues. It was broken into four sections; previous restoration resulted in the misalignment of one large section and several of the decorative stone inlays (fig. 7). Two of the stone inlays were missing large portions, and one stone inlay and two and a half black stone dividers were missing entirely. Along the central break, there was substantial loss to the micromosaics in the scenes of the Capitoline Hill and the Doves of Pliny, and more

Fig. 7. The tabletop photographed under raking illumination showing misalignment, losses, and surface dirt (Courtesy of Historic New England)

than half of the scene of Castel Sant'Angelo was missing. Finally, the tabletop surface was very dirty and etched in places.

5.2 TREATMENT OBJECTIVES

The objectives of the treatment were to stabilize the condition of the table, preventing further damage, as well as to make the table suitable for display. As an organization of historic house museums, Historic New England often takes a minimal approach to treatment. The institution prefers that objects undergoing treatment retain their patina or sense of age in order to harmonize with their period setting. On the other hand, decorative objects like the tabletop require a high level of finish to recreate their intended appearance. For this reason, a highly restorative approach, including aesthetic reintegration, was chosen for this treatment.

5.3 SURFACE CLEANING

The tabletop was cleaned with calcium-saturated distilled water with the pH raised to 8.5 using ammonia. A small amount of Triton XL-80N was added to improve detergency. The water was saturated with calcium by adding precipitated calcium carbonate until no more would go into solution in order to reduce leaching and change in surface gloss (Lauffenburger et al. 1992). A pH of 8.5 was chosen because although a higher pH has been proven to reduce etching of the marble, a pH higher than 9 might affect the glass tesserae. Sections of pietre dure were then rinsed with ethanol and mineral spirits to remove grease or other residues. Sections of micromosaic were rinsed with ethanol only, because of the potential solvent sensitivity of the colored wax between the smalti.

5.4 DISASSEMBLY AND REASSEMBLY

The misaligned sections were disassembled by wicking acetone into the joins using a pipette, as the adhesive from the previous restoration dissolved quickly in acetone while the original adhesive only swelled. The pieces were then reattached with a 30% (w/v) solution of Paraloid B-72 in acetone, heavily bulked with glass microballoons. Despite some overlap in solubility with the original adhesive, B-72 was chosen because it is much more readily reversible in acetone than the original adhesive, and because the glass microballoons make the new adhesive easily distinguishable. The colored marble pieces were reset by first applying the bulked B-72, then gently pressing the stone fragments until level with the surface of the table, and finally removing any excess adhesive from the surface using acetone. Gaps around the re-set stones were filled with Modostuc and then inpainted with Gamblin Conservation Colors.

The four sections of the tabletop were reassembled using a 35% (w/v) solution of B-72 in acetone. Alex Carlisle, Supervising Conservator, Historic New England, made curved wooden gluing cauls and designed a complex clamping system to distribute the pressure evenly around the table (fig. 8).

5.5 TREATMENT OF PIETRE DURE

5.5.1 Past Approaches to the Treatment of Pietre Dure

The OPD is the leader in the conservation of pietre dure objects. Their conservation approach is rooted in their expertise in craftsmanship; they state that "restoring Florentine mosaic with the original materials and techniques is the ideal method, the one most suitable for giving back to these works of art their decorative value and material worth (the two being closely connected) in the way that was originally conceived by their makers" (Giusti 1994, 146). While utilizing newly created stone inlays for treatments, the OPD follows modern conservation principles of documentation, distinguishability, and reversibility (Acidini 2008). For example, in the treatment of a tabletop from the Palazzo Ducale of Mantua, new stone pieces were cut in the traditional manner, then adhered to slate and screwed into the original table,

Fig. 8. Clamping system used to join the tabletop sections (Courtesy of Historic New England)

with a minute gap between the original and the repair, thereby remaining reversible and distinguishable. In some cases, the OPD uses non-stone materials for fills. To recreate a Greek breccia that was no longer available, the OPD used a mixture of marble chips, pigment, and polyester resin cast in a mold and then cut to shape. On an object belonging to the Prado where the color and patterning of the missing stones were not known, the OPD used *scagliola* (polished, tinted plaster) to fill losses (Griffo 2009).

Outside of Italy, a combination of traditional and new methods has been used to conserve pietre dure objects. In his treatment of ebony cabinets with pietre dure panels, Chastang (2012) considered using other adhesives such as Paraloid B-72 and hide glue but ultimately used a 2:1 mixture of beeswax and colophony, a modified version of the original adhesive, to reattach lifting stone inlays. Because of the difficulties in sourcing stones that would exactly match the remaining originals, Chastang filled losses with a mixture of carnauba wax, shellac wax, dammar, and pigment, which replicated the original color and gloss yet remained reversible. For his treatment of a Czech pietre dure panel, Schott (2000) used pigmented polyester resin, which was cast out as a sheet on a plate of glass, cut to shape using a jeweler's saw, and finally adhered with fish glue over a paper barrier. According to Chastang (2012), the difficulty of making fills has led some to take alternate approaches that many conservators would not consider acceptable: trimming rough break edges for easier repair or removing entire broken sections and then completely replacing them with new stones.

In the case of the Historic New England tabletop, while it might have been desirable from an aesthetic viewpoint to replace the missing stone inlays with newly cut stone, this method was impractical for several reasons. First, the conservation department at Historic New England did not have access to the materials, equipment, or specialized expertise to do lapidary work. Second, two of the stone slabs were only partially missing. It would have been difficult to cut a piece to exactly fit the rough break edges and even more unlikely to find a replacement slab that matched the coloring and pattern of the original.

Having ruled out filling the losses with real stone, the question became what to use instead. Scagliola and tinted wax-resin mixtures have been used by the OPD and Chastang, respectively, but both lack the translucency of natural stone. Polyester resin has been used by the OPD and Schott. While translucent, polyester resin has issues of toxicity and permanence, with a susceptibility to yellowing. Instead, conservation-grade epoxy was used, which is translucent, of relative low toxicity, of high lightfastness, and can be easily mixed with lightfast pigments.

5.5.2 Treatment of the Missing Stone Inlay

The stone that was missing entirely allowed the most freedom in compensation. A pink and yellow inlay was chosen because similarly colored stones appeared on comparable tables, because the colors harmonized with the rest of the table, and because it was different from what was extant on the table, as each stone sample is unique. An imitation of a veined marble was selected because it was easier to replicate than a conglomerate stone such as breccia or lumachella (although the OPD has successfully replicated breccias by using marble chips). In order to be historically accurate, the design of the stone was based on an example, Corsi 200, from the Corsi Collection of Decorative Stones (Oxford Museum of Natural History 2012). The shape of the colored stone was traced onto a piece of wood that had been planed to an appropriate thickness; the wood was sawn to shape, sanded further, and then coated with shellac. A silicone rubber mold was made of the wood blank. The first mold had the top surface facing down, with the intention of reducing the need for sanding or finishing, but this made it impossible to see the veining and mottling during creation of the fill. A new mold was made with the open face of mold being the "show face." This made it easier to manipulate the appearance of the fill, but the fill did require some polishing after curing. The fill itself was made by mixing various shades of epoxy (EpoTek 301) tinted with dry pigments and bulked with fumed silica (fig. 9). After the epoxy cured, the fill was adhered with a 30% (w/v) solution of B-72 in acetone. Minor gaps along the edges were filled with Modostuc and then inpainted with Gamblin Conservation Colors (fig. 10).

5.5.3 Treatment of the Black Dividers

Replacement black marble dividers were made by casting epoxy, heavily tinted with black pigment and bulked with glass microballoons, into a polyvinyl siloxane (PVS) putty mold made from an original divider (which had been temporarily removed during the rejoining and realignment process described above). After the fills set, they were polished with progressively finer Micro-mesh to replicate the original gloss. The fills were shaped and then adhered in place with a 30% (w/v) solution of B-72 in acetone.

5.5.4 Treatment of the Orange and Black Stone

To fill the losses of the orange and black stone, tentatively identified as a breccia with white quartz druzy overgrowth (cf. Corsi sample 781), a multistep process using previously cured pieces of epoxy was used. First, a layer of 30% (w/v) solution of B-72 in acetone bulked with glass microballoons was applied in the area of the loss to create a flat base for the fill. A 15% (w/v) solution of B-72 in acetone was used both to isolate the edges of the loss and to protect temporarily the surface surrounding the fill. A liner of Japanese tissue, previously toned with acrylic paint and coated with a 10% (w/v) solution of B-72 in acetone, was inserted in the loss above the bulked B-72 to increase reversibility (fig. 11a). Small pieces of dental plate wax were placed in the fill to act as resists for sections chosen to be filled with another color later (fig. 11b). Epoxy (EpoTek 301) was allowed to partially cure then mixed with dry pigments and bulked with fumed silica. Gray-, black-, white-, and beige-tinted epoxy along with cured black epoxy chips were placed in the fill in imitation of the original stone. After the epoxy cured, the wax was removed mechanically and with mineral spirits. Previously cured orange-tinted epoxy

Fig. 9. Fabrication of the tinted epoxy fill in its silicone rubber mold (Courtesy of Historic New England)

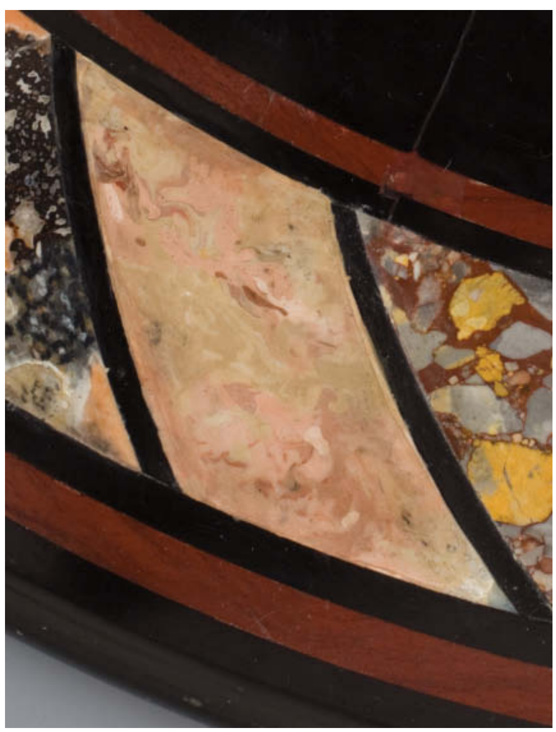

Fig. 10. The completed replacement stone inlay (Courtesy of Historic New England)

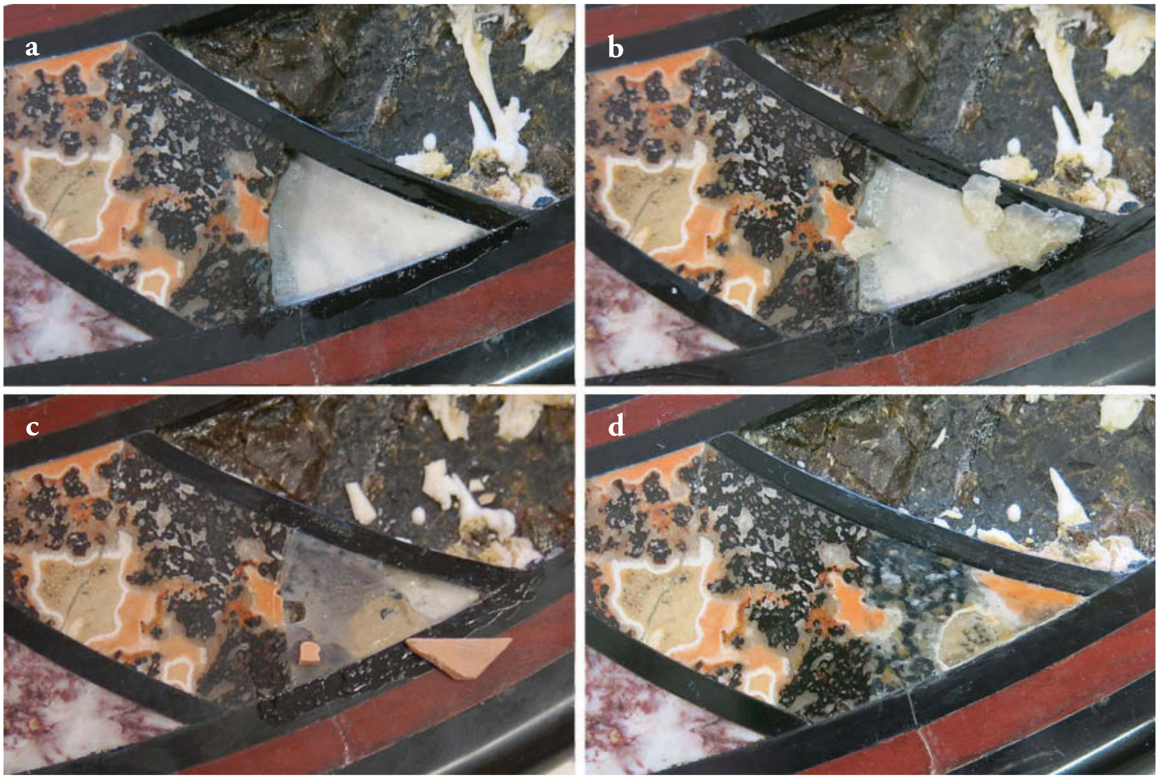

Fig. 11. Steps in the filling and inpainting of the orange and black stone: 11a. applying a paper barrier layer; 11b. reserving areas with wax; 11c. placing orange epoxy chips into the reserved areas after the gray-, beige-, and white-tinted epoxy cured; and 11d. the completed fill (Courtesy of Historic New England)

was shaped with a jeweler's saw and scalpel then placed in the reserved areas (fig. 11c). White-tinted epoxy was used to fill the gaps between the orange pieces and the rest of the fill in imitation of the quartz druzy effect. After the epoxy cured, the surface was smoothed with sandpaper and Micro-mesh, and the temporary B-72 barrier surrounding the fill was removed. Fine details which couldn't be achieved with epoxy alone were added with Gamblin Conservation Colors in an isopropanol diluent. After curing, the epoxy fill was polished with Micro-mesh then coated with Acrysol WS-24 to create a high gloss (fig. 11d). The same high gloss could have been achieved with continued Micro-mesh polishing alone, but using Acrysol WS-24 saved time. This fill demonstrated that the translucency and depth of the original stone could be more closely matched by using tinted epoxy with painted details than by using paint alone.

5.5.5 Treatment of the Purple and Green Stone

A similar multistep approach was taken for the loss to the green and purple stone, which resembles a diopside-containing metagabbro from Corsica (cf. Corsi sample 964). The area of loss was prepared in the same way as the orange and black stone (see section 5.5.4). Striated purple epoxy (EpoTek 301) chips were made by mixing multiple shades of purple-tinted epoxy, casting the epoxy onto polyester sheet, and carefully drawing the colors across each other with a toothpick to create patterns (fig. 12). After the epoxy cured, it was broken into chips with irregular edges; these were placed onto the Japanese tissue liner and adhered with epoxy bulked with fumed silica. Then various shades and opacities of green-tinted epoxy were dribbled around the chips, with clear, untinted epoxy added as necessary. The fill was finished as above (fig. 13).

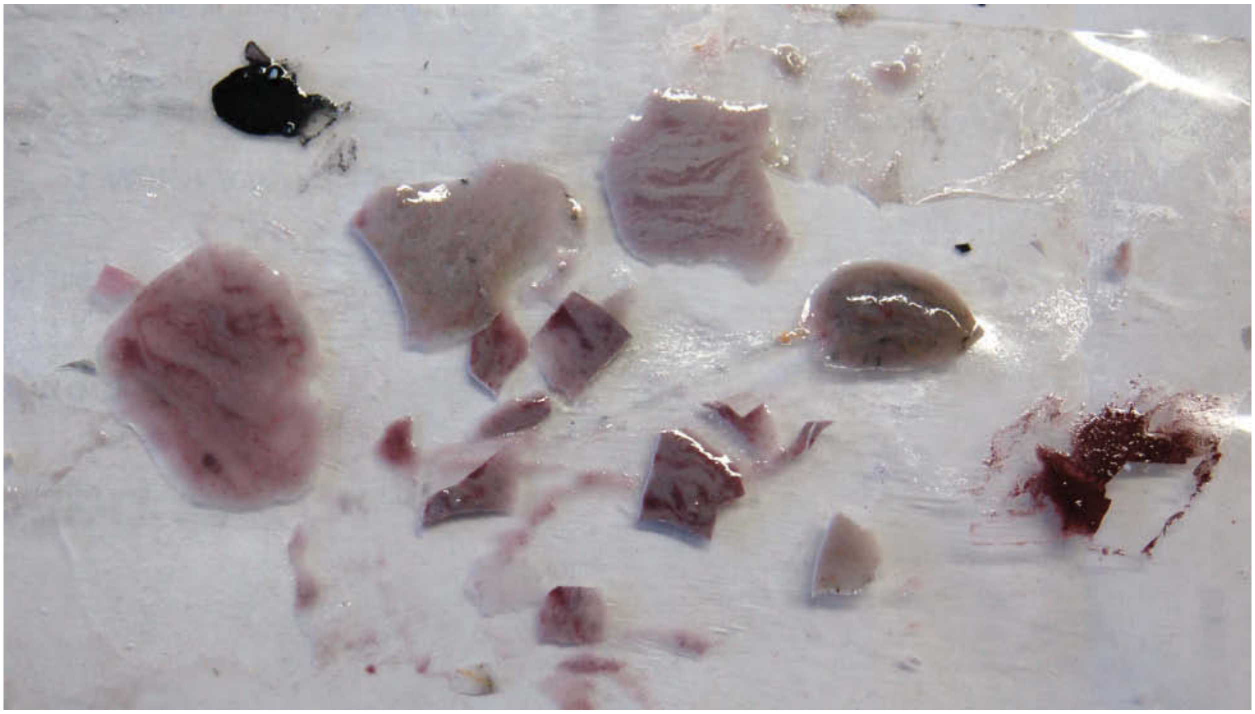

Fig. 12. Creating striated epoxy chips (Courtesy of Historic New England)

Fig. 13. The purple and green stone after treatment (Courtesy of Historic New England)

5.6 TREATMENT OF MICROMOSAICS

5.6.1 Approaches to the Treatment of Micromosaics

The simplest approach for Historic New England's tabletop would have been to create toned fills for the areas of loss, but the damage was located directly in the center of the table. As mentioned above, micromosaics are mass-produced objects, with a fairly limited visual repertoire. Certain scenes like the Doves of Pliny are produced over and over again. As another copy of a print can inform the replication of lost sections, it was both possible to recreate the missing portions using other examples and desirable to eliminate the visually distracting damage by using a more restorative treatment approach.

Although several books have been written on the history of micromosaics, almost nothing has been published on their conservation, aside from an unpublished German dissertation (Welsch 2011) and an article on the present-day work of the Studio del Mosaico Vaticano (Di Buono 2014). Craft-based approaches are still used by some. For example, in her treatment of an object from the Gilbert Collection, Laura Hiserote, a micromosaic artist, removed any broken or chipped smalti, replaced lost smalti with new glass smalti, filled in between smalti with colored "grout," and then polished the entire surface (Hiserote 2003).

Like the conservation of the pietre dure, using a traditional craft-based approach was both impractical and undesirable. The conservation department lacks the equipment and the skills to make new

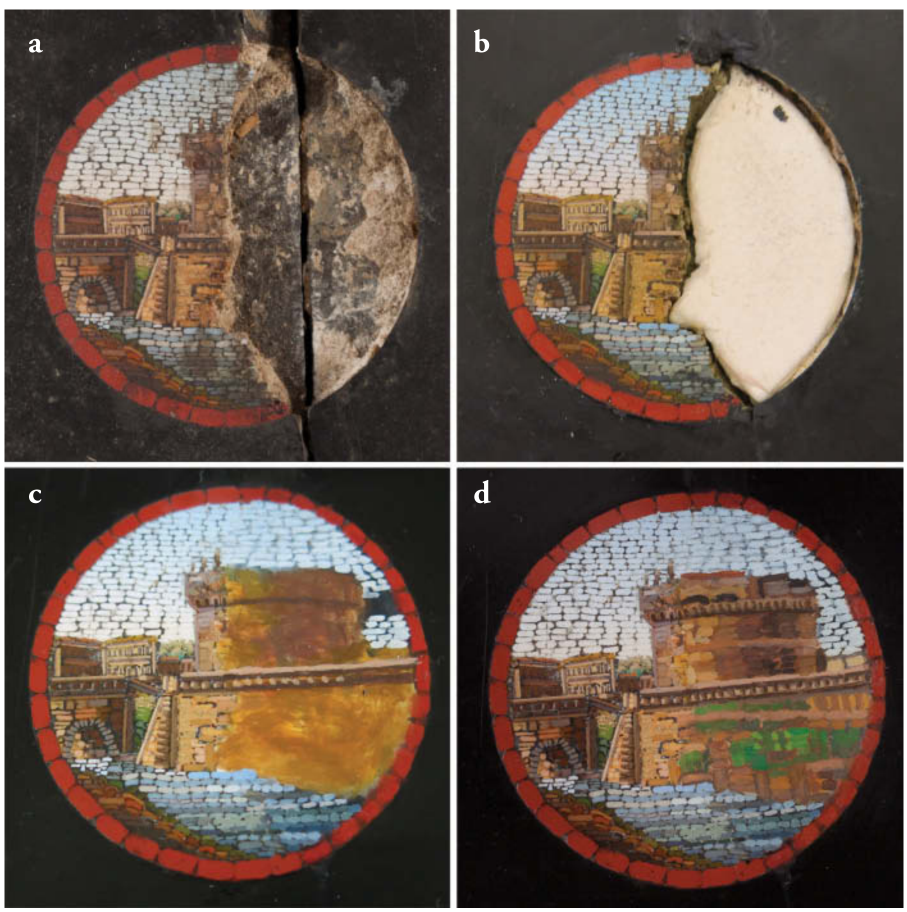

Fig. 14. Steps in filling and inpainting the micromosaic of Castel Sant'Angelo: 14a. the micromosaic before treatment; 14b. filling the bulk of the loss with matboard; 14c. during inpainting; 14d. after inpainting (Courtesy of Historic New England)

Fig. 15. The micromosaic of the Doves of Pliny, before treatment (Courtesy of Historic New England)

Fig. 16. The micromosaic of the Doves of Pliny, after treatment (Courtesy of Historic New England)

smalti, and even with the best documentation, the use of new glass smalti doesn't fit current conservation standards of distinguishability and reversibility. The idea of making smalti out of tinted epoxy or Paraloid B-72 was briefly considered but then dismissed due to time constraints. But this possibility should be kept in mind for the future, especially if only a small range of colors and shapes is needed.

5.6.2 Filling for the Micromosaics

Instead of using new smalti made of glass or resin, it was decided to replicate the look of the smalti using a multistep filling and inpainting approach. The first step in compensation was to fill the lacunae. Acid-free matboard was used to fill the bulk of the large, deep losses in the micromosaics of Castel Sant'Angelo and the Doves of Pliny. The shaped matboard was consolidated with dilute B-72 and adhered in place with a 10% (w/v) solution of B-72 in acetone bulked with glass microballoons (figs. 14a, 14b). Then for all the micromosaics, the remainder of the loss was filled with Modostuc. Tinted washes of Gamblin Conservation Colors in isopropanol were applied over the Modostuc in order to replicate the colored wax and dirt surrounding the original smalti.

5.6.3 Inpainting the Micromosaics

The inpainting of the micromosaic designs was based on similar examples found online and in published references. In order to recreate the micromosaics' appearance, individual lines were painted over the tinted background fills using small but medium-rich strokes of Gamblin Conservation Colors in

Fig. 17. The tabletop after treatment (Courtesy of Historic New England)

Fig. 18. The tabletop and its base after treatment (Courtesy of Historic New England)

an isopropanol diluent (fig. 14c). Gamblin paints were chosen because of their high refractive index, easily controllable gloss (adjusted with Laropal A-81), and low color shift compared to acrylics. Micro-mesh was used to tone down excess gloss or bumps in the brushstrokes. The two-step inpainting process recreated the gloss and height difference between the smalti and the colored wax background (figs. 15, 16).

5.7 POLISHING AND COATING THE TABLE

The table was coated to increase gloss, unify the surface, and provide some protection against wear and handling. Different coatings were tested: 7% B-72 in Cyclosol, 10% Regalrez 1126 in Shellsol 340 HT, and Butcher's Paste Wax. Butcher's Paste Wax gave the best results, saturating the surface without looking artificial. However, the wax did not hide the fine damages to the surface. Micro-mesh was used to reduce the most noticeable etching of the black stone near the center of the table. The table was then given a coat of Butcher's Paste Wax, taking care to avoid rubbing the wax over the micromosaics because of the solubility of the colored wax. After the wax dried slightly, the surface was buffed to increase shine (Figs. 17, 18).

6. CONCLUSIONS

This project provided an opportunity to research the materials and methods of two fascinating but rarely encountered techniques. Approaches to their conservation, especially as practiced in Europe, were explored. Some aspects of these conservation methods, such as using resin to recreate stone, were adapted for this project, but others, such as using glass smalti, were found to be impractical and unsuitable. The finished treatment demonstrated that using a modern conservation approach instead of a more traditional craft-based approach could be both aesthetically successful and meet current standards of reversibility and distinguishability between original and new materials. This project also showed the need for continued research and practical projects on micromosaics and pietre dure. For example, more research needs to be done into the materials of micromosaics, especially the "mastic." Future treatment projects could optimize the use of epoxy to replicate decorative stones, including complex stones like breccias.

ACKNOWLEDGMENTS

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NOTES

1. For Fourier transform infrared (FTIR) spectroscopy, each sample was analyzed using an IlluminatIR infrared microspectrometer (SensIR, now Smiths Detection, Danbury, CT), in combination with an Olympus BX50 polarized light microscope. The IlluminatIR is equipped with an MCT (mercury telluride, cadmium telluride) detector and interchangeable objectives including a contact attenuated total reflectance (ATR) objective with zinc selenide focusing crystal and diamond ATR window. The samples were placed on a Low E-glass slide (Smiths Detection) and analyzed using the contact ATR objective. A total of 64 scans were gathered for the background spectrum and 128 scans for the sample spectrum in the 4,000–650 cm^{-1} region at a resolution of 4 cm^{-1}. Spectra were captured in absorbance mode, processed according to a 1st derivative absolute value, and searched against a number of spectral libraries, including the IRUG Spectral Database Edition 2000. Spectral software included QualID 2.51 (Smiths Detection), as well as GRAMS 7.01 and Spectral ID 3.02 (Thermo Galactic, Waltham, Massachusetts).

2. Polarized microscopy was performed using an Olympus BX-50 microscope under visible light and UV epi-illumination. Photomacrographs were taken with an Olympus Q-Color 5 digital camera using a 10X objective. The visible light source was a halogen lamp (750W, 120V, polarizing filters); the ultraviolet source was a mercury xenon lamp (OSRAM Xenophot Longlife HLX 64623 100W 120V) in combination with an Olympus 11000 filter cube (excitation filter = 320–380 nm, suppression filter = 420 nm).

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SOURCES OF MATERIALS

Acrysol WS-24, EpoTek 301, fumed silica, glass microballoons, Paraloid B-72
Conservation Resources
5532 Port Royal Rd.
Springfield, VA 22151
800-634-6832
http://www.conservationresources.com/

Butcher's Bowling Alley Paste Wax
The BWC Company, Inc.
15559 Union Ave. Ste. 208
Los Gatos, CA 95032
800-569-0394
http://www.bwccompany.com/

Calcium carbonate (precipitated chalk), Gamblin Conservation Colors, Modostuc
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com/

Dry Pigments
Kremer Pigments
247 W. 29th St. C
New York, NY 10001
212-219-2394
http://www.kremerpigments.com/

Triton XL-80N (no longer available; Surfonic JL-80X is a replacement)
Museum Services Corp.
385 Bridgepoint Dr.
South Saint Paul, MN 55075
651-450-8954
http://www.museumservicescorporation.com/

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AN UNEXPECTED SURFACE: RESEARCH AND TREATMENT OF A 19TH CENTURY MOUNTED OYSTER SHELL BY FROMENT-MEURICE

EMILY BROWN

An oyster shell set into a delicate gold, silver, and gilt-silver metal mount belonging to the Walters Art Museum required treatment. Made in the late 1870s in Paris by the celebrated goldsmith firm Froment-Meurice, the object was damaged and heavily tarnished. Analytical testing and literature research indicated that the silver components might, in part, contain an originally applied patination layer (oxidized silver or *argent noir*). Since intentionally patinated silver surfaces are rare in museum collections and literature resources are scarce, it was decided not to polish the silver components, while the object would be cleaned overall and tarnish reduced only on the gilt-silver and gold components. After careful testing, an acidified thiourea solution made with sulfuric acid and gelled with xanthan gum was used to reduce the tarnish on the delicate gold and gilt-silver components. The formulation of the gel allowed for an extremely controlled application, and treatment resulted in a bright, shiny surface for the gilt-silver and gold metal, which required no additional buffing or polishing. The intent of this article is twofold: first, it will present current research, resources, and further avenues to investigate oxidized silver within the context of the Froment-Meurice workshop; second, it will describe an efficient, controlled method to chemically reduce tarnish on delicate gold and gilt-silver surfaces.

KEYWORDS: Froment-Meurice, Gold, Gilt-silver, Silver, Oyster shell, Pearl, Oxidized silver, *Argent noir*, Patina, Tresors D'Argent, Tarnish removal, Thiourea, Xanthan gum gel

1. INTRODUCTION

An oyster shell set into a delicate gold, silver, and gilt-silver metal mount was tarnished and damaged, requiring treatment (fig. 1). Attributed to the celebrated Parisian goldsmith Émile Froment-Meurice, the object belongs to the Walters Art Museum (WAM) in Baltimore, Maryland. William Walters, a successful and wealthy Baltimore businessman, acquired the piece through his Paris art dealer George Lucas, who paid a sum of money to the Froment-Meurice firm on November 7, 1878 (Briggs 2015). This purchase likely includes this object and may have included several other objects owned by William Walters. In a contemporary description of items in the Walters collection, the author mentions a "handsome private table service," as well as a mounted oyster shell "from Meurice" sitting in the parlor of the Walters' townhome:

> [A] charming conceit in gold and silver, representing two little boys attempting to pry open a huge pearl oyster, which is supported by two gilt mermaids, and sprigs of seaweed in gold are seen lying in the polished interior of the shell. (Lamb 1892, 256)

Much of the history of usage, care and handling, display, and storage of the oyster shell is undocumented and was unknown until the 1970s. One historic image exists of the oyster shell with another similar object (fig. 2). This photograph was likely captured in the mid- to late 1930s, around the time the Walters collection was being cataloged for the establishment of a public museum, then named the Walters Art Gallery. Based on the object's undamaged appearance in this image, it was damaged after this date—how it was damaged is unknown. What *is* known is that after this time, the object was stored in a room lined with rubber floor mats. Over many years, these mats generated hydrogen sulfide pollutant gas, which hastened tarnishing of the silver objects stored in the room, including the mounted oyster shell—a fact well known to current WAM staff (Craft 2015).

During the examination and literature research phase of this project, I came across Judy Rudoe's 1993 paper describing the popularity of patinated silver in France beginning in the mid-19th century, and its use by Froment-Meurice. For objects with this decorative finish, a chemical solution is applied to the surface to intentionally create an artificial, dark tarnish, often referred to as oxidized or colored silver,

Fig. 1. Émile Froment-Meurice, *Two Putti Discover a Pearl in Oyster*, ca. 1878, oyster shell, pearl, silver, gold, gilt-silver, 21.9 × 16.3 × 15.25 cm, Walters Art Museum, #57.1015 (Courtesy of the Walters Art Museum)

Fig. 2. Object on left: same as figure 1; object on right: artist, title, date, and materials unknown, 6.7 × 6 cm, Walters Art Museum, #57.1017 (Courtesy of the Walters Art Museum)

French gray, or *argent noir* (darkened silver) (Selwyn 2004). This information, combined with observations made during examination and limited analytical investigation, led me to believe that a portion of the silver components on the Walters mounted shell may have been given an intentionally patinated surface at some point in its history.

This project was not intended to be a technical study; however, the possibility of the object having an originally patinated surface was intriguing enough to warrant my continued interest and further investigation. With the time and resources available, I was not able to find or examine works with an oxidized silver surface, nor was I able to locate published photographic examples of these surfaces. Research indicates that the existence of these types of surface finishes are rare in museum collections; thus, my colleagues and I decided and that a conservative treatment approach was most appropriate to preserve any remnants of original finish for potential future analysis.

2. THE GOLDSMITH FIRM FROMENT-MEURICE

The goldsmith firm Froment-Meurice was founded in the early 19th century by François-Désiré (F.D.) Froment-Meurice and was continued after his death in 1855 by his son Émile (Marchessaeu 2003). F.D. created many elaborate silver, gilt-silver, and gold pieces enhanced with enamels and jewels in the Neogothic and Neorenaissance style. Among his most known works is the toilet set of the Duchess of Parma, which was displayed in the Great Exhibition of 1851 in Hyde Park, London, and is now in the collection of the Musée d'Orsay. Many published sources, both in French and English translations, describe the works of Froment-Meurice under F.D.'s direction, such as world exhibition catalogs and his biography penned by Philippe Burty. It is through these resources that Rudoe gleans information about F.D.'s use of oxidized silver in his designs and the materials he may have used to produce them.

F.D. passed away in 1855, just as he brought his firm into international renown. At the time of his death, Émile was 18 years old and apprenticed in the firm's workshop located at 372 rue Saint-Honoré, Paris. He did not take direct lead until 1859. Until about 1865, works created by Froment-Meurice follow in the stylistic tradition of F.D.

Émile retained the international renown established by his father and continued to create sumptuous pieces for royalty, foreign heads of state, the Church, and wealthy patrons. Under his direction, the firm became the official goldsmith for the City of Paris. He is known for creating a three-tiered papal crown for Pope Leo XIII commemorating his golden jubilee of priesthood in 1888, and exhibiting in the 1865 and 1867 international expositions. Unfortunately, company documents no longer exist. According to Briggs (2015), they were destroyed by fire, perhaps caused by the collapse of Émile's house at 49 rue d'Anjou on April 25, 1913 (*New York Times* 1913). Tragically, Émile and his wife, Rose-Félicie-Berthe Thomas de Montcourt, were killed. The *New York Times* reported on April 26, 1913, that the two were dining with their grandson François when the house collapsed into a 20-ft. excavation adjoining the property. Rescuers located the victims in the rubble by following the cries of François, who miraculously survived with only a few bruises.

2.1 FROMENT-MEURICE AND OXIDIZED SILVER

In Napoleonic Era France and England, there was a resurgence of gilding as a means of promoting the wealth and aura of the newly burgeoning Neoclassic French Empire. Pre-existing works in silver were typically gilt overall by means of mercury fire gilding. However, by the 1840s, electroplating technology was patented and became widely utilized in the goldsmith industry as a safer, less expensive alternative (Vitali 1997). Rudoe (1993) writes that in 1840s France, it was fashionable to create antiqued or oxidized silver surfaces by way of intentionally darkening or coloring the surface using chemical means, and that F.D. employed this technique for his works:

> Froment-Meurice's biographer, Phillipe Burty, described several oxidized items and noted that the writer, Eugéne Sue, who commissioned several pieces of silversmith's work from Froment-Meurice, discussed with the artist which parts were to be in *argent noir* [black silver]. In one of his letters to Froment-Meurice, Sue even requested, "a small bottle of liquid to blacken the bright silver" (Burty 1883 p.23). (Rudoe 1993, 162)

Two examples of jewelry pieces with surviving oxidized surfaces attributed to F.D. exist in the collection of the British Museum, notably a necklace (accession #1978, 1002.725) and a finger ring (accession #AF.2578). Froment-Meurice and many of his contemporary metal artisans were able to create stunning works that utilized the combination of bright gold and silver against darkened silver surfaces. Oftentimes these objects would contain other materials such as enamels, jewels, and ivory, resulting in richly textured and complex surfaces.

2.2 TRESORS D'ARGENT

A more recent publication can now be added alongside Rudoe's research—the 2003 French catalog *Tresors D'Argent [Silver Treasures] Les Froment-Meurice*, authored by Daniel Marchessaeu. This catalog accompanied an exhibition at the Musée de la Vie Romantique [The Museum of Romantic Life] in Paris, from February 4 through June 15, 2003, and contains many examples of the firm's work under the direction of both F.D. and Émile.

In general, the catalog text is art historical in nature rather than technical (Pouliot 2015; Quandt 2015). Works represent the artistic grandeur the firm is known for—exquisite objects in silver, gilt-silver, and gold combined with glass, enamels, jewels, and figured stone. Also apparent among the selection are objects with combination of bright silver and gold metal paired with dark metal surfaces, or dark stone and black enamel. Many of the material descriptions in the catalog for these objects are simply "argent" or "silver," even when the accompanying image displays a uniform, homogeneous dark surface appearance. One such example is *Presse-papiers commandes par la duc d'Aumale*, which is described as "Porphyre, argent, or, ivorie, email et aquarelle sur ivorie," or "Porphyry [rock], silver, gold, ivory, enamel and watercolor on ivory," seen in figure 3 (Marchessaeu 2003,154, 208).

However, *Lyre d'argent a la memoire de Victor Hugo*, dated 1885, is described as "argent, argent oxyde, tôle peinte," or "silver, silver oxide, painted sheet metal" (Marchessaeu 2003, 206), indicating that the silver is in part intentionally patinated to appear dark. As can be seen in figure 4, the silver surfaces appear very dark overall, which makes it difficult to draw conclusions about the care and treatment the object received, or how the current appearance relates to its manufacture, or history of display and use.

The most remarkable works in the catalog are two objects and one drawing that bear a striking resemblance to WAM 57.1015: one extremely similar mounted oyster shell (private collection) (fig. 5), a smaller silver object (private collection) (fig. 6), and a contemporary design drawing dated 1878 (collection of Patrimonio Nacional, Madrid) (fig. 7).

When compared to WAM 57.1015 in figure 1, figures 5 and 6 display bright gold and silver surfaces, which may lead the viewer to believe that the mounted oyster shell in the Walters collection was intended to have a similar appearance. However, it is important to note that both *Coquille d'huître* and *Coupe couquille*, as well as *Presse-papiers commandes* (see fig. 3), belong to private collections where their history and care is unknown and that objects of this type were not mass produced but made for clients to their individual liking.

2.3 FROMENT-MEURICE IN AMERICAN COLLECTIONS

Although most of the work by Froment-Meurice is housed in European collections, pieces do exist in American museums, albeit in limited numbers. Examples include *Jewel Casket* at the Los Angeles County Museum of Art (accession #M2005.174a–b) and *Centerpiece* at the Philadelphia Museum of Art

Fig. 3. Émile Froment-Meurice, *Presse-papiers commandes par la duc d'Aumale*, 1886–1888, materials unknown, 21 × 23 × 12 cm, Private collection (Courtesy of Marchessaeu 2003, 154)

(accession #1980-41-1), and a very intriguing silver and gold shield made around 1881, which was designed by Gustave Doré.

Commissioned by the government of Argentina, this shield was presented to US Ambassador Thomas O. Osborn to commemorate his assistance negotiating the boundary between Argentina and Chile. It is listed in the 1907 catalog of the Art Institute of Chicago (AIC) under inventory #1451. The catalog describes the object as "An elliptical shield of oxidized silver, with borders and divisions between panels in gold and enamel," and "On a scroll is an inscription in Spanish dated Buenos Ayres, July 13, 1881. The

Fig. 4. Émile Froment-Meurice, *Lyre d'argent a la memoire de Victor Hugo*, 1885, argent, argent oxyde, tôle peinte [silver, silver oxide, painted sheet metal]. Maison de Victor Hugo, Paris, inv. #1004 (Courtesy of Marchessaeu 2003, 206)

Fig. 5. Émile Froment-Meurice, *Coquille d'huître*, ca. 1880, coquille d'huître, perle, argent de argent doré, dans son écrin d'origine gainé de cuir rouge [shell, pearl, silver and silver gilt, in its original case of red leather], 20.5 × 13 cm, Private collection (Courtesy of Marchessaeu 2003, 20, 212)

Fig. 6. Émile Froment-Meurice, *Coupe couquille*, ca. 1880, argent, socle de marbe rouge [silver, pedestal of red marble], 14.4 × 15.7 × 14.3 cm, Private collection (Courtesy of Marchessaeu 2003, 113, 213)

Fig. 7. Anonymous, *Projet pour une coupe in émail, vermeil, huître, perliére*, 1878, Patrimonio Nacional, Madrid (Courtesy of Marchessaeu 2003, 85, 220)

substance of this inscription is given in English above" (Art Institute of Chicago 1907, 324). In 1907, the shield was listed as being on loan from Thomas O. Osborn, although evidence suggests that the shield was at one point in the collection of the Chicago History Museum (Clark 1935). A short article and image of this object is found in the December 5, 1894, issue of the journal *The Jewelers' Circular and Horological Review* (fig. 8). Along with the commemorative lyre to Victor Hugo, this may be further evidence that Froment-Meurice was producing silver objects with oxidized finishes in the late 19th century, and therefore it is possible that the Walters mounted oyster shell may contain such a surface.

2.4 CHEMICALS USED TO COLOR SILVER IN THE 19TH CENTURY

Rudoe's 1993 article refers to several sulfide-containing chemical compounds used by arts-and-crafts silversmith Henry Wilson in 1903 to color silver: barium sulfide, ammonium sulfide, and

Fig. 8. Artist unknown, *Shield Presented to Thomas O. Osborn, U.S. Minister, by the Argentine Republic*, ca. 1881; collection, materials, and measurements unknown (Courtesy of *The Jewelers' Circular and Horological Review Vol. XXIX* [No. 19] 1894)

potassium sulfide. Additionally, Drayman-Weisser (1984) writes in her technical study of an archaeological silver kanthros of the late 19th century Parisian restorer Leon André, who would "antique" archaeological silver objects using silver chloride after the removal of corrosion products.

During my consultation with Drayman-Weisser (2015), she noted that a lavender color, which is visible on the head of the detached Froment-Meurice putto (see section 3.2.1), looked very similar to a color found on the kanthros. She believes that this color is a by-product of the silver chloride restoration treatment that may have been carried out by André's workshop in the late 19th or early 20th century. XRF analysis was unable to detect chlorine at the time of her study, as it was not within the detection range of the instrument. Since the kanthros is in the study collection of the WAM, the author was able to visually examine the object to compare the surface appearance and color—the two lavender colors were indeed strikingly similar.

3. *TWO PUTTI DISCOVER PEARL IN OYSTER* BY ÉMILE FROMENT-MEURICE

3.1 DESCRIPTION

The object (see fig. 1) depicts two putti playfully discovering a pearl inside an open oyster shell set into and supported by two decorative nets of seaweed—a clasp and a false hinge. In the bottom half of the shell, an irregular natural pearl is set in a carved cavity. The shell, putti, and seaweed are held aloft by a merman and mermaid, who have intertwined fish tails that gracefully extend into the waves of the sea that form the foot. This decorative stem is mechanically attached with a metal screw and nut to the round base. Two small maker's marks on the outside of the round base—a boar's head and the initials F.M., and an ear of wheat in a lozenge—attribute the piece to Froment-Meurice (Briggs 2015). XRF analysis determined that the two putti are composed of a silver-copper alloy containing a trace amount of iron, the seaweed clasp and hinge from a gold-silver alloy, the decorative stem from a silver-copper alloy, and the round base of a silver-copper alloy with a gold-enriched surface (Gates 2015; Matsen 2015).

The decorative stem and putti are likely lost wax cast and finished by chasing with tools to add fine surface details. The gold seaweed clasp and false hinge appear to be made by a variety of techniques, including casting, stamping, hand forming, granulation, and finishing with fine tools, where all pieces are soldered together. In addition, a white metal is visible in places on the interior of the false hinge. The hinge may therefore be composed of at least two different metal alloys, where all parts are soldered together and then electroplated with gold to give the surface a uniform color and appearance.

The seaweed clasping the bottom half of the shell is soldered to the two outstretched hands of the merman and mermaid of the decorative stem, which is made from several cast and chased pieces soldered together. The gilt-silver base appears to be either lost wax cast or stamped, and likely gilt by way of electroplating.

The putti, shell, and seaweed were originally attached together mechanically by means of small metal pins on the metal pieces, which were inserted into corresponding holes in the shell. Interestingly, x-ray radiography shows that the pearl, originally adhered into the cavity in the bottom half of shell, contains a small hole drilled through its length. Considering that it does not appear to mount the pearl in the shell, it is possible that the pearl was repurposed from a piece of jewelry.

3.2 CONDITION AND EXAMINATION

Prior to treatment, this inherently fragile object was in poor condition overall. It was damaged and in five separate pieces: the top half of the oyster shell, the natural pearl, the seaweed hinge, and one putti were all detached from the decorative stem and bottom half of the oyster shell (see fig. 1). Surface dirt and grime was evident overall. Two different types of adhesive residues from possibly two prior campaigns of repair were also evident on several areas of the shell and metal components. The false hinge was bent out of its original alignment and could no longer attach properly or support the top half of the shell. Both halves of the shell were also very fragile and exhibited weakening of the layered structure at the edges, which was prone to delamination, flaking, and breaking.-

The metal surfaces displayed a variety of tarnish and corrosion phenomena (fig. 9). Specifically, the silver surfaces on the putti and decorative stem exhibited extreme darkening from what appeared to be silver tarnishing, but a close microscopic examination revealed a complex surface appearance. Overall, these surfaces exhibited a homogenous shiny, steel-grey color with a subtle purple-blue iridescence. A matte black, powdery corrosion product appeared to sit on top of this color and in some places was visible underneath and creeping out over the adhesive. Also visible under the adhesive were areas of bright silver, which would indicate a "clean" or polished surface.

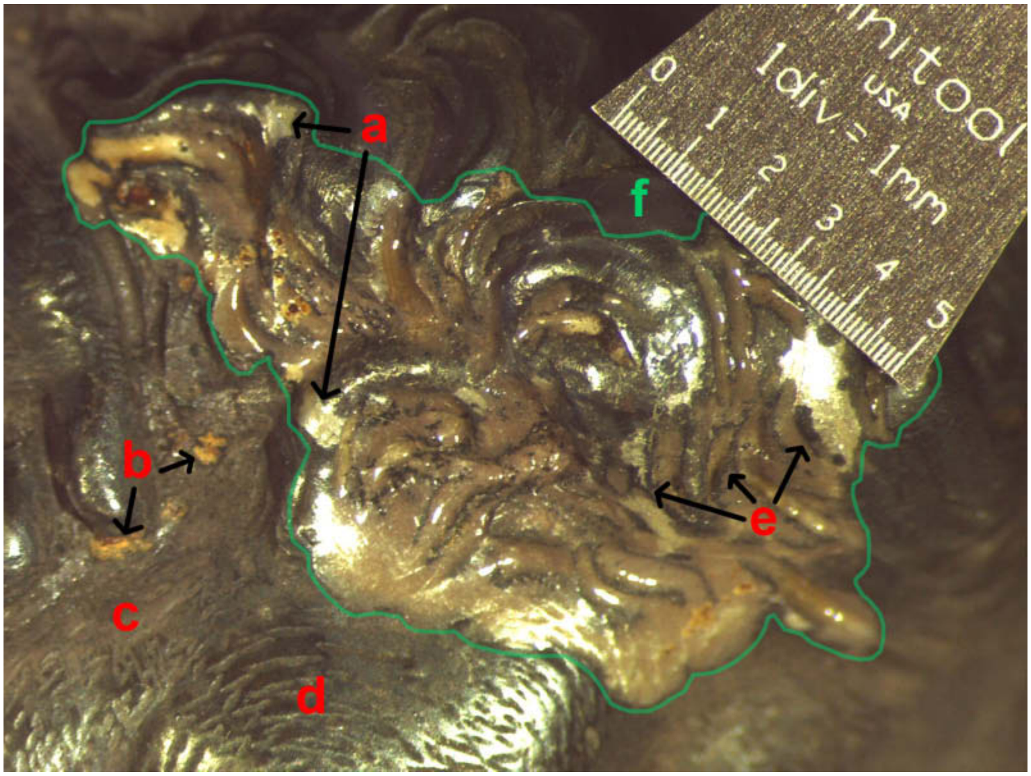

Fig. 9. Head of putto in area partially covered with aged adhesive. a: shiny silver; b: iron corrosion; c: matte lavender color; d: steel-gray color; e: matte black powder. Image captured using a Leica IC80 digital camera with LED illumination. (Courtesy of the author)

In addition to this a matte, lavender color was visible in the recesses of the design on the two putti, as were local spots of iron corrosion. The lavender color, most visible in the hair and back of the neck, is consistent with the appearance of halide corrosion seen on archaeological silver objects (Craft 2015; Lauffenburger 2015; Selwyn 2004), and very similar to the lavender seen on the silver kanthros mentioned in section 2.4. As the kanthros is in the study collection of the WAM, I was able to examine the object as a comparison—the two lavender colors were strikingly similar. This color was not seen on the decorative stem of the oyster shell; instead, the recesses of the stem were brighter—more of the appearance of polished silver. There was no evidence of an overall protective coating, although the object was probably exposed to household cleaning products during the course of its history as a decorative object in the Walters' parlor. Objects conservation staff with long-standing knowledge of both the collection and the history of cleaning products used in the past thought that a product that could impart a lavender-colored residue would not have been used on this object, as it was purchased by William Walters soon after its manufacture and has little conservation or display history.

The gold surfaces of the seaweed net also displayed heavy accumulations of black tarnish and powdery black material rather than the steel-gray color seen on the putti and decorative stem. High points appeared brighter, as did the outside of the hinge, which was likely protected from air and pollutants due to lying on that surface during storage. In some places, particularly parts of the underside of the clasp and inner area of the hinge, bright gold was visible through a covering of aged adhesive. The gilt-silver surface of the round base displayed uneven and blotchy tarnish on both the top and underside, where fingerprints were visible. The surfaces of the top of the base and bottom of the foot, which were protected from atmospheric pollutants, were bright metal with very little darkening. These areas, which have been protected from tarnishing, heavily suggest the gold and gilt surfaces were originally intended to appear as bright gold. Literature resources discussed in section 2.1 also support the conclusion that bright gold surfaces were intended and sought after to portray the rich opulence of these types of decorative objects.

3.2.1 XRF Analysis and Interpretation

Due to time constraints and the treatment-focused nature of this project, in-depth technical analysis of all aspects of the corrosion products observed was not undertaken. Again, conclusions as to the nature and cause of the blackened surfaces rely heavily on the extensive experience the Walters conservation staff has with the collection and its conservation history. Limited XRF analysis was undertaken to explore the composition of the alloys and surface tarnish associated with the silver components with WAM conservation scientist Dr. Glenn Gates, as well as with conservation scientist Catherine Matsen in the Scientific Research and Analysis Lab at Winterthur Museum. The geometry of the object in relation to instruments used in both institutions prevented the analysis of key areas of interest, including the recess of the decorative stem.

Sulfur was detected on all metal components analyzed, including the gold seaweed net, clasp, round gilt base, and foot of the decorative stem. Both the putti and decorative stem were composed of a silver-copper alloy; however, iron was also detected in the alloy of both putti, which corresponds to the appearance of iron corrosion on both parts. Chlorine was also detected on the head of the detached putto, with a higher response rate associated with the lavender color visible in the recesses (Gates 2015). As mentioned in section 2.4, the 19th century Parisian restorer Leon André would use silver chloride to intentionally antique silver, and therefore an argument could be made that a chloride-containing solution was used to patinate the surface of the putto. Conversely, chlorine could also be present as a result of handling. Given the fact that the putto was detached from the object for so long, it is entirely likely that it was handled more frequently than other components.

4. DEVELOPING A TREATMENT RATIONALE

This project was undertaken with the consultation of WAM conservation staff members Meg Craft, Julie Lauffenburger, and Terry Drayman-Weisser; conservation scientist Dr. Glenn Gates; and Jo Briggs, curator of 18th and 19th Century Art. Many goals of the overall treatment were clear: clean the surfaces by removing dirt and grime, and repair the object, making it whole. It was also clear from observation and literature resources that the gold and gilt surfaces exhibited tarnish rather than an intentional coloring and should be cleaned to reveal a bright, shiny gold surface.

As described previously, the nature of the silver surfaces was less clear. The stratigraphy was complex, inhibiting an understanding of how the surfaces may have been originally prepared, and cleaned or polished in the past. Literature and analytical research previously described cast a note of caution for the wholesale removal of tarnish. Rudoe documents F.D.'s use of oxidized silver and the popularity of the fashion in Western goldsmith arts until World War I; however, there is no literature reference yet found as to whether Émile employed the technique for this work apart from descriptions found in *Tresors D'Argent* and the 1907 catalog of the Art Institute of Chicago. It is also apparent that there is a scarcity of published literature about the use of oxidized silver from an art historical or technical perspective, as well as from the conservation treatment or investigation viewpoint.

Given the rarity of known oxidized surfaces produced in the 19th century in museum collections, I deemed it prudent that a conservative approach be taken in the treatment of the silver surfaces of the mounted oyster shell. We decided that the best approach would be to clean the object overall to remove accumulated dirt, grime, and adhesive residues, but to only remove tarnish on the gold and gilt-silver metal components. Gold seaweed components would be reshaped and the pieces reassembled. This course of treatment would make the object whole again and restore a brighter, well cared for appearance in keeping with 19th century aesthetics of shiny gold surfaces contrasted with matte black as is evident in literature research while preserving options for future treatment and analysis.

4.1 CLEANING TESTS

Cleaning tests using cotton swabs with solvents and mild abrasives on the metal surfaces, as well as the shell and pearl, were conducted. Dirt and grime were effectively removed with 1:1 deionized water:ethanol, and the adhesives were removed with the 1:1 mixture or acetone. In general, mild abrasives caused a lightening of the steel-gray color on the decorative stem, but they did not generally affect the lavender color of the putto as readily. Unfortunately, areas of tarnish cleaned on the gilt-silver base were patchy and uneven using mild abrasives.

5. TREATMENT

5.1 SURFACE CLEANING AND CONSOLIDATION

Treatment began with surface cleaning to remove dirt and grime from the metal and shell components using swabs made with low-lint cotton (Webril Wipes) dampened with a combination of 1:1 deionized water:ethanol, or dilute Triton XL-80N in deionized water, which was cleared with 1:1 deionized water:ethanol and 1:1 acetone:ethanol. Aged adhesive was removed or reduced with either deionized water or acetone where possible. In some cases, complete removal from the object would place too much strain on delicate forms. Once the surface was cleaned, flaking areas of shell were consolidated on the surface using dilute Paraloid B-72 in acetone.

5.2 TARNISH REDUCTION USING ACIDIFIED THIOUREA

Acidified thiourea chemically dissolves silver sulfide tarnish, and complexes with and sequesters the free silver ions, resulting in the removal of tarnish from the surface (Selwyn 2004). In current conservation practice, thiourea is seldom used on silver objects due to side effects observed to adversely affect the surface, namely overcleaning, etching, forming unknown surface complexes, and increasing the rate of retarnishing, as well as health hazards to the user (Contreras-Vargas, Ruvalcaba-Sil, and Rodríguez-Gómez 2013). A recent study (van Santen 2014) corroborates these observations. Instead, mildly abrasive materials such as calcium carbonate and alpha alumina are widely used to polish silver.

However, in the case of the mounted oyster shell, it was determined that cleaning with abrasive materials would remove an unacceptable amount of original material from the gilt-silver surfaces, as well as place undue mechanical stress on the intricate and delicate seaweed forms. With these physical limitations, thiourea remains the best nonabrasive treatment option for objects of this type. After careful testing and consultation with Richard Wolbers, I decided to use a gelled solution of acidified thiourea to chemically reduce tarnish on the gold and gilt-silver components. This would achieve optimum physical control over application and contact time. A solution of thiourea and sulfuric acid was gelled with xanthan gum using the following recipe derived from one commonly used at WAM, gelled with xanthan gum (Wolbers 2015):

- 2 g xanthan gum
- 100 mL deionized water
- 5 mL concentrated sulfuric acid
- 8 g thiourea

The gel was made first by adding the xanthan gum to the water, letting it sit overnight, then adding the sulfuric acid and thiourea to the gel after it formed. Different acids may be used to acidify the

Fig. 10. Small cotton pads held with plastic tweezers to reduce risk of abrading the surface (Courtesy of the author)

thiourea, including hydrochloric, formic, and phosphoric acids (van Santen 2014). In this case, sulfuric acid is used to allow for quick action of the gel, which decreases dwell time, and thus time allowing thiourea to complex with the surface (Drayman-Weisser 2015).

In general, the thiourea gel was applied with a dry cotton pad, swab, or small brush, then rinsed several times with deionized water delivered with a cotton pad, swab, low-lint tissue (Kimwipe), or bristle brush. Areas were then dried with a Kimwipe and 1:1 acetone:ethanol. Specific application methods for the various components are as follows.

Gilt-silver base: Thiourea gel was used to reduce tarnish by applying in small amounts on cotton pads held with plastic tweezers (fig. 10). The gel was gently manipulated for up to 10 seconds before removing with a dry cotton pad, then immediately cleared and rinsed twice with small cotton pads wetted with deionized water and dried with Kimwipe tissue. A 1:1 acetone:ethanol mixture was applied to drive water off the surface. The clearance solvent was observed to remove an additional layer of grime or possibly a previous protective coating. Overall, the surface was treated with three applications of the gel, with two additional applications in areas of heavy tarnish (figs. 11, 12). Application areas did not exceed approximately 1 x 1 cm, which allowed for quick application, removal, and rinsing in under 20 seconds per application.

Seaweed hinge: Tarnish was reduced on the gold hinge by applying small amounts of gel with a small sable brush or a rolled cotton swab. Like the round base, the gel was gently manipulated for up to 10 seconds before removing with a dry brush or swab and rinsing with deionized water. Depending on the location, rinsing was done with a wetted swab, a larger round bristle brush or large sable brush, a wetted Kimwipe, or a wetted cotton pad. Brushes were very effective in cleaning the delicate, curving surface, and often the surface was rinsed and dried by placing a Kimwipe over the area and then gently tamping with a wet bristle brush (fig. 13). This pushed the wipe into the recesses of the form and removed the remaining gel. Dry bristle brushes were used to dry and buff the cleaned area, and aided with removing loose tarnish.

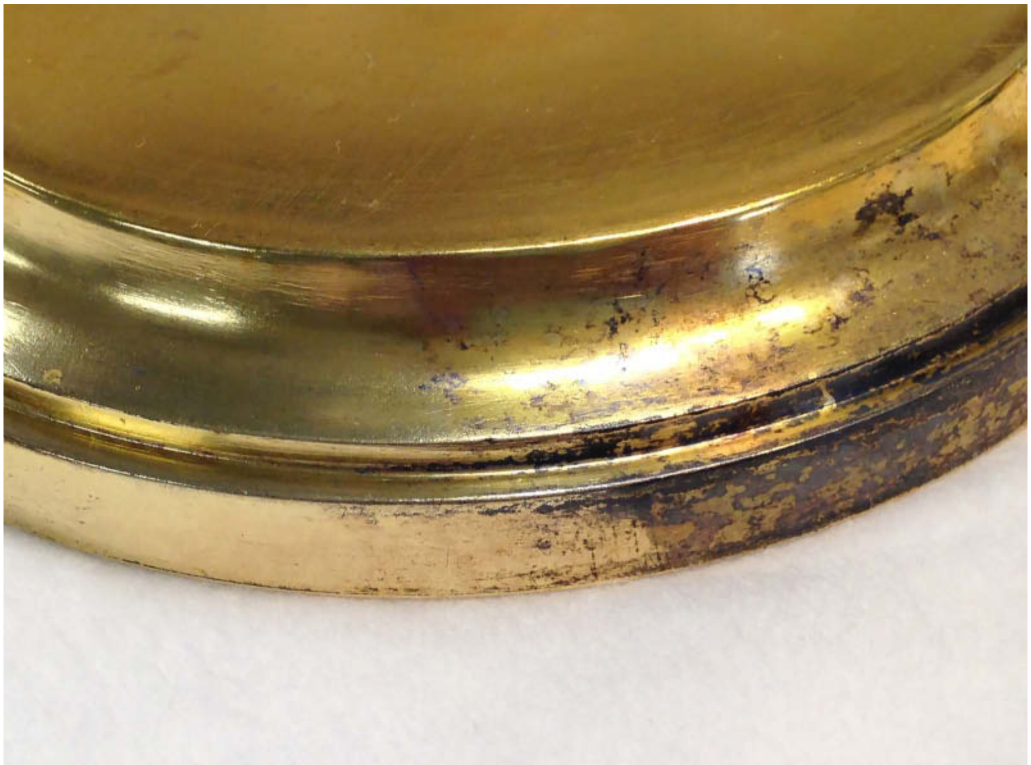

Fig. 11. During tarnish removal of the gilt-silver base (Courtesy of the author)

Fig. 12. During tarnish removal of the gilt-silver base, showing two small maker's marks (Courtesy of the author)

Fig. 13. Rinsing the gel using a Kimwipe and bristle brush wetted with deionized water (Courtesy of the author)

Fig. 14. Using a ring stand to hold the mounted shell upside down during treatment (Courtesy of the author)

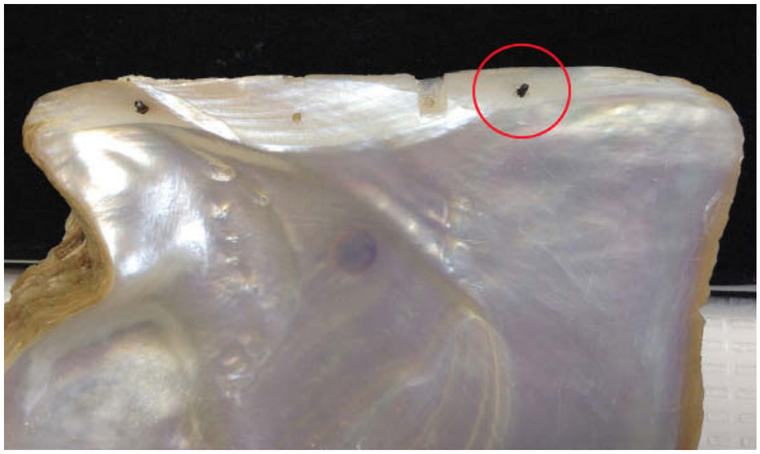

Fig. 15. The new pin circled in red (Courtesy of the author)

Fig. 16. After treatment, fully assembled (Courtesy of Walters Art Museum)

Fig. 17. After treatment, partially assembled (Courtesy of Walters Art Museum)

Fig. 18. The outside of the custom housing (Courtesy of the author)

Fig. 19. The inside of the custom housing (Courtesy of the author)

Seaweed clasp: Tarnish was reduced on the gold seaweed clasp in a very similar manner to the gold hinge with the same dwell time per application. Additional steps to protect the oyster shell were taken: where room allowed, silicone release Mylar was used to protect the shell by inserting it between the gold and shell, and the silver putti and decorative stem were protected by wrapping the components with Parafilm M. To allow access to the underside, the object was rested against a soft pillow or held upside down using a ring stand (fig. 14).

5.3 ASSEMBLING THE EXTANT COMPONENTS

The natural pearl was adhered to the carved cavity in the interior of the bottom half of the oyster shell with a 3:1 blend of 40% (w/w) Paraloid B-72:40% Paraloid B-48N in acetone:ethanol (approximately 10% ethanol w/w) (referred to as 3:1 B-72:B-48N). A resinous material that filled the ends of the small hole drilled through the length of the natural pearl was toned with Golden Fluid Acrylics to visually integrate the darkened material.

An additional support pin was fashioned from stainless steel black annealed mechanics wire and adhered in the empty end hole on the interior top half of the shell with 3:1 B-72:B-48N (fig. 15). The detached putto was adhered in place using 3:1 B-72:B-48N bulked with a fumed silica matting agent and tinted with silver-colored graphite powder.

Although the hinge and top half of the shell could be assembled onto the mounted shell component (fig. 16), the decision was made to leave the object partially unassembled to facilitate safer travel, handling, and storage while off display (fig. 17). A multifunctional box (figs. 18, 19) was made to keep the components together safely while in storage and hand-carrying transport. This box included a Pacific Silvercloth upholstered interior to scavenge for pollutants that would tarnish the surfaces. Instructions were provided in the proper assembly procedure, along with recommendations to use a temporary soft wax to secure the pieces while on display.

6. RESULTS

Treatment resulted in an overall cared for appearance that in many ways is in keeping with images of similar objects by Froment-Meurice and the aesthetics of the time. The acidified thiourea gel successfully reduced tarnish on the gold and gilt-silver metal, resulting in a bright, shiny surface that required no additional polishing. The gel allowed for excellent physical control over dwell time and application, and minimized or eliminated contact with sensitive shell and silver components. Although the presence of a patination layer is still unconfirmed, the dark surface has been retained for possible future study.

7. FURTHER RESEARCH

This project has provided many avenues for additional research and investigation, including the following topics:

1. Study and analysis to better understand how thiourea gel interacts with gold and gilt-silver surfaces, and any long-term preservation issues.
2. Study and analysis of soiled treatment materials to determine the nature and amount of original material removed by acidified thiourea in comparison to abrasive polishing, such as with cosmetic sponges, calcium carbonate, and alpha alumina. Results would provide quantitative information as to whether gelled solutions of thiourea are an appropriate option for tarnish reduction on gilt-silver surfaces, where the gilding layer is particularly vulnerable to removal via abrasive cleaning.
3. Identifying additional primary resources as to the process and manufacture of coloring silver in the 19th century, particularly in France. This would improve the understanding of this technique and aid in the analysis of objects to identify original patination finishes.
4. Study and analysis of 19th century silver objects documented to have patinated surfaces. This may include comparing patinated surfaces to nonpatinated surfaces, developing methods of detecting and identifying these surfaces using both nondestructive (XRF) and destructive (FTIR, XRD, SEM-EDS, and cross section) analytical methods.

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SOURCES OF MATERIALS

Fumed silica-hydrophobic, Webril Wipes
Museum Services Corporation
385 Bridgeport Way
South St. Paul, Minnesota 55075
(651)450-8954
http://www.museumservicescorporation.com/scat/sa.html

Golden Fluid Acrylics, General's graphite powder
Dick Blick Art Materials
PO Box 1267
Galesburg, IL 61402
800-828-4548
https://www.dickblick.com

Kimwipe, Parafilm M, Thiourea
Fisher Scientific
800-766-7000
https://www.fishersci.com

Pacific Silvercloth
University Products
800-628-1912
https://www.universityproducts.com/pacific-silvercloth-and-silver-storage-tray.html

Paraloid B-48N, Paraloid B-72, Silicon release Mylar
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com

Triton XL-80N
Discontinued by Dow Chemicals

Xanthan gum
The Personal Formulator
97 South Red Willow Rd.
Evanston, WY 82930
307-264-0367
http://www.personalformulator.com/wvss/product_info.php?products_id=197

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RESIN AND LAC ADHESIVES IN SOUTHWEST ARCHAEOLOGY AND MICROCHEMICAL TESTS FOR THEIR IDENTIFICATION

CHRISTINA BISULCA, MARILEN POOL, AND NANCY ODEGAARD

The peoples of the Southwest used a variety of organic adhesives including pine resin and insect lac (shellac). A survey at the Arizona State Museum characterized over 100 artifacts with resinous materials or residues using Fourier transform infrared spectroscopy. Less expensive and more accessible methods—UV-induced visible fluorescence and microchemical testing—were also used for characterization and their accuracy was compared to Fourier transform infrared spectroscopy results. For pine resin, the Raspail test was used; for insect lac, a new microchemical test was developed based on the pH sensitivity of anthraquinone dyes present in insect lac exudates. Results show that microchemical tests are generally reliable even with archaeological materials. This is important as archaeological artifacts are aged and adhesives are often contaminated with burial accretions. By systematically evaluating these tests, further insights were gained. Most importantly, the Raspail test was found to indicate any terpenoid exudate and is not specific to pine resin. These results show that although microchemical tests continue to be useful, care should be taken when interpreting results.

KEYWORDS: Microchemical test, Raspail test, Southwest archaeology, Pine resin, Insect lac

1. INTRODUCTION

In 2011, the Arizona State Museum (ASM) was awarded a Save America's Treasures Grant for the conservation and rehousing of the Archaeological Perishable Collection. This collection has over 30,000 artifacts including basketry, sandals, wood artifacts, bows, arrows, textiles, cordage, vegetal artifacts, and botanical specimens representing 2,000 years of history in the Southwest. These artifacts sometimes contain plant and insect exudates as adhesives, like pine resin or "creosote lac," a shellac type excretion from lac insects endemic to the Southwest.

Despite the extensive use of these adhesive materials, there have been few studies for their scientific identification in Southwestern archaeological collections. The presence and identity of organic adhesives on artifacts in museums and repositories is typically not documented. In a search of ASM's museum collections database, only a single object was described as containing insect lac. Most adhesive materials were either not listed or were erroneously described as a plant "gum" or "pitch." Incorrect material identification and inconsistencies in nomenclature have been found in both the archaeological and ethnographic literature for the Southwest. "Gum" was the conventional or generic term used well into the 20th century to describe all resinous materials (Coville 1892; Kidder and Guernsey 1919; Pepper 1920; Castetter and Underhill 1935; McGregor 1941). However, the botanical definition of gum specifically refers to polysaccharide exudates produced by some plants in response to wounding (Langenheim 2003).

The conservation survey and storage upgrade presented an opportune time to examine the entire collection, allowing for trends to be noted across different cultures, artifact types, and time periods. The survey also assessed the use of non-instrumental methods—in particular, micro-chemical testing—for the analysis of adhesive materials. In conservation there has been a trend of using increasingly advanced analytical equipment and data processing for materials characterization in museum objects. However, there is a continued need for simple, reliable, and inexpensive methods that can be used without specialized instrumentation or while in the field. Such methods are particularly relevant with recently acquired archaeological collections undergoing processing through cultural resource management firms. This project evaluated the reliability of these less costly techniques by comparing results with those from FTIR.

2. BACKGROUND

Arizona archaeology in the period from ca. 100–1500 CE is dominated by three main cultural groups: the Hohokam, the Mogollon, and the Ancestral Pueblo (Anasazi). These groups occupied very distinct environmental regions. Consequently, the plant materials available to each group were distinct. Trends in adhesive use by each culture have already been noted in native pottery repairs (White et al. 2009).

The Hohokam were located in the arid Sonoran Desert in southwestern Arizona and northern Mexico. In this region, the main adhesive material available was insect lac (fig. 1). The lac insects that produce it are in the same family (Keriidae) as the lac insects of Asia that are used for the commercial production of shellac. In North America there are seven known species in the *Tachardiella* genus, which is only found in the Americas. The lac produced by these insects is often termed "creosote lac" because the species *T. larreae* hosts on the creosote bush (*Larrea tridentata*). However, the other species host on different plants (Kondo and Gullan 2011) and this term is somewhat of a misnomer. This excretion by the insects of the Southwest not yet been fully characterized, but other studies (Fox et al. 1995; Stacey et al. 1998; Derrick et al. 1999) and analysis at ASM indicates that it is similar to shellac, which is a polyester with a minor wax component.

The Mogollon in Arizona were primarily located in the dense pine and fir forests of the Mogollon Rim but also extended into the Chihuahua desert regions of New Mexico, Arizona, and north-central Mexico. The Ancestral Pueblo occupied the Colorado Plateau of the Four Corners region which is primarily shrubland and pinyon-juniper woodland (Plog 2008). For these two cultures, various pine resins are the most abundant adhesive material available (Bohrer 1973; Minnis 2010). The pine species used by these cultures is typically assumed to be pinyon pine because this tree is so highly resinous.

Pine resin is a water-insoluble terpenoid exudate secreted in response to injury (Langenheim 2003). Terpenoids are produced by conifers, and the types of terpenoids produced is varied depending on taxon. In most pine (*Pinus* spp.) resins, the predominant terpenoids are abietic and pimaric type acids (Langenheim 2003; Mills and White 2012). Although the resin used archaeologically is assumed to be pinyon pine, it is possible that it was obtained from other pine species or other conifers that are found in these regions, some of which produce terpenoid exudates (Mills and White 2012).

Anthropological and ethnobotanical sources cite other possible plant materials used historically. Mesquite gum is a commonly referenced material, particularly as a pottery repair adhesive, paint, and

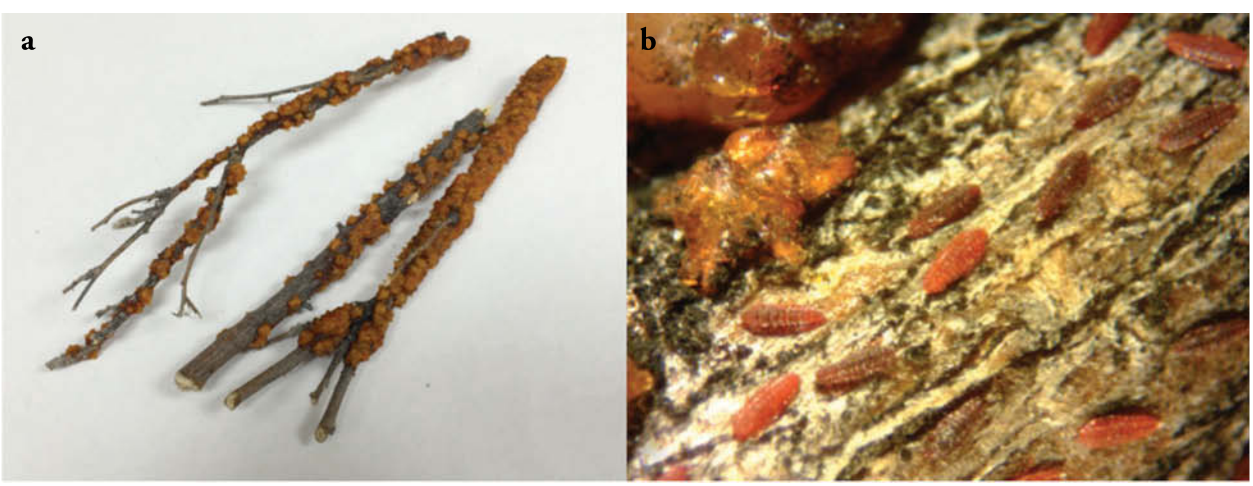

Fig. 1a. Insect lac exuded by the species *Tachardiella fulgens* hosting on the rosary babybonnet (*Coursetia glandulosa*) collected in Tucson, Arizona; 1b. Newly hatched lac insects on the specimen, left (*T. fulgens*). (Courtesy of Christina Bisulca and Marilen Pool)

adhesive in arrow manufacture (Castetter and Underhill 1935). There are also various starches and mucilages from cacti, seeds, and roots which could also have been used (Castetter and Underhill 1935; Odegaard 1997). Chemically, gums, starches, and mucilages are all water-soluble polysaccharides. However, polysaccharide materials have not yet been detected in a survey of archaeological repairs on pottery of the region in ASM's collections (White et al. 2009).

3. MATERIALS AND METHODS

Artifacts were initially examined under visible light and longwave ultraviolet radiation (365 nm). When organic adhesive materials were identified, they were sampled for analysis with Fourier transform infrared spectroscopy (FTIR) and microchemical tests. In total, 127 artifacts were sampled for analysis.

FTIR spectroscopy was performed on a Thermo Scientific Nicolet iS10 spectrometer with a Smart-iTR attachment, equipped with a HeNe laser and DGTS detector. Spectra were recorded in reflection mode, from 4,000 to 650 cm^{-1}, 64 scans at 4 cm^{-1} resolution. Identification was assisted by correlation with ASM's reference spectral database as well as other commercial libraries.

After identification with FTIR, select samples were also tested with microchemical methods to assess the effectiveness of these testing protocols. The "Test for Rosin using Sulfuric Acid (Raspail Test)" and the "Test for Complex Carbohydrates using o-Toluidine" were carried out as described in Odegaard et al. 2005. Due to the small number of samples found with polysaccharide material, the o-toluidine test is not discussed in this article. For updated protocols for using this test on anthropological collections and the interpretation of results see Bisulca et al. (2016).

For materials identified as pine resin, the Raspail test was performed. Using a spot plate, the sample was soaked in a saturated sugar solution for approximately 10 seconds. Excess sugar solution was removed and one drop of concentrated sulfuric acid (H_2SO_4) was added to the sample. A "raspberry red" color indicates the presence of pine resin. This color reaction with fresh pine resin will form in about one minute, but with older processed samples, the color can take up to 30 minutes to form.

To test for the presence of unprocessed insect lac, a new chemical test was devised. A sample about the size of the head of a pinhead was allowed to soak in two to three drops of 1.0M sodium hydroxide (NaOH). A purple color in the sample or surrounding solution indicates a positive for lac because the unprocessed exudate contains anthraquinone dyes that change color depending on pH.

This new microchemical test for insect lac is based on the fact that the insects of the Keriidae family produce dyes within their bodies and eggs that are orange to red. In *Kerria* spp. from Asia, this dye is extracted for commercial use and known as lac dye. The dye is composed of a group of related hydroxyanthraquinones known as the laccaic acids (Bechtold and Mussak 2009). Although the precise chemistry of the dyes from *Tachardiella* spp. has not yet been characterized, anthraquinones from shellac and other scale insects are chemically similar (Santos et al. 2015). The color of these anthraquinones is dependent on pH: for other insect anthraquinones (e.g. carminic acid, laccaic acids), the color will vary from orange to red in acidic solutions, to violet in alkaline conditions (Ketmaro et al. 2010; Bechtold and Mussak 2009). The surrounding lac exudate will swell and eventually hydrolyze in strong alkaline solutions (Limmatvapirat et al. 2005), which also helps to promote the dissolution of the anthraquinone dyes into solution for this test.

FTIR and microchemical testing was also completed on various reference materials for comparison. Insect lac from *T. fulgens* was collected on *Coursetia glandulosa* from Sabino Canyon, northeast of Tucson, Arizona, and *T. larrea* was purchased from the Colorado River Indian Tribes from the Lower Colorado River area close to Yuma, Arizona. Pinyon pine resin (*Pinus edulis*) was collected on the Navaho reservation approximately 30 miles west of Canyon de Chelly, Arizona. Additional terpenoid

Table 1. Raspail Test on Various Plant Terpenoids*

Exudate Type	Family	Species Tested	Color Reaction
Diterpenoid, Abietane/ pimarane	Pinaceae	*Pinus edulis, P. ponderosa, P. thunbergii, P. halepinus*	Red
Diterpenoid, Labdane	Araucariaceae	*Araucaria angustifolia*	Red
	Cupressaceae	*Cupressus arizonica, C. sempervirens*	Red
		Juniperus deppeana, J. scopulorum, J. virginiana, J. chinensis	Red
Triterpenoid	Burseraceae	Commercial Mexican copal (*Protium* or *Bursura* spp.)	Red, Brown
	Anacardiaceae	*Pistacia lentiscus, P. atlantica, P. chinensis*	Red, Brown
	Dipterocarpaceae	Commercial dammar	Red, Brown

*unless designated "commercial," all samples were collected directly from the plant source.

resins were collected from the University of Arizona Campus Arboretum (https://arboretum.arizona.edu/). Reference samples of pinyon pine resin and insect lac were heated in an oven and burned under flame to assess the effects of heat processing on microchemical tests and FTIR. For other reference gums and resins, samples were obtained from the Getty Conservation Institute Binding Media Reference Kit (Striegel and Hill 1997).

4. MICROCHEMICAL TESTS ON REFERENCE MATERIALS

The Raspail test is most commonly used for the qualitative determination of rosin (pine resin) size in paper by the procedure adapted by TAPPI (TAPPI 408). Although this test has been used for almost a century, the mechanism of the color reaction has never been published. Early references note that a red to purple color change is observed with other materials including proteins and fats. Due to the possibility of false positives, this study assessed other materials, in particular other plant exudates which may be encountered in artifacts. Terpenoid plant resins tested in this survey are listed in table 1.

Color reactions of different terpenoid resins using the Raspail test are shown in figure 2. In fresh samples, a color reaction was immediately observed on the surface of the sample. After several minutes, the red color reaction indicating a positive was visible in the solution surrounding the sample usually along with streaks of yellow and brown. This test was successful on all *Pinus* species tested. The test also produced positive results even after the resin was heated to 200°C (fig. 2, row B). This was tested because in anthropological samples it is assumed that the resin would have been heated prior to use, and heating pine resin to render it fluid has been documented ethnographically (Tanner 1982).

This test also resulted in a positive reaction for other diterpenoid resins. Pinaceae resins are primarily composed of tricyclic diterpenoids of the abietane or pimarane type (Dev 1989; Otto and Wilde 2001). Other conifers—such as cypress, sequoia, and juniper-like trees—typically produce dicyclic labdane-type diterpenoids, which are the most common terpenoid class found in resinous exudates

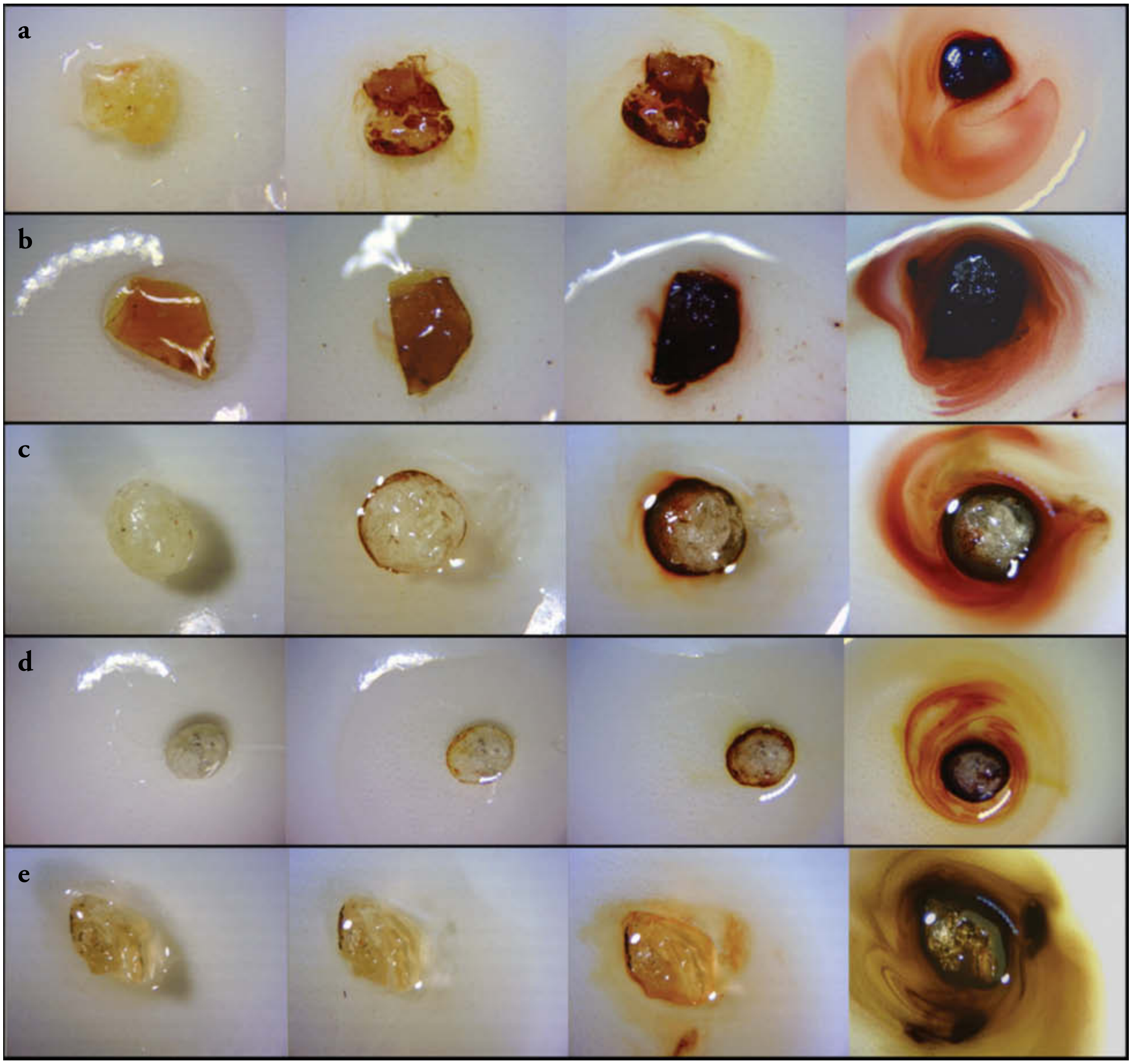

Fig. 2. Raspail test color reactions. Columns from left to right: before adding H_2SO_4 (conc.), immediate color reaction with H_2SO_4, color after 1 minute, color after 5 minutes. Rows: 2a. *Pinus edulis* (pinyon pine) exudate showing a typical color reaction; 2b. *Pinus edulis* after heating to 200°C; 2c. Labdane diterpenoid exudate from *Araucaria angustifolia* showing a positive color reaction; 2d. Triterpenoid resin from *Pistasia lentiscus* (mastic) showing a positive color reaction. 2e. Mesquite gum (*Prosopis glandulosa*) showing a negative reaction. (Courtesy of Christina Bisulca)

(Otto and Wilde 2001). In Arizona, this includes the Arizona cypress (*Cupressus arizonica*) and various junipers (*Juniperus deppeana, J. scopulorum, J. monosperma,* etc.) (Kearney and Peebles 1960). Like Pinaceae, these families are known to be highly resinous (Langenheim 2003) and their exudates could be encountered in artifacts. The labdane diterpenoids tested from Cupressaceae and Araucariaceae families all resulted in a positive red color reaction (fig. 2, row C). The labdane diterpenoids are the primary class of exudates that polymerize to form ambers (Lambert et al. 2008), and this explains why this microchemical test is also reported to work on ambers (Odegaard et al. 2005).

Triterpenoid resins (i.e., dammar, mastic) are also common plant exudates encountered in museum collections. Mexican copal is a triterpenoid resin that has been identified in archaeological artifacts

Table 2. NaOH Test for Insect Lac in Reference Materials

Sample	Appearance in UV	NaOH Test
T. fulgens, stick lac	Neon orange	Violet
T. fulgens, heated 200°C	Orange	Violet
T. fulgens, heated open flame	No fluorescence	Brown
T. larrea	Neon orange	Violet
T. larrea, heated 200°C	Neon orange	Violet
T. larrea, heated open flame	No fluorescence	Brown

(Stacey et al. 2006) and could potentially be encountered in ASM's collections. Triterpenoid resins were also found to result in a positive reaction with the Raspail test, although less consistently than the diterpenoid resins. Most samples showed an immediate red to orange color reaction at the surface, and sometimes produced a red to reddish-brown color reaction in the solution (fig. 2, row D).

As both di- and triterpenoids can produce a positive color reaction with the Raspail test, one should exercise caution in interpreting their results. A positive reaction can indicate any number of terpenoid exudates and is not necessarily diagnostic of abietic acid, a main component in most pine resins. Most controls tested (polysaccharides, proteins, waxes) produced a brown or yellow color in solution (fig. 2, row E). However, a red or violet color was also noted with certain proteins (albumin, egg yolk). In these cases, the color developed on the sample material only and not in the surrounding solution.

Microchemical test and UV results on reference samples of lac from Arizona are shown in table 2. The test using NaOH was successful on all fresh and heated lac samples. However, with excessive burning in open flame until charring occurred, samples no longer showed the color response. This would be expected, as the dyes are undoubtedly broken down in this process. It should also be noted that this test will not work on commercial shellac as the dye component is typically removed in processing.

5. ANALYSIS OF ARCHAEOLOGICAL MATERIALS

FTIR identification of insect lac and pine resin in archaeological samples is shown in figure 3. For tree resins, archaeological samples showed the best spectral correlation with Pinaceae resins based on FTIR. Further details on differentiation of the class of terpenoid exudates with FTIR are given elsewhere (Gianno et al. 1987; Tappert et al. 2011; Seyfullah et al. 2015).

In testing collections, the Raspail test gave a positive result for all materials determined to be pine resin with FTIR. Results were easiest to observe using a stereomicroscope, as archaeological samples often turned brown with areas of red positive reaction. When testing unknown materials, it is important to always compare results to known positive reactions (Odegaard et al. 2005). It should be stressed that this test will result in a positive red for other terpenoid-based tree exudates and does not necessarily indicate pine resin.

In testing archaeological collections, approximately 75% of insect lac resulted in a positive purple reaction to the NaOH test. In positive results, a purple color was visible in the testing solution or as purple areas within the resin when viewed under a stereomicroscope (fig. 4). Often the color change is

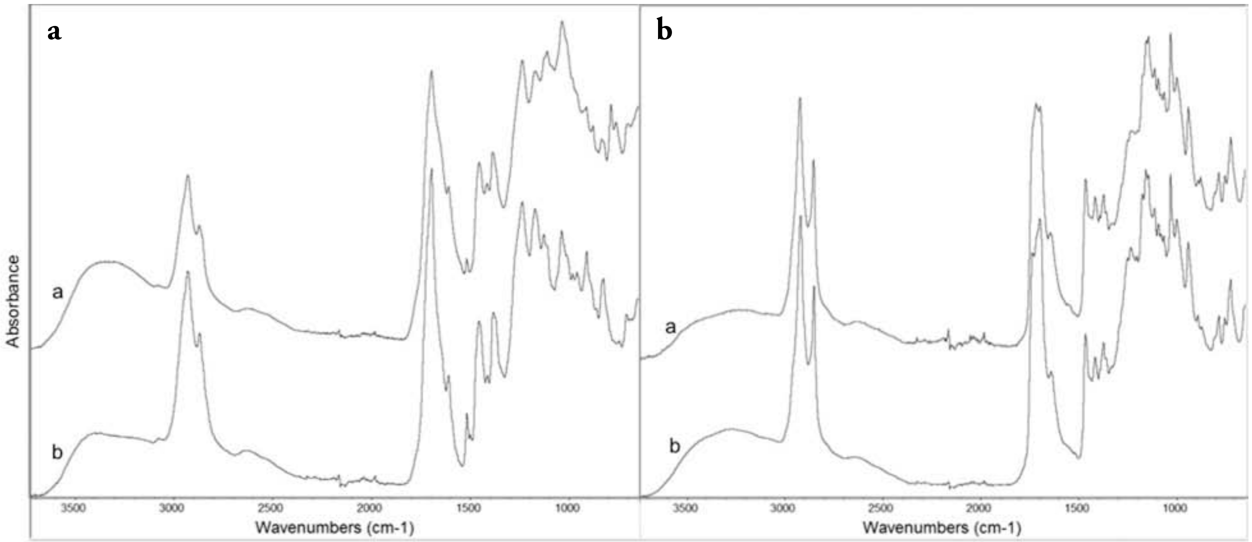

Fig. 3a. Pine resin sample from Ancestral Pueblo sealing ring, Cave X, cat no. A-14374 (a) and pinyon pine resin, ASM reference collection (b); 3b. Insect lac sample from Hohokam ball, Casa Blanca, cat. no. 2309 (a) and creosote lac (*Tachardiella larreae*), ASM reference collection (b). (Courtesy of Christina Bisulca)

visible only in localized areas of the sample as the dye is contained in the insects and eggs, not the lac exudate.

In cases where the NaOH test was not successful, the insect lac sample often appeared black, possibly due to charring. In these cases, because the sample itself was black this may have masked the color reaction. Lack of a color reaction may also be due to processing, as this material would have been heated during original processing. The insect anthraquinones that have commercial use (i.e. cochineal and lac dye) are known to be thermally stable (Fernández-López et al. 2013). However, burning the lac most likely results in the breakdown of these dyes. The anthraquinone dyes in insect lac are also somewhat water-soluble, so it is also possible that they have been lost, particularly at the surface where these objects were sampled.

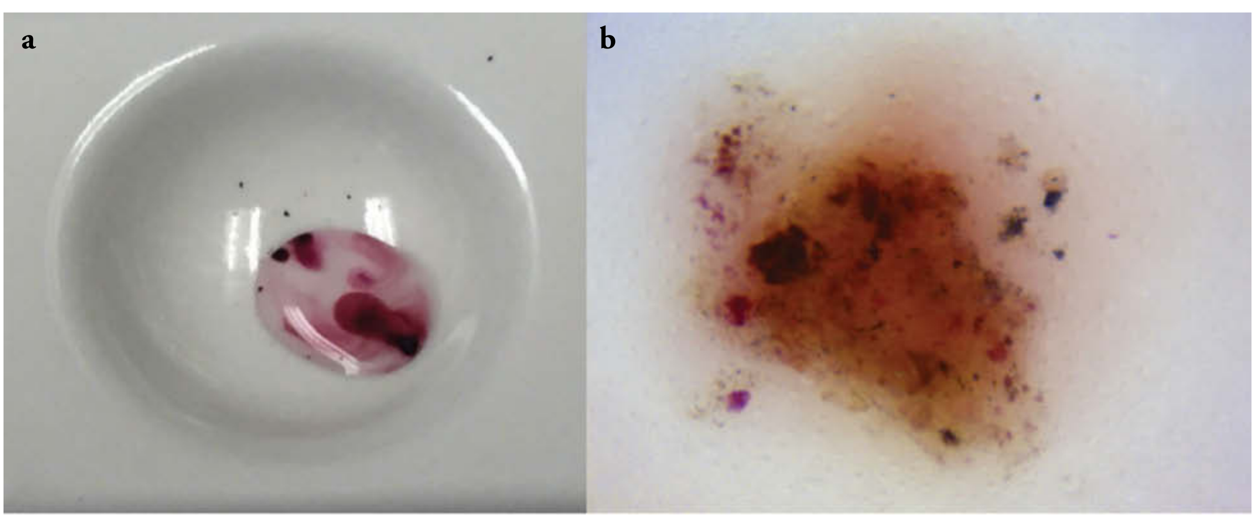

Fig. 4a. Spot test plate showing strong color reaction from an unprocessed lac sample from collections, cat. no. B-89, stick lac, Ventana cave; 4b. Microphotograph of sample showing purple color reaction in small areas. (Courtesy of Christina Bisulca)

Table 3. UV Identification in Collections*

Color	Insect Lac	Pine Resin	
Orange	10 (45%)	Green	13 (50%)
Green	3 (15%)	Orange	7 (27%)
No observed fluorescence	8 (40%)	No observed fluorescence	6 (23%)
Total	21 (100%)		26 (100%)

*Table lists the total number of artifacts tested and percentage of each by adhesive identified.

Because the collection was surveyed with UV radiation prior to analysis, it allowed for the assessment of reliability of identification using UV alone. While this type of examination is useful, it was not found to be reliable for the identification of these materials. This method gives positive identification only roughly half the time (table 3). More problematic is that this method can lead to incorrect identification, which in the assessment of collections at ASM could be as much as 25% of the time.

6. ADHESIVE USE IN SOUTHWEST ARCHAEOLOGY

The adhesive materials found in the archaeological artifacts of the Archaeological Perishable Collection defined by culture is shown in figure 5a. As expected, the adhesive materials found in Hohokam artifacts are predominantly insect lac and Anasazi predominantly pine resins. Surprisingly, the Mogollon used both adhesives, and approximately 60% of adhesives identified were insect lac. The use of insect lac in the Mogollon and Ancestral Pueblo regions has not been previously identified. For the complete results of this adhesives survey see Bisulca et al. (2017).

Several artifacts were found to have a polysaccharide based material. It is not possible to determine the precise identity of these materials (plant gum, starch, mucilage, etc.) based on FTIR alone. This is a particular problem with archaeological materials as they often are contaminated with soils, clays, or other aluminosilicates that overlap with bands characteristic of polysaccharides. However, these artifacts may indicate the potential use of plant polysaccharides like mesquite gum or seed and root starches (Odegaard 1997).

Some artifact groups demonstrate possible selection of these adhesives based on their material properties. The use of insect lac and pine resin in the Mogollon arrow foreshafts is shown in figure 5b. Both pine resin and insect lac were found used in this artifact group. However, as a hafting material, primarily insect lac was found. On three arrow fragments (A-17168-x3, x8, x9), both materials were used in the same artifact where insect lac was used in the hafting and pine resin in the tenon joint (fig. 5c). Insect lac appears to be the preferred material for hafting among the Mogollon. The preference for insect lac is likely because it is a stronger, less brittle material than pine resin, making it a superior material for this particular application. This example shows the cultural significance of adhesives and why identification of these materials is important to understanding collections.

7. CONCLUSION

This survey of adhesive materials in the ASM's perishable collections showed that both insect lac and pine resin were used by each of the main cultural groups represented in the archaeological record of Arizona.

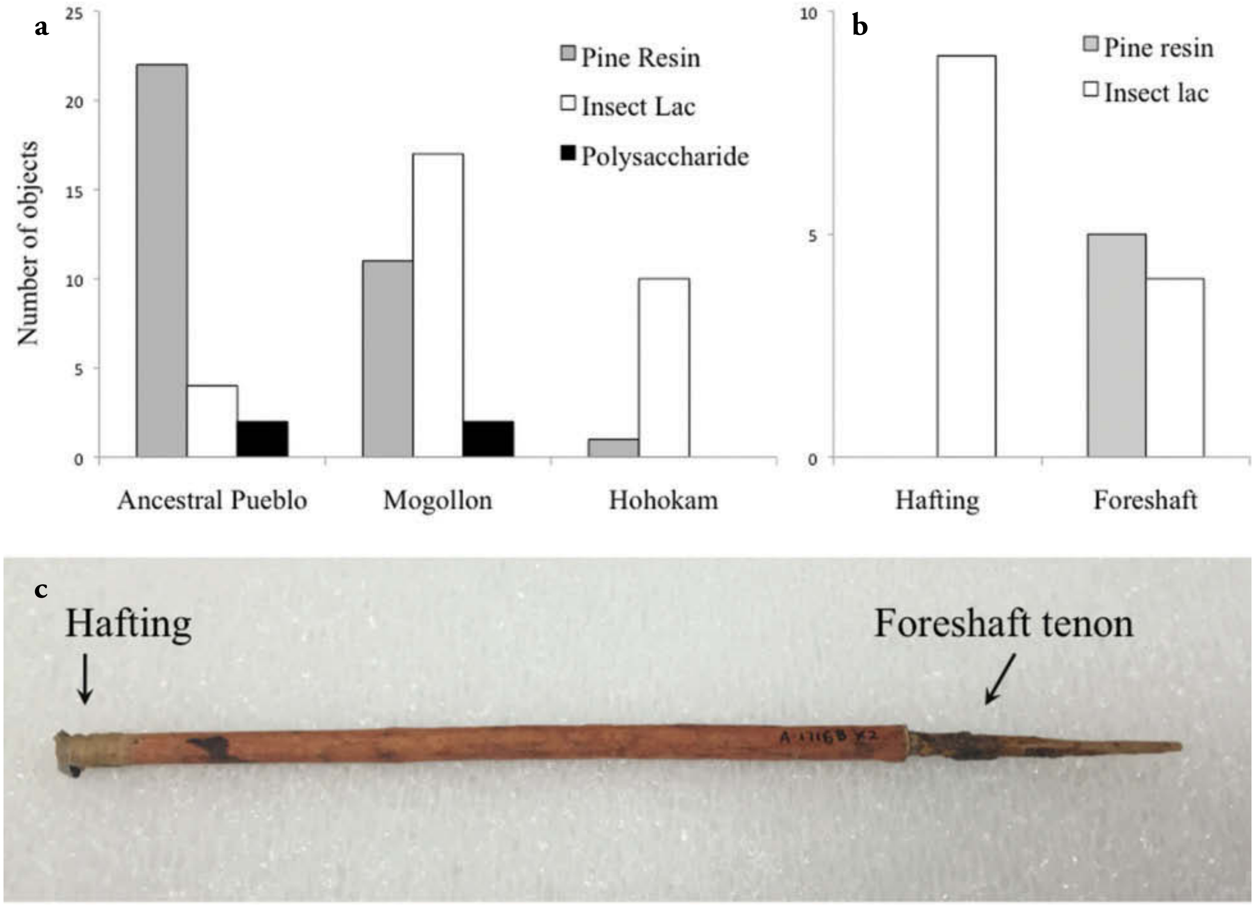

Fig. 5a. Objects with pine resin, insect lac or polysaccharide adhesives in the ASM Archaeological Perishable Collection by culture; 5b. Use of adhesive materials in Mogollon arrow foreshafts; 5c. Arrow foreshaft, Mogollon, Red Bowl Cliff Dwelling, 1325-1400 CE, A-17168. In the arrow pictured insect lac was found in the hafting and pine resin on the tenon joint. (Courtesy of Christina Bisulca and Marilen Pool)

Results highlight that historic terminology and catalog information can be misleading for the identification of these types of organic materials. Through this research, conservators updated and improved the collections records and also increased understanding of the collections, not only for preservation but for deeper comprehension of the material culture of the Southwest. Non-instrumental methods—in particular, microchemical testing—was found to be reliable showing these methods continue to be great benefit for understanding collections. Although UV analysis can be helpful in the identification of adhesives, results are not accurate and, more importantly, are often misleading.

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CONSERVATION OF JOAN MIRÓ'S BRONZE SCULPTURES AT THE MUSEUM OF MODERN ART

MEGAN RANDALL, LYNDA ZYCHERMAN, AND ROGER GRIFFITH

The Museum of Modern Art owns three major bronzes by Joan Miró: *Lunar Bird* (1966), *Solar Bird* (1966), and *Personage and Bird* (1968). This article will examine the sculptures' original casting and finishing processes, compare variations within their editions and metallurgical analyses, and review their condition and corresponding treatments. At the beginning of this project, both *Solar Bird* and *Personage and Bird* were deemed unexhibitable due to serious condition issues. *Solar Bird* was acquired in 2005 and came into the museum after decades of outdoor exposure without regular maintenance; as a result, its patina was significantly degraded. Treatment involved steam cleaning and applying tinted hot wax layers to revive saturation and appearance. *Personage and Bird* had a lifting surface that was consolidated and losses were toned.

KEYWORDS: Joan Miró, Bronze, Susse Foundry, Parellada Foundry, Patina, Metallurgical analysis, Hot wax

1. OVERVIEW

Joan Miró (1893–1983) was one of the most eminent and prolific artists of the 20th century. He utilized a wide range of mediums and artistic practices, and within his sculpture worked in stone, wood, plaster, ceramics, assemblages, and bronze. This article focuses on Miró's bronzes from the 1960s. The Museum of Modern Art (MoMA) Miró holdings include three important bronzes: *Lunar Bird* (fig. 1) and *Solar Bird* (fig. 2) (both edition 2/5) cast in 1966 at the Susse Foundry in Paris, France, and *Personage and Bird* (figs. 3a–c) (edition 1/2) cast in 1968 at the Parellada Foundry in Barcelona, Spain. At the time of this project's inception in fall 2014, both *Solar Bird* and *Personage and Bird* had never been displayed at MoMA and were considered unexhibitable due to severe condition and appearance issues. The goal of this research was to produce and execute treatment plans so that both sculptures could be displayed.

MoMA's three sculptures only represent a small sample of Miró's bronze making. Throughout his lifetime, Miró worked with seven different bronze foundries in Europe. In France, Miró collaborated with Susse Foundry from 1962 to the late 1970s, the Scuderi Foundry from 1971 to 1977, the Clementi Foundry from 1963 to 1973, and the Valsuani Foundry for a short period from 1971 to 1973. In Barcelona, Spain, Miró first worked with the Gimeno Foundry from 1945 to 1956 and then the Parellada Foundry from 1965 until his death in 1983. Miró also worked with the Bonvicini Foundry in Verona, Italy, from 1970 to 1981 (Fernandez Miró, Ortega Chapel, and Martinez 2006). The majority of Miró's relationships with foundries lasted a decade or more, and Miró produced bronzes at these foundries simultaneously. Miró's selection of foundry was likely based on its location, as well as its casting and finishing techniques. Given the number of bronzes that Miró produced in his lifetime and the variety of foundries he employed, we can assume that Miró had a deep understanding of foundry casting technology and was able to communicate his desired results to individual founders.

The two foundries represented in this study are the Susse Foundry in Paris and the Parellada Foundry in Barcelona. At the Susse Foundry, Miró produced large-scale smooth-formed sand-cast bronzes with traditional dark patinas. These large-scale sculptures are a well-recognized type of Miró bronze casts. The editioned *Lunar Bird* and *Solar Bird* are both collected and displayed by major institutions, as are the other versions that Miró made of these forms in marble, wood, plaster, and in bronze at different scales. In contrast, the Parellada Foundry provided an outlet for Miró's more experimental casting and produced sculptures smaller in scale, formed from assemblages of found objects with highly unique and expressive, streaky patinas over a rougher, textured surface

Fig. 1. Joan Miró, *Lunar Bird*, 1966, bronze, 228.5 x 198.2 x 144.9 cm, The Museum of Modern Art, 636.1994 (Courtesy of The Museum of Modern Art)

Fig. 2. Before treatment. Joan Miró, *Solar Bird*, 1966, bronze, 120 x 180 x 101.9 cm, The Museum of Modern Art, 242.2005 (Courtesy of The Museum of Modern Art)

Fig. 3a. Before treatment, front; 3b. Side; 3c. Back. Joan Miró, *Personage and Bird*, 1968, bronze, 102.9 x 59 x 19 cm, The Museum of Modern Art, 635.1994 (Courtesy of The Museum of Modern Art)

(Fernandez Miró, Ortega Chapel, and Martinez 2006). Despite the popularity of the Susse Foundry casts, Miró produced relatively few individual bronzes with this foundry, in comparison to the 90 different editions (over several hundred bronzes) cast at the Parellada Foundry. These casts are less well known in the United States because they are more often collected privately or remain in Europe.

2. *LUNAR BIRD* AND *SOLAR BIRD* OVERVIEW

The forms of *Lunar Bird* and *Solar Bird* were first made in bronze in 1946 at the Gimeno Foundry in Barcelona. These casts were small in scale with *Lunar Bird* and *Solar Bird* at 20 and 13 cm tall, respectively (Fernandez Miró, Ortega Chapel, and Martinez 2006). *Solar Bird* was modeled first, followed by *Lunar Bird*. These forms were considered a pair by Miró, like the sun and the moon, or woman and man (Fernandez Miró, Ortega Chapel, and Martinez 2006).

Twenty years later in 1966 at the Susse Foundry, Miró produced these forms again in large scale with *Lunar Bird* over 2 m tall and *Solar Bird* 1 m tall and almost 2 m long. Both of these MoMA sculptures are edition 2/5 and came into the collection from their original owners. *Lunar Bird* (along with *Personage and Bird*) was gifted to MoMA in the Gordon Bunshaft Bequest of 1994. *Solar Bird* was acquired by MoMA from the Cigna Corporation in 2005. They were no longer a matched pair visually due to their differing exhibition and environmental histories. The following sections describe the two sculptures and will give details on the research and treatment steps we took to return *Solar Bird* to an appearance and condition that matched *Lunar Bird*.

2.1 *LUNAR BIRD* AT MOMA

Since its acquisition in 1994, *Lunar Bird* has been periodically on view in the MoMA sculpture garden for an approximate total of seven years (Museum of Modern Art 2016). While on view, the sculpture has been regularly maintained with annual cleaning and wax treatments. This sculpture is in excellent condition and retains the original surface qualities as produced by the Susse Foundry. *Lunar Bird* has an even, dark patina, and the surface is smooth without any disfiguring scratches or marks. There is some slight wear that is consistent with its age, time spent outdoors, and visitor interaction; however, the overall appearance of the patina is uniform. The sculpture's appearance is consistent with other casts of the edition, including cast 1/5 at the Hirshhorn Museum and Sculpture Garden, 4/5 at the Nasher Sculpture Center, 5/5 at the Foundation Beyeler, and E.A. I/III at the Broad.

2.2 *SOLAR BIRD* ACQUISITION AND CONDITION

Solar Bird's outdoor exhibition and maintenance program prior to coming into MoMA's collection was a dramatic contrast to that of its partner *Lunar Bird*. *Solar Bird* was purchased from Miró's Paris gallery, Galerie Maeght, by Cigna Corporation (Fernandez Miró et al. 2006). The sculpture was first installed in Philadelphia before being moved to Cigna's headquarters in Bloomfield, Connecticut, and regular maintenance was likely not performed. Decades of northeastern outdoor exposure resulted in a streaky, chalky, light green corrosion product spread across the surface. Throughout the years, visitor interaction resulted in small scratches on the side of the sculpture and light graffiti on the top of the horn (figs. 4a, 4b). Tenacious black patches were also present on the horn of the sculpture. They appeared to be either an old coating or localized patination effort of a previous restoration campaign. The unsatisfactory visual appearance of *Solar Bird* needed treatment prior to exhibition. Although the edition of *Lunar Bird* was consistently dark brown/black in appearance, the following research into the edition of *Solar Bird* showed that its surface was intentionally varied with the earlier editions 1/5 through 3/5 dark green in appearance and the later editions 4/5 and 5/5 nearly black.

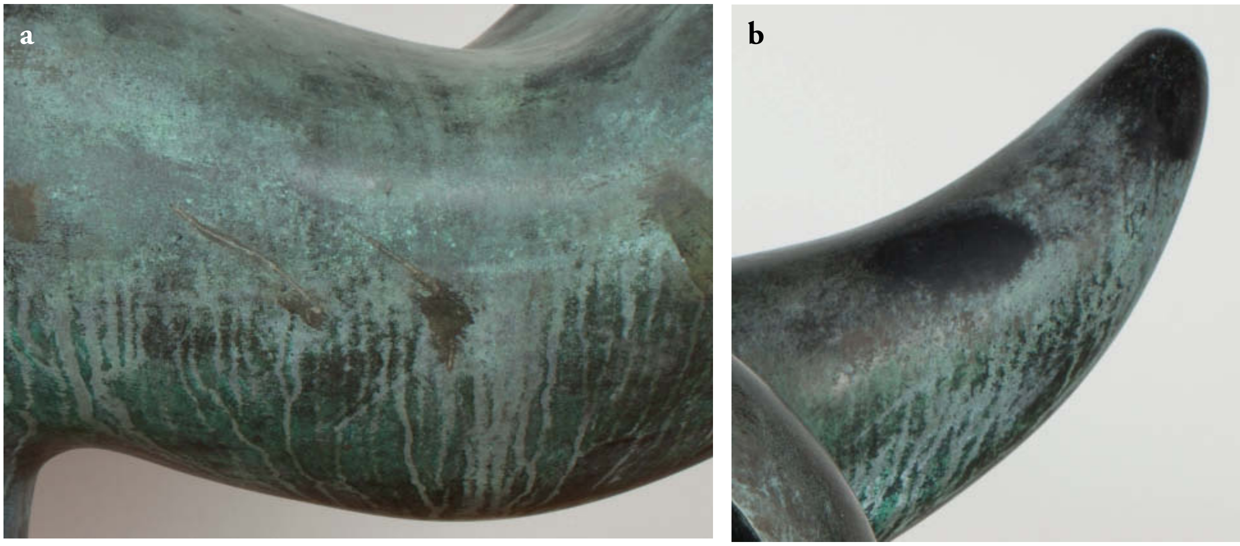


Fig. 4a. Detail of scratches and streaky surface on *Solar Bird's* body; 4b. Detail of dark patches, possibly prior to the restoration campaign (Courtesy of The Museum of Modern Art)

2.3 SOLAR BIRD FOUNDRY INFORMATION

Henri Lacroix, manager of Susse Foundry (2003–present) shared information from the Susse Archives through letters and a personal interview conducted with Megan Randall at the foundry in April 2016. Edition 2/5 (MoMA's) was the first bronze cast. It left the foundry July 27, 1966, for Galerie Maeght; it weighed approximately 272 kg, and its patina took the patinator Rospabe 15 hours to complete. Oddly, although the Susse Foundry ledgers list the patina color for the other four examples in the edition, it unfortunately did not list the patina color for this one (Susse Foundry Archives n.d.).

The other casts from the *Solar Bird* edition had more complete information entered into the Susse Archive notecards. Edition 1/5, owned by the Art Institute of Chicago (AIC), had a patina applied cold that was dark green in color. Communications with AIC in 2005 revealed that the sculpture was treated in 1993 due to degradation of the surface from outdoor exposure and visitor interaction. Areas were selectively repatinated, and the entire sculpture was waxed (Zycherman 2004). Edition 3/5, owned by the San Diego Museum of Art (SDMA), also had a cold, dark green patina. This cast was on display outdoors at SDMA, and large sections of the surface patina were worn away from heavy visitor interaction. In 1994, SDMA treated this sculpture by locally repatinating areas of loss, coating the sculpture in Incralac, then coating it with wax (Wharton and Stofflet 1994). Editions 4/5 and 5/5, owned by The Broad and the Locks Gallery, respectively, were originally patinated using a hot process and were listed as black in color. After interviewing Mr. Lacroix and reviewing the Susse Archives, we determined that the foundry typically produced identical patinas for their editions. In the event that different patinas were applied to different casts from the same edition, they would almost always vary gradually as exemplified by the shift in patina in *Solar Bird*. We concluded that MoMA's edition 2/5 would probably have matched editions 1/5 and 3/5 in its patination process and final appearance.

The alloy listed by the foundry was 75% copper, 21% zinc, 2% lead, and 2% tin. Quantitative XRF[1] performed at MoMA on the horn of *Solar Bird* generally supported the foundry alloy proportion at 83% copper, 15% zinc, 3% lead, and 2% tin (table 1A). The higher ratio of copper in the XRF spectra could be a result of dezincification, a process that occurs in copper-zinc alloys when the percentage of zinc is above that of 15 weight percent as seen in *Solar Bird*. In dezincification, the zinc preferentially corrodes out of the alloy in the presence of oxygen and water, leaving behind a copper-rich surface (Young et al. 2009). The years of outdoor exposure on the surface of *Solar Bird* could have caused this

Fig. 5. Steam cleaning *Solar Bird* in the MoMA sculpture garden (Courtesy of The Museum of Modern Art)

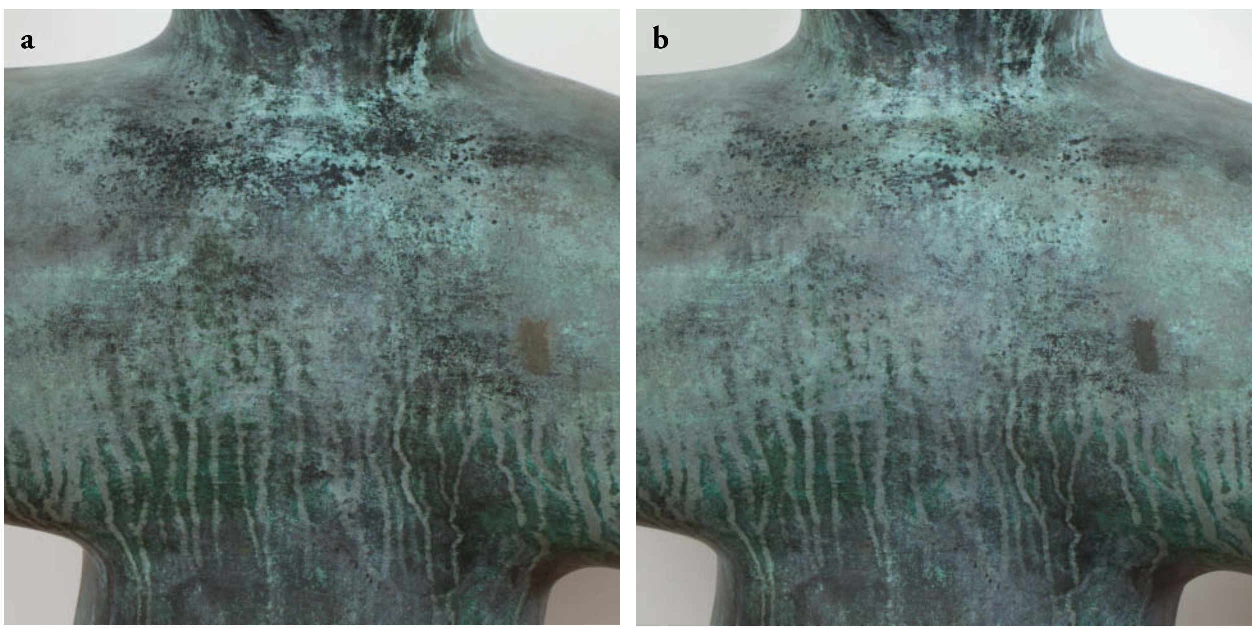


Fig. 6a. Before steam cleaning; 6b. After steam cleaning, the surface is more even and lighter overall (Courtesy of The Museum of Modern Art)

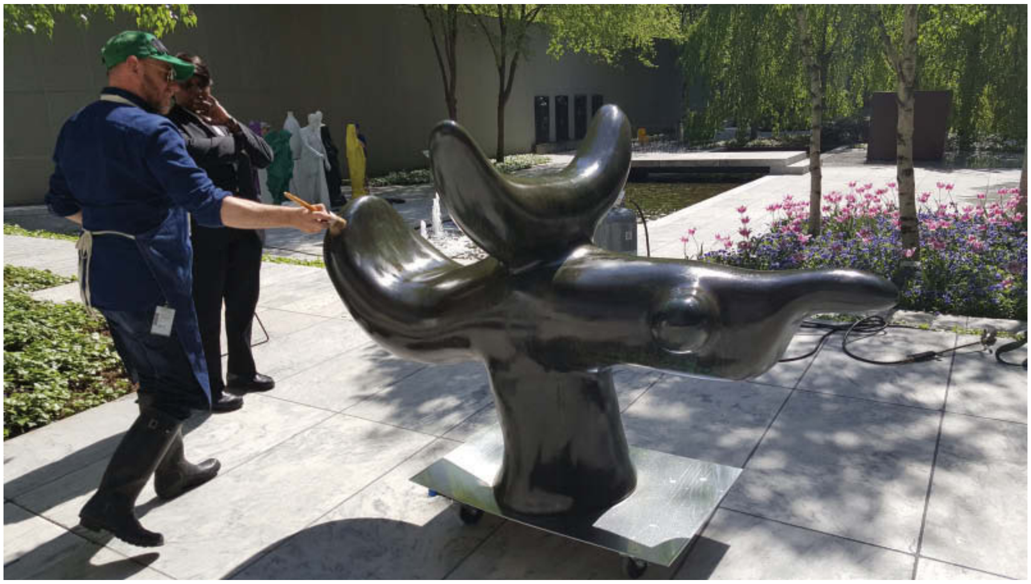


Fig. 7. Application of tinted hot wax layer to *Solar Bird* in the MoMA sculpture garden (Courtesy of The Museum of Modern Art)

phenomenon. Radiography and visual examination showed that the sculpture was cast in three parts: base, body, and horns.

2.4 *SOLAR BIRD* TREATMENT

Ultimately, MoMA's treatment goal was to achieve a dark green and relatively uniform surface, consistent with the appearance of editions 1/5 and 3/5. Early correspondence in the late 1960s between Susse Foundry and the owners included directions to maintain the sculpture with silicone waxes, which are notoriously difficult to remove. Indeed, treatment reports of the 1/5 and 3/5 editions of *Solar Bird* at AIC and SDMA included the removal of notably tenacious wax coatings. Localized repatination on the 1/5 and 3/5 editions were necessary due to areas of the surface that were worn completely bare due to visitor interaction. Fortunately, MoMA's 2/5 edition did not contain any silicone wax or other old tenacious surface coatings, allowing us to clean the surface easily with steam. The surface exhibited some evidence of visitor interaction in the form of scratches and graffiti; however, they were shallow and small enough to blend into the surrounding surface after the wax application. The overall chalky, light green areas were even and well adhered enough to the bronze substrate that stripping or additional patination were judged unnecessary. Areas of intact dark green were used as a guide for the final overall surface appearance.

The sculpture was steam cleaned with an industrial 3,500 psi unit. This phase was accomplished over a morning in MoMA's outdoor sculpture garden (fig. 5). This combination of pressure and heat was successful in removing any remaining residue from old protective coatings, as well as any dirt, grime, guano, or other accretions on the surface. The result from the morning cleaning was an overall evening and lightening of the surface (figs. 6a, 6b).

The second stage of treatment was the tinted hot wax application followed by cold wax. Again, the sculpture was treated in the MoMA sculpture garden. After heating with a torch to drive off any residual moisture in the bronze, a layer of paste wax tinted with burnt umber was applied to the hot surface and then heated again overall with the torch (fig. 7). After the surface was cool enough to touch, the wax layer was buffed by hand. A second layer of wax tinted with lamp black was then applied, again to a surface preheated overall, and was buffed by hand after cooling. The sculpture was brought into the MoMA sculpture conservation lab, where two more coats of clear paste wax were applied and buffed by hand. The resulting surface was significantly more even, dark, and saturated in appearance. Although

Fig. 8. *Solar Bird* after steam cleaning and hot and cold wax treatment (Courtesy of The Museum of Modern Art)

some of the drips and streaks from its original condition are still visible through the tinted wax coatings, it reads as relatively uniform from a normal viewing distance (fig. 8).

3. *PERSONAGE AND BIRD* OVERVIEW AND PROVENANCE

Miró's *Personage and Bird* presents a contrast to the casting methods, condition issues, and treatment of *Solar Bird*. MoMA acquired this sculpture in 1994 as part of the Gordon Bunshaft Bequest, which also contained *Lunar Bird*. Prior to entering MoMA's collection, the work was on view inside Bunshaft's Travertine House in East Hampton, New York (Lange 2014), and in the *Miró Sculpture* exhibition at the Pace Gallery in New York in 1984 (Schjeldahl 1984). Images of these installations do not offer a clear picture of the sculpture's condition at the time of the photographs.

3.1 *PERSONAGE AND BIRD* CONDITION AND VISUAL ANALYSIS

When the sculpture was uncrated for an internal photography request, significant and alarming areas of flaking surface were found on the pedestal of the sculpture (fig. 9). The sculpture was immediately sent to sculpture conservation for analysis, stabilization, and treatment. In our laboratory, we had not seen a sculpture with such unique condition issues before. We initiated research into the materials and manufacturing process of the bronze.

The model for *Personage and Bird* comprises found materials, such as a flattened basket for the head, with the handles as the ears; the eyes, nose, and limbs were taken from a deconstructed celluloid doll. The body is an undulating wax sheet, and a roughly molded iconic bird sits atop the head. Miró wrote about his process of creating sculptures from found objects, stating that he would "create a phantasmagoric world of living monsters; use things found by divine chance, bits of metal, stone etc"

Fig. 9. Detail of pedestal of *Personage and Bird* containing surface flakes (Courtesy of The Museum of Modern Art)

(Rowell 1986, 175, 191). The patina, executed by Josep Parellada who created all of the Parellada patinas from the 1960s and 1970s (Penrose 1970), was applied in drips of light and dark green, yellow, and black, which extend from the basket down to the base, as if the patinator used a sponge saturated with chemicals and squeezed it out over the head of the sculpture. In crevasses throughout the sculpture, particularly concentrated in the texture of the basket, there is a pink, powdery substance (fig. 10). The bronze appears to have a thin "skin" (Jeffett 1990, 19), granular and sandy in texture, covering much of its surface, which when seen in raking light before treatment was lifting significantly away from the

Fig. 10. Detail of pink investment embedded in basket texture of *Personage and Bird* (Courtesy of The Museum of Modern Art)

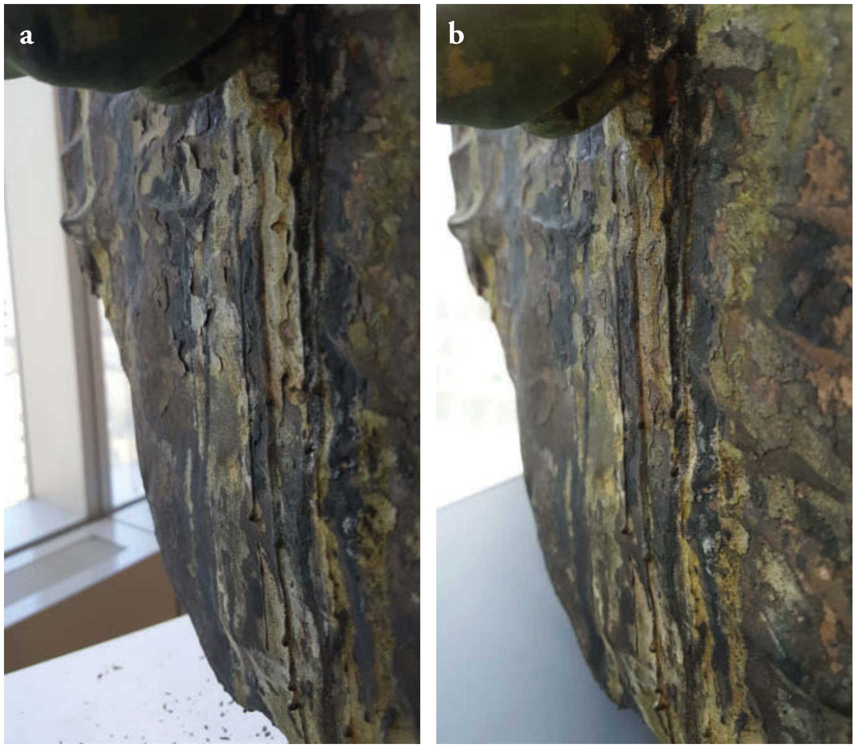


Fig. 11a. Before surface consolidation in raking daylight of *Personage and Bird*; 11b. After surface consolidation in raking daylight (Courtesy of The Museum of Modern Art)

bronze substrate (fig. 11a). Reflectance transformation imaging (RTI) taken on the back of the sculpture captured the severity and topography of this flaking (fig. 12). This process helped highlight not only the lifting of the surface but also subtle tenting over many areas not readily apparent in the normal documentation photographs.

Fig. 12. Screen shot of RTI viewer application of back of *Personage and Bird* (Courtesy of The Museum of Modern Art)

Fig. 13. Mosaiced radiograph of *Personage and Bird* (Courtesy of The Museum of Modern Art)

A systematic catalog of the various patination colors and surfaces over the sculpture revealed trends in the condition and stability of the surface. Dark brown smooth surfaces near the top of the basket and along the edges of the body on the front and the back were areas of old patina loss that had oxidized and darkened over the years. The middle of the body on the front and back of the sculpture contained the highest percentage of recent surface loss, characterized by a now visible light pink smooth surface. A set of radiographs taken over the top half of the sculpture showed the weld joins of separately cast pieces in the basket and the bird, and also revealed some porosity through the center of the body (fig. 13). Unfortunately, neither visual examination nor radiography explained the severity or cause of the flaking surface.

3.2 PARELLADA FOUNDRY VIDEO

To better understand the process of manufacture and how it impacted the condition of the sculpture, we studied a 1987 video (in Catalan) of the Parellada Foundry, produced by the Miró Foundation. This provided insight into the unusual casting techniques of the foundry (Fundació Joan Miró 1987). Narrated by Manel Parellada, son of Josep, the video reveals details of their casting process from the creation of the rubber mold through the finishing of the bronze surface. The molten bronze was poured into pink investment molds, and after cooling the solid sculpture was broken out of the mold and cleaned until approved by the foreman. At this point, the sculpture was brought into the finishing room where the gates were cut and the surface was finished using a variety of electric (or pneumatic) and hand tools.

Fig. 14. Joan Miró, *Personage*, 1968, bronze, Nasher Sculpture Center, NC.1985 (Courtesy of Megan Randall)

Of particular importance in this video was the lack of any chemical or power wash of the bronze surface prior to finishing. Clean surfaces are usually preferred for finishing work and welding/soldering, as well as for stable patination results. The pink powder on the lowest areas of the surface texture of *Personage and Bird* clearly indicates that a layer of investment was intentionally left on the surface of the bronze after casting and the patina was applied over this surface. Given that bronze shrinks a small percentage upon cooling, the cast would be slightly smaller than the wax model around which the investment was built. This would explain the tenting and flaking of the surface, as the investment was originally formed around a slightly larger wax model.

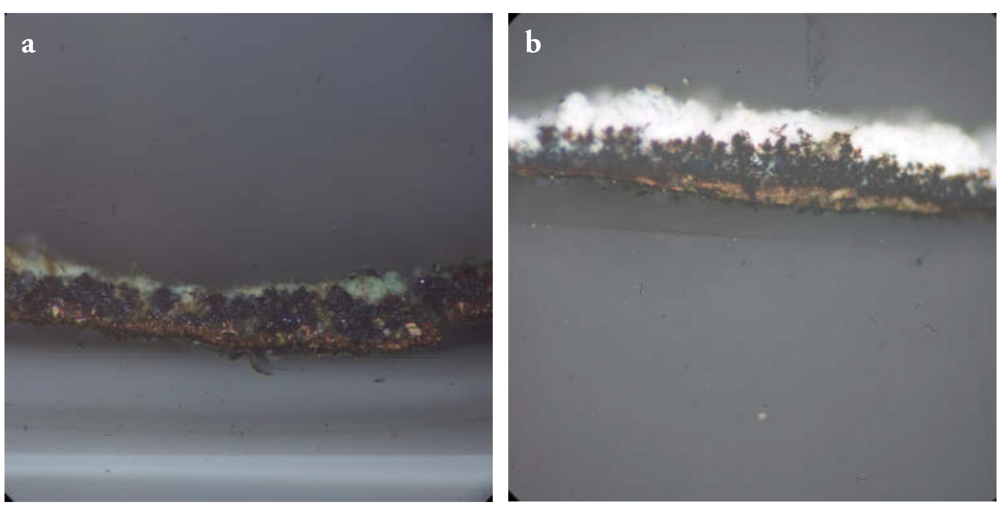
3.3 OTHER PARELLADA CASTS, *PERSONAGE AND BIRD* 1968

To verify these observations and conclusions regarding the unusual manufacture and patination, we were able to examine another 1968 Miró cast from the Parellada Foundry: *Personage*, edition 2/2 from 1968 (fig. 14), belonging to the Nasher Sculpture Center. Although the Nasher *Personage* does not exhibit the bold, drippy patina application over the body, the texture, quality, and color of the surface of the basket appears almost identical to the basket in MoMA's *Personage and Bird* (figs. 15a, 15b). Darkened areas of old surface loss and a light green sandy skin were preserved in the recesses along with the characteristic pink powder. Slight lifting along the edges of the skin was visible on the Nasher *Personage*; however, little or no new loss was observed. We hypothesize that the contours and shape of the bronze mechanically locked the investment in place, whereas the smoother, flatter areas of the body did not provide such support.

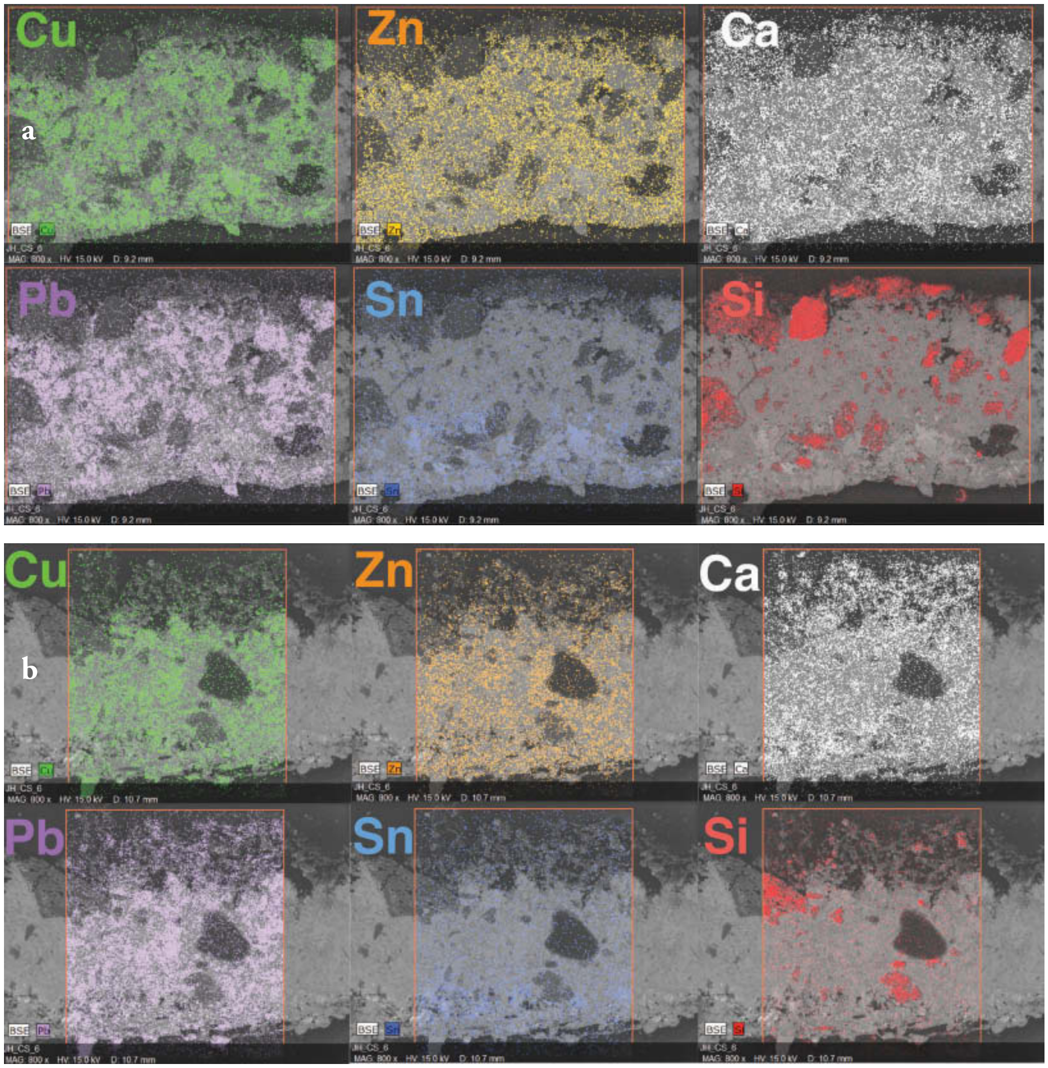
Fig. 15a. Surface detail of *Personage*. Nasher Sculpture Center, NC.1985 (Courtesy of Megan Randall); 15b. Surface detail of basket surface on *Personage and Bird* (Courtesy of The Museum of Modern Art)

3.4 VISUAL CROSS SECTION ANALYSIS OF *PERSONAGE AND BIRD* AND *PERSONAGE* SURFACE FLAKES

While uncrating the Nasher *Personage*, a small flake was found in its packing material. Nasher gave permission to take the sample back to New York to mount it and compare it in cross section to a flake from *Personage and Bird*. Microscopically, both samples appeared similar. Each sample displayed a loose stratigraphy of dark gray metallic material around a copper-like strip with white powdery material on top (figs. 16a, 16b). Given that these samples were representative of what we thought was a discrete layer of investment, it was interesting to find what appear to be alloying components within the cross section.



Figs. 16a–b. Photomicrographs of surface flakes at 100x of MoMA's *Personage and Bird* (a) and Nasher's *Personage* (b) (Courtesy of Megan Randall)



Figs. 17a–b. SEM-EDS element maps of copper, zinc, calcium, lead, tin, and silicon of MoMA's *Personage and Bird* (a) and Nasher's *Personage* (b) surface flakes at 800x (Courtesy of Megan Randall)

3.4.1 SEM-EDS Cross Section Analysis of *Personage and Bird* and *Personage* Surface Flakes

At the Conservation Center at New York University, both samples were examined under the SEM and analyzed using energy dispersive spectroscopy (EDS). In both samples, the alloying elements of copper, zinc, tin, and lead were identified, along with investment elements of calcium and silicon. At 800x, the elements previously identified were mapped across the width of both samples. Although each element is distributed across the width of the cross section, the distribution of each element placement differs (figs. 17a, 17b). The "surface" of the sculpture was essentially formed from a layer of metal mixed with investment. The poor adhesion of the investment and the slight shrinking of the bronze cast upon cooling as mentioned earlier contributed to its tendency for flaking.

3.5 XRF ANALYSES OF *PERSONAGE AND BIRD*

Quantitative XRF[1] was performed on two areas of the sculpture (on the body and on the exposed metal on the rim of the base), and a metallographic section was taken from inside the bottom rim. The goal of the analyses was to interpret the metallurgical aspects of the cast. The first set of quantitative XRF

Table 1. Results of the XRF Quantitative Analysis on MoMA's *Solar Bird* and *Personage and Bird*

Average percentage	A. *Solar Bird*	B. *Personage and Bird* (base)	C. *Personage and Bird* (body)
Fe	—	—	2 ± 1
Cu	83 ± 1	81 ± 3	68 ± 8
Zn	14 ± 1	8 ± 2	14 ± 12
As	—	1 ± 1	2 ± 1
Pb	3 ± 1	5 ± 1	3 ± 1
Sn	5 ± 1	4 ± 1	5 ± 1

Note: Ten readings were taken from the horn and body of *Solar Bird*. Four readings were taken from exposed metal on the bottom surface and eight readings on the body of *Personage and Bird*.

spectra were recorded on four areas of the front of the body where the outer skin of the bronze had flaked away, leaving a large enough section to accommodate the 5-mm spot size of the instrument (table 1C). The alloy percentages from these readings were approximately 68% copper, 14% zinc, 5% tin, and 3% lead; however, the standard deviation associated with these results shows that the percentage of the metals varied significantly, which was representative of an irregular surface and did not characterize the internal alloy percentages. This is likely a result of a variety of factors, including the amount of residual investment embedded in the surface and the use of patination chemicals. The four readings taken across the cleaned, unpatinated bottom rim of the sculpture, however (table 1B), were 81% copper, 8% zinc, 5% tin, and 5% lead. The composition of the base was much closer to the known Parellada Foundry alloy recipe of 85% copper, 5% zinc, 5% tin, and 5% lead (Parellada Site Visit and Interview 2016). Given the exposed metal of the base and the alignment of the acquired XRF data with the archival recipe given by Parellada, the quantification of the XRF data is likely representative of the *Personage and Bird* alloy.

3.6 SEM-EDS METALLOGRAPHIC SECTION ANALYSIS OF *PERSONAGE AND BIRD*[2]

As a way to examine the interface of the bronze alloy with its surface, a metallographic section was taken out of the bottom rim of the bronze. This sample was extracted so that it would not be visible after the sculpture was remounted on its base. As a result, it only contained a preserved portion of the interior surface interface and not the exterior surface. This sample was mounted and examined with the SEM-EDS unit at 1000x at both the interface of the interior surface and within the bulk of the metal sample. The element maps of the edge of the sample showed a copper deficiency at the interface that was filled with a concentration of both zinc and lead. In the center of the sample, the alloying elements were evenly distributed (figs. 18a–c).

The cleaning and finishing practices of Miró with the Parellada Foundry were anything but usual. Without the cleaning that would normally take place after casting (acid bath, power wash, sanding), a casting skin of investment mixed with metal and oxides that was probably always formed during casting (representative of figure 18b) was not removed. This layer was naturally very porous, and further elemental migration likely occurred as a result of the acid attack during the patination process.

3.7 COMPARISON OF OTHER CASTS FROM *PERSONAGE AND BIRD* EDITION

Fortunately, we had access to two other casts from the edition for comparison of their surfaces and states of preservation. A nominative cast licensed by the artist's estate in 1987 for the Reina Sofia,

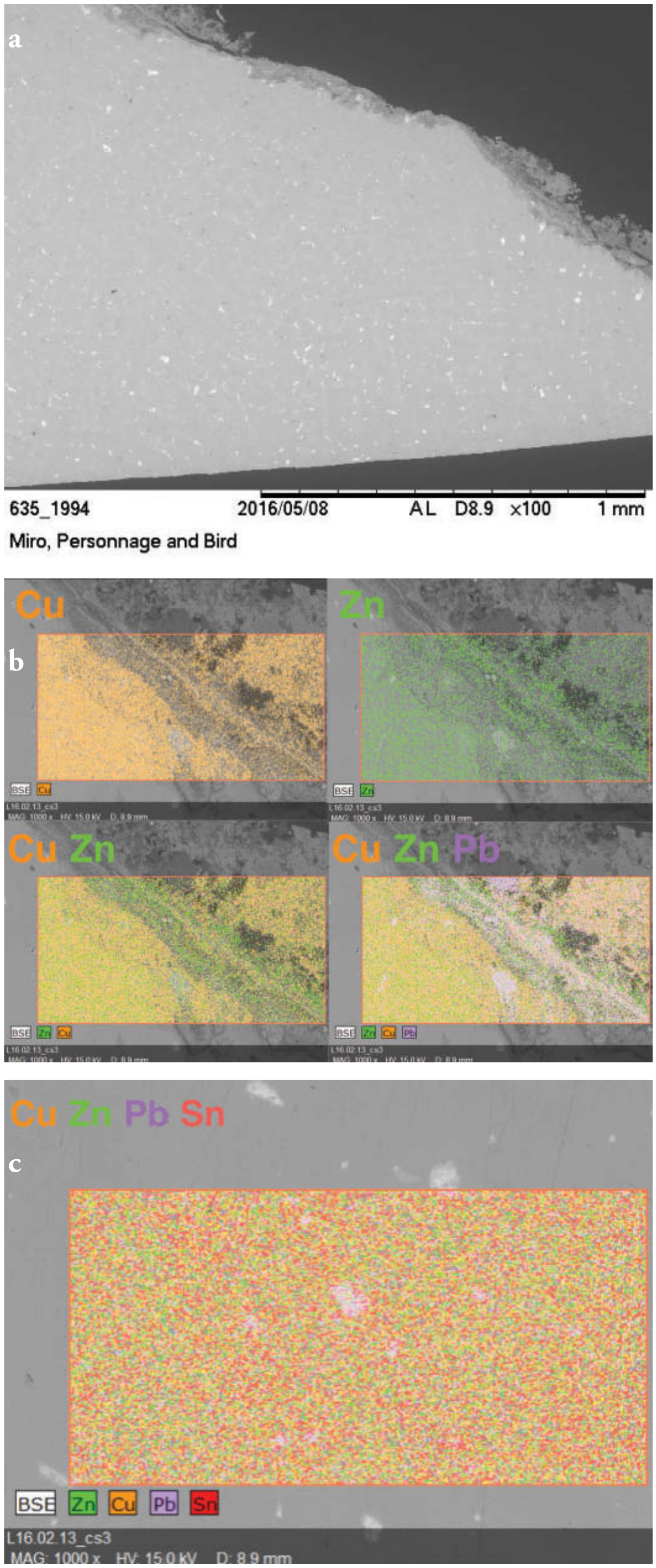


Fig. 18a. SEM image of metallographic sample at 100x; 18b. SEM-EDS element maps of copper, zinc, and lead at 1000x at the surface of the sample; 18c. SEM-EDS element map of copper, zinc, and lead at 1000x in the interior of the sample (Courtesy of Megan Randall)

cast and patinated by Manuel Parellada at the Parellada Foundry, was displayed at the Nasher Museum of Art at Duke University in 2014–2015. The surface and condition of the 1987 cast was considerably distinct from that of the 1968 MoMA cast. There did not appear to be any flaking or loose surface, and in general the texture was compact and smooth. The drips were concentrated in the center of the body, and they appear to be applied by splattering the chemical as opposed to the long drips of the 1968 MoMA edition patinated by Josep Parellada.

The 0 cast of the edition, also from the 1968 casting in the Parellada Foundry, owned by the Barcelona City Council, was on extended loan to the Miró Foundation. The surface appearance and texture are very similar to the MoMA example. Specifically, pink investment was seen embedded in the basket, the general texture was granular and sandy, old loss was visible near the edges of the body and the high points of the basket, and the pattern and color of the drips were similar to MoMA's edition. The condition of the cast was significantly better than MoMA's cast, with almost no new loss with the exception of an inch-wide circular loss near the bottom right section of the back.

3.8 PARELLADA FOUNDRY INTERVIEW

In the hopes of verifying the observations of materials and condition of Miró's Parellada casts, we visited the Parellada Foundry on April 12, 2016, to interview the third-generation owners Manuel and Jordi Parellada, grandsons of Josep and sons of Manuel Sr. (Parellada Site Visit and Interview 2016). As neither Manuel nor Jordi spoke English, Elisabet Serrat, paintings conservator at the Miró Foundation, joined the visit as interpreter. This visit confirmed several aspects of their casting process, most importantly that the casting skin and investment were left on the sculpture intentionally at Miró's request. Manuel and Jordi recalled that Miró was very strong in his idea that he did not want the casts to be "too clean," and that Miró frequently shouted "Don't touch it—I like it!" when a sculpture had achieved his desired appearance. They stated that Miró choose the Parellada Foundry specifically for the surfaces and patinas that they were capable of producing, and that some surface loss at the time of casting and finishing was expected and accepted by Miró.

3.9 TREATMENT OF *PERSONAGE AND BIRD*

There is an inherent contradiction between Miró's acceptance of some amount of surface and patina loss that inevitably happened at the foundry or later on, and his desire for the rough appearance of the patina that Parellada Foundry provided. Our treatment plan for the MoMA edition of *Personage and Bird* sought a balance between stabilizing and preserving the remaining rough surface and visually minimizing the areas of recent loss.

The first step of the treatment was the stabilization of the casting skin, which included both consolidating intact areas of casting skin throughout the sculpture and then setting down flaking and lifting areas of surface on the bronze substrate. The copolymer Paraloid B-48N was chosen for its stability and affinity for bonding to bare or primed metals (Down et al. 1996). A dilute (approximately 5% w/v) solution of B-48N in xylenes was applied to the surface using a soft-tipped syringe. The dilute consolidation did not noticeably change the appearance or saturation of the surfaces. The application of the resin in xylenes allowed the consolidant to penetrate through and under the casting skin and effectively connect the investment layer to the bronze substrate (see fig. 11b).

A more viscous solution (approximately 20% w/v) of B-48N in acetone was used to seal and set down flaking and lifting. The fast evaporation of the acetone and higher percentage of resin provided the necessary strength and tack to set down (and keep down) the lifting areas. Some sheen was evident in areas where the more viscous solution was used, and after the consolidation was complete, local reduction of the sheen was performed with foam swabs and acetone. Last, recent areas of loss on the surface were toned with Golden Matte Fluid Acrylic paints (figs. 19a, 19b, 20a, 20b).

Figs. 19a–b. Front (a) and back (b) of *Personage and Bird* after consolidation and surface toning (Courtesy of The Museum of Modern Art)

4. CONCLUSION

The atypical processes of the Parellada Foundry under Miró's instruction produced incredibly expressive, textured, and colorful bronzes. These surfaces, or casting skins, routinely removed in most foundry practices, are not securely attached to the underlying bronze. The combination of inherent vice with time resulted in an unfortunate loss of surface and texture. The Susse Foundry, in contrast, employed fairly

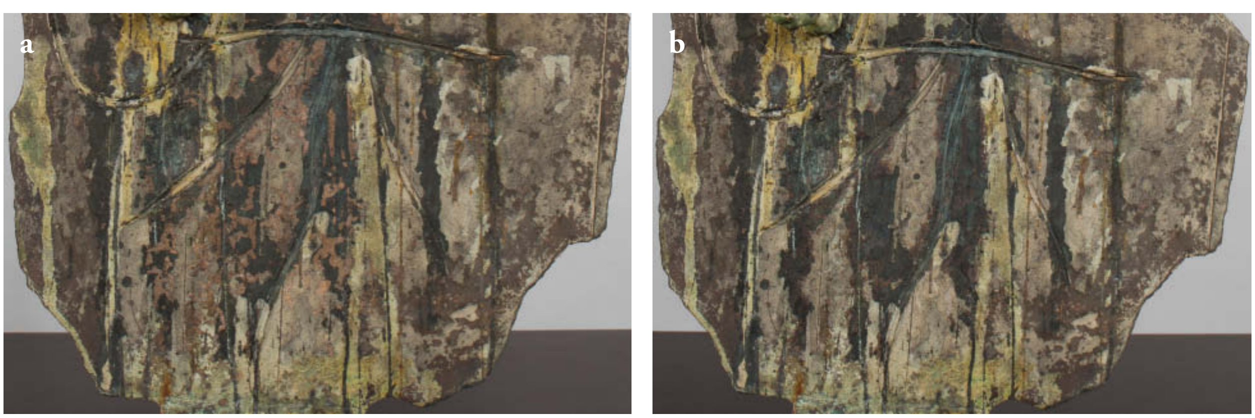


Fig. 20a. Before toning of *Personage and Bird*; 20b. After toning of *Personage and Bird* (Courtesy of The Museum of Modern Art)

standard practices of casting, finishing, and patination in their production of large-scale, uniform, and beautifully finished bronzes. However, lack of maintenance or periodic evaluations of condition ultimately resulted in *Personage and Bird* and *Solar Bird* both with severe condition issues.

Many of the conclusions and insights discovered during the research of this article would not have been possible without visiting the foundries in person. Both the Parellada and the Susse foundries communicated many details of technique and process through oral histories maintained throughout generations and owners. Although bronzes are often considered some of the more robust objects in museum collections, dedicated and concerted efforts to maintain, monitor, and understand their materials and surfaces can be essential to assessing their condition and future stability. Fortunately, thanks to the collaboration and generosity of numerous individuals and institutions, it is now possible to view more of the remarkable range of Miró's creative bronze making within MoMA's collection.

ACKNOWLEDGMENTS

We would like to thank our colleagues at MoMA who made the completion of this research, analysis, and treatment possible, including Jim Coddington, Anne Umland, and Ana Martins. Thank you to the Nasher Sculpture Center for access to their Parellada cast and to Hannelore Roemich and Michele Marincola at the Conservation Center at the Institute of Fine Arts for support and access to the SEM unit. Thank you to Manuel and Jordi Parellada from the Parellada Foundry and Henri Lacroix from the Susse Foundry. And finally, thank you to Elisabet Serrat and Teresa Montaner from the Miró Foundation and to Pilar Ortega and Joan Punet Miró from Successió Miró.

NOTES

1. Conditions for quantitative XRF analyses: Bruker Tracer IIISD, Rh target, Si-Drift detector, 40 keV, 3 mA, 12-mil Al/1-mil Ti/1-ml Cufilter, 180-second data acquisition time, in-house empirical calibration developed with S1Cal and ARMI (Evergreen, CO) and CHARM (MBH Analytical Limited) certified reference bronzes. Results presented correspond to the average and standard deviation of 10 measurements on the body and horn of the sculpture for *Solar Bird*, 8 measurements on the body of *Personage and Bird* (in areas where the underlying metal is exposed), and 4 measurements under the base.

2. Conditions for SEM-EDS analyses and sample preparation: TM3000 Hitachi Scanning Electron Microscope coupled with Bruker EDS and Quantax software at 15 keV for 90-second data acquisition time, analytical mode. Buehler EpoxiCure resin and hardener (in 4:1) were used to mount the surface flakes of the Nasher *Personage* and MoMA *Personage and Bird*, as well the metallographic section. The metallographic section was extracted using a jeweler's saw with a 0.15-mm-wide blade. The sample was cleaned and degreased prior to mounting. All samples were polished in cross section. Sample preparation was considerably informed by chapters 13 and 14 of *Metallography and Microstructure of Ancient and Historic Metals* by David Scott.

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SOURCES OF MATERIALS

Buehler EpoxiCure 2 Resin and EpoxiCure 2 Hardener
Buehler
33 Lewis Rd., Ste. 2
Binghamton, NY 13905
847-295-6500
http://www.buehler.com

Crystal Clear Paste Wax
Woodcraft
215 Westport Ave.
Norwalk, CT 06851
203-847-9663
http://www.woodcraft.com

Golden Matte Fluid Acrylic paints
Dick Blick Art Materials
PO Box 1267
Galeburg, IL 61402
309-343-6181
http://www.dickblick.com

Paraloid B-48N
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com

Pigments
Kremer Pigments
247 W. 29th St.
New York, NY 10001
212-219-2394
http://www.shop.kremerpigments.com

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CONSERVATION AND INVESTIGATION OF AN ANCIENT HUMAN BURIAL AT ABYDOS, EGYPT

LUCY SKINNER, CORINA ROGGE, ISLAM SHAHEEN, AND SALIMA IKRAM

Excavations at Abydos during 2012 uncovered several graves in the sand at the base of a giant dune in the North Cemetery, including one well-furnished human burial from the Middle Kingdom (around 1800 BC) requiring urgent conservation intervention. The conservation and investigation of this burial is the focus of this article.

The first phase of the project took place in 2012 and combined field conservation, block-lifting the body within the remains of the coffin, and transfer of the "block" to the on-site magazine at Abydos. Thanks to a grant from the American Research Center in Egypt, a small team returned to Abydos for five weeks in 2015 and three weeks in 2016 to complete the treatment, analysis, and investigation of this and other bio-archaeology remains. Careful planning was essential throughout the project to ensure that we had sufficient materials (both imported and sourced locally in Egypt) and suitable personnel in the field to carry out conservation treatment and investigation of the burial. Analytical equipment, including a Bruker portable x-ray fluorescence spectrometer and an Agilent portable Fourier transform infrared spectrometer, were imported to enable scientific analysis and materials investigation in the field. The project was ambitious in its aims, striving to demonstrate that rigorous and high-quality research is possible in a challenging environment (regarding both logistics and resources) through the application of determination and ingenuity.

KEYWORDS: Archaeology, Egyptology, Field conservation, Block-lift, Human remains, Bio-archaeology

1. INTRODUCTION

Abydos is an ancient Egyptian sacred site containing temples, cemeteries, and settlements, situated about 6 miles from the west bank of the river Nile, at 26° 10′ N, in Upper Egypt (O'Connor 2011). Professor David O'Connor at the Institute of Fine Arts, New York University (NYU-IFA), holds the permit to excavate at a part of Abydos, and for several decades this has allowed research teams from various universities and museums in the United States to carry out excavation and research there. The primary goal of the North Cemetery excavations, directed by Dr. Matthew Adams over the past 15 years, has been the conservation and stabilization of the important mudbrick structure—the Shunet el Zebib. The Shunet el Zebib (fig. 1) is the last of the second dynasty monumental mudbrick funerary enclosures in the Northern Cemetery and was built for King Khasekhemwy (ca. 2611−2584 BC) (O'Connor 2011).

During the 2012 season, excavations were carried out on the northern side of the Shunet in advance of and to facilitate the mudbrick restoration work on the Shunet's north wall. Conservation has been an integral part of the NYU-IFA project since at least 2000. The primary author has been coming to Abydos since 2009 and has developed a deep understanding of the materials, the technology, and, most importantly, the vulnerability of the artifacts commonly excavated at Abydos.

Since it spanned three excavation seasons, the team involved in the project was large and it varied considerably over the years. The main participants include Lucy Skinner, principal investigator and lead conservator; Corina Rogge, conservation scientist at the Museum of Fine Art, Houston; Salima Ikram, bio-archaeology expert, x-ray operator, and professor at American University, Cairo; and Islam Shaheen, imaging specialist and conservator working at the Grand Egyptian Museum. Others mentioned in this article include Mohamed Ibrahim, who was the conservation assistant during 2015 and 2016, and Deborah Vischak, the archaeologist who excavated the grave.

In preparation for the restoration of the Shunet el Zebib, everything at the foot of the wall had to be cleared away to prevent the destruction of any antiquities that lay buried beneath the desert's surface. This revealed two coffins, complete with human remains. The focus of this article is on one of the two coffins and its contents that were excavated during the 2012 campaign, and conserved and investigated in the summers of 2015 and 2016. It is an account of a modern conservation treatment and investigation

Fig. 1. View of the north side of the Shunet el Zebib excavation area (Courtesy of Lucy Skinner)

with unexpected discoveries and tantalizing results in a challenging archaeological field environment where such conservation intervention and archaeometric investigation is rare.

2. DISCOVERY AND EXCAVATION

2.1 DISCOVERY

It is common in excavations around the Shunet to find isolated burials dating from the Middle Kingdom or younger. In the second week of excavations, it quickly became apparent in one of the excavation squares that three rectangular wooden panels lying on the ground next to each other formed the composite lid of a coffin—possibly originally sourced from wooden boxes or reused from other coffins (Cooney 2008). Once the decayed wood was drawn and carefully removed, it was possible to see the rim of a rectangular box coffin underneath.

This small, crooked box (190 x 45 cm) was patched together in three sections, in a similar fashion as the lid. It could originally have been a smaller coffin that was cut in two and lengthened with a central panel to fit a larger body. It was oriented east-west along the line of the Shunet's external wall. At first, the distorted shape of the coffin led us to believe that the grave had been robbed in antiquity, but we came to believe it is more likely that the shifting sand of the dune above and around the coffin caused this deformation (it is possible to see the distortion in figure 11).

As Dr. Debbie Vischak, the archaeologist, proceeded to excavate to the right side of the coffin, the top of a small basket was exposed. Termites had long since devoured almost all of the vegetable fibers from the coil-formed basket (termites are a particularly common form of deterioration to organic artifacts at Abydos). This left behind a fragile shell over frass, interspersed with a few grass fibers in the shape of the basket. Once conserved, the contents of the basket were revealed (fig. 2). Inside and spilling over the side was a string of blue faience beads held together with the original thread. Some unidentified dried vegetal material, a faience cylinder bead, and a faience scarab bead were also discovered inside.

Fig. 2. The grave goods (from top right, S shape): Basket, three Egyptian alabaster pots, scarab, fish beads, berries and seeds, ointment lump, faience beads on string, and two hippo ivory clappers. NYU-IFA. (Courtesy of Gus Gusciora)

The scarab has a small piece of original cordage sticking out of it. The hieroglyphs on the scarab have been studied by the epigrapher Bryan Kramer, revealing the name of a known Middle Kingdom official, Senebsumay, who was the royal seal-bearer of [undeciphered]. Based on this official's name, the grave was dated to around the end of the 12th to the beginning of 13th dynasty (1800−1700 BC) (Martin 1971).

To the north of the coffin, we found two clappers made of hippopotamus tusk (see fig. 2). To form a clapper of this type, the entire tusk would be sawn down the length, creating slivers of about 0.5 cm thick. A hand shape with fingernails and a bracelet design would be carved into the pointed end, and finally the carving would be polished (the sheen has survived burial). This type of ivory object (although often decorated in a different way) has been found in other graves from the late Old Kingdom through to the New Kingdom, including several at Abydos. Clappers have frequently been found together with wood or ivory female figurines and copper alloy mirrors (although not in this case), and may have been utilized in mortuary temples by Hathoric priestesses who danced for the dead king in his semblance of Re (Morris 2017).

Several of the fingertips on the clappers are broken and smoothed off, indicating that the initial damage occurred in antiquity and continued use in religious ceremonies wore the break edges down. They are not size matched and may have come from tusks of different animals, which is curious, because often a matching pair of clappers were cut from one hippo tusk (Krzyszkowska and Morkot 2000), although size can vary depending on from where on the tusk it is sliced. Pressure exerted in the grave had caused one of the clappers to be snapped in half. After rejoining the two halves using Paraloid B72, the clappers were packed carefully and have been registered and taken to the government store near Sohag.

A second basket was also found, originally placed near the foot on the northeastern side, on the exterior of the coffin. This one was difficult to recognize as a basket because it looked like a lump of termite frass attached to the coffin side. The basket must have tipped over in the grave, as the contents were found spilling out underneath it. These included three miniature vessels carved from Egyptian alabaster (calcite) (see fig. 2, top middle). One had a chipped calcite lid, held in position on top with a textile strip, inside of which was the powdery remains of black kohl eye makeup. A sample of the powder from inside was collected for analysis. The other two (one of which was a double-bodied vessel) contained the remnants of some sort of paste or dried liquid. These items were also registered and taken to the government storeroom. Ideally, the human remains will be reunited with these artifacts in the future to allow future researchers the possibility of examining the entire assemblage while acknowledging the "deep interconnectedness of these different elements in the grave" (Balachandran 2009, 202).

Among the other items formerly inside the second basket were a large number of what appeared to be berries and seeds (food for the deceased); two tiny, fish-shaped beads (see fig. 2); a small, rectangular, gray stone object with many parallel striations along and around its edges (a model palette, maybe for grinding makeup); a tiny, smoothed, black stone with a flat face (possibly a model grinder to go with the palette); and last, a smooth, rounded, light-brown lump of an unidentified material (see fig. 2).

2.2 EXCAVATION AND CONSERVATION OF SMALL FINDS

The basket and objects discovered in the vicinity of the grave were stabilized in the field before being carefully excavated and taken to the dig house for further treatment.

The small basket was consolidated in the field using Paraloid B72, 3% in (75:25) acetone:ethanol. Once stable, it was undercut with a stiff plastic board (created by cutting down a flexible plastic chopping board) to support it from underneath and prevent collapse. In the dig house, sand was excavated from in and around the basket to reveal the degraded remains of the fibers. A solid, dark organic fragment on one side may have been the basket lid.

Once cleaned in the conservation lab, all items were photographed. Analysis of the artifacts remaining at the dig house took place in 2016.

While continuing to clean within the grave, Dr. Vischak was surprised when a beaded headband emerged from the sand. A visual assessment quickly revealed that the beads remained wrapped around the head of a well-preserved skull. We proceeded to clean the burial, removing sand from inside the coffin (fig. 3). The body was revealed, wrapped in the remnants of textile with pieces of skin in position and perfectly preserved braided hair still attached to the head.

2.3 IN SITU CONSERVATION AND BLOCK-LIFTING THE BURIAL

Although extremely fragile, the exceptional state of preservation of the burial and the information that could be retained by removing it from the ground as a unit warranted a departure from conventional dissociative archaeological methods.

Leaving the burial in the ground and preserving it in situ was not an option due to the potential risk of looters and because of the proximity of the burial to the Shunet wall where there was high risk of damage from the overlying mudbrick conservation campaign. Therefore, it was necessary to block-lift it in its entirety. This was done by building a box around the burial, filling the empty space around and above the coffin and human remains with expanding foam to create a firm structure, and undercutting the entire block for transport back to the dig house. The following is a description of this process:

- The fragile, fragmentary, and wobbly state of the coffin and the absence of decoration on its surface helped us decide, after documentation, to reduce the height of the coffin walls using a craft knife and spatula to facilitate excavation of the skeletal remains.
- Cyclododecane (CDD) was melted in a double boiler over a butane stove and brushed over cotton gauze strips applied to the coffin and the body to consolidate their surfaces (fig. 4). This is a well-practiced method developed on archaeological sites in Egypt (Balachandran 2010; Skinner and Kariya 2017). The benefit of using CDD is that although it does function in a strengthening capacity, it also has the ability to sublime at room temperature. This means that

Fig. 3. The partially excavated and exposed body (Courtesy of Lucy Skinner)

once the burial had been block-lifted and transported, we could be reassured that the consolidant would gradually disappear, leaving no residue.

- Once the edges of the burial were protected as described, we dug away and leveled the surrounding sand so that the burial sat up on a pedestal.
- All surfaces of the burial were covered with aluminum foil to provide a barrier layer.
- A box design was drawn and constructed by a local carpenter, comprising a four-sided frame screwed together at the corners to ensure that it could be easily taken apart during the following stages. The inner surfaces of the box were lined with aluminum foil to prevent the expanding foam from sticking to them. The box was heavier than hoped for, but fit snugly when lowered over the prepared burial.
- Any undercuts around the body were filled with cotton wool. Wedges made of aluminum foil were placed down between the coffin and the wooden box to fill space around the coffin and economize on the amount of foam needed to cover the burial, and a two-part expanding urethane foam was mixed and poured on and around the coffin to support, stabilize, and fix everything

Fig. 4. Application of cheesecloth impregnated with CDD to the coffin and burial. NYU-IFA. (Courtesy of Gus Gusciora)

together as one (fig. 5). The foam was poured first, thinly, in a single layer into the cavity around the side of the coffin and then over the surface of the body. This gave the foam room to expand upward, rather than sideways, preventing pressure being exerted on the burial itself. Once it had fully expanded and cured, additional foam was added where necessary on top until the burial was covered. There was not enough foam to fill the box, but at this stage it was not necessary.

Once the foam had fully set, we were ready to perform the block-lift, the first part of which was "the undercut." Iron guidance rods were first hammered through at intervals underneath the box until the point of the rod was visible on the other side (fig. 6).

Fig. 5. Pouring expanding foam around the burial, inside the box. NYU-IFA. (Courtesy of Gus Gusciora)

Fig. 6. The Egyptian archaeology team inserting guidance rods. NYU-IFA. (Courtesy of Gus Gusciora)

The local blacksmith prepared three thick, sheet-steel plates, each with two metal loops welded to one edge. These plates were lined up on top of the iron guidance rods and hammered underneath the wooden box until they stuck out the other side. A scaffolding pole was slotted through the loops, creating a useful handle (fig. 7). Fortunately, we only had to insert the metal plates through sand, but it still was not easy to get them all the way underneath and out the other side. Once undercut, the box, with the metal plates now forming the base, was slid across to a wooden board and transferred to a large wooden lifting cradle.

One of the most rewarding elements of being at Abydos is working alongside the local Egyptian archaeologists and workmen with their endless enthusiasm and enormous strength. The team bonded while taking turns to carry the extremely heavy burial box on the cradle over 500 m to the storage magazine (fig. 8), while others followed issuing encouragements and forming the entourage.

Back at the dig house, a lid was constructed for the box to protect the burial until the time of our return.

3. CONSERVATION AND INVESTIGATION IN THE FIELD-LAB

A grant received from the American Research Center in Egypt enabled work to continue on this burial as part of the Abydos Bio-archaeology Conservation project. The aim was to stabilize the burial both from below and above, investigate the coffin construction, and conserve the human remains, preserving them for the future. It may sound extreme, but it was decided that the burial needed to be turned over to conserve the coffin and construct a secure mount from underneath. The author's previous experience working in Egypt has shown that no matter how well the top surface of an Egyptian coffin panel is conserved, if the underside is not stabilized and mounted on a secure base, it is unlikely that the object will survive long-term storage due to compression damage and subsequent slumping and movement of material.

The second stage of the project was supposed to take place during 2014 but was delayed for a year as a result of security issues in Egypt, and finally happened during the summer of 2015. A plan was set in motion, and most materials required were purchased in Egypt and transported to Abydos overland.

Fig. 7. The burial box with metal sheets and board partially slid underneath before being transferred to a lifting cradle. NYU-IFA. (Courtesy of Lucy Skinner)

3.1 INVERSION AND STABILIZATION OF THE COFFIN BASE

The first and most nerve-racking part of this stage involved inverting the burial box. But first, to secure the burial firmly inside the burial box without adding to its weight, expanding foam (cans of commercially available wall cavity-filling foam, obtained in Cairo) was squirted into the box, along with chunks of Ethafoam and mattress foam put in to decrease the volume needing to be filled. The box was

Fig. 8. It was heavy! NYU-IFA. (Courtesy of Gus Gusciora)

Fig. 9. The cleaned and consolidated underside of the coffin (Courtesy of Danny Doyle)

filled almost to the top with foam, leaving space for the foam's expansion, and the lid was secured back in position.

Ratchet tapes were strapped around the box and the wooden lifting cradle and ratcheted tight to hold everything together. Padding in the form of a heavy fiber mattress was added to the side of the box to cushion the turn, and with the help of Egyptian workmen, the burial and its cradle was rolled upside down. The inversion went smoothly, although there was a little further loss of sand from the base. After unfastening the ratchet tapes, the cradle was lifted off, followed by the three metal plates.

We began the process of removing loose sand, some of it dark and semisolidified—impregnated with body fluids—to reveal the underside of the coffin. The sides of the coffin were held in position by the expanding foam that had been applied from the top and had extended around the edges (fig. 9).

Clearly, the coffin was made of three sections, similar to the sides and lid, and painted red and black, just as the sides had been. Although now displaced, four cross braces would have originally lifted the base of the box coffin off the ground—a common design feature for Middle Kingdom coffins (Taylor 1989). The middle section of the coffin had slipped to the right side, and the central portion of the body, wrapped in textile, was lying on the ground, directly on the sand. A long unpainted plank of wood running along the length of the right side of the coffin base is what had kept the three sections of coffin together while it was carried to the burial site. Traces of linen textile found on the outside of the central section suggest that cloth strips may have been wrapped around the coffin to hold the three sections in place. Such strips are also used to secure coffins and to help move them (Ikram, pers. comm.).

After fully documenting the coffin base, it was selectively consolidated where needed. Mowital B60-H, a polyvinyl butyral available in the UK as an alternative to Butvar B98 (Butvar has a proven track record for the consolidation of dry wood [Spirydowicz et al. 2001]), and Paraloid B72 and were tested to gauge their effectiveness for strengthening the deteriorated wood. Alternative consolidants considered include methyl cellulose and a commercially available alkoxysilane (Conservare OH100) tested on decayed wood at Abydos in 2014 (Davis and Chemello 2014). Although these might be practical alternatives for smaller artifacts or when the darkening of paint surfaces is a concern, neither imparted a significant increase in strength to the large, heavy, and crumbly remains of the coffin base. Both Paraloid B72 and Butvar B98 were found to darken the wood (but this was not of great concern since the coffin base would be concealed), but only Paraloid B72 imparted sufficient strength and so was used at 10% in (50:50) ethanol:alcohol.

3.2 BUILDING A MOUNTING SYSTEM

Once the solvents had evaporated, we were ready to construct a mount for the coffin. In the spirit of minimal intervention, the aim was to create a solid base and rigid support while not permanently physically attaching (gluing) the mount to the coffin. This was carried out as discussed next.

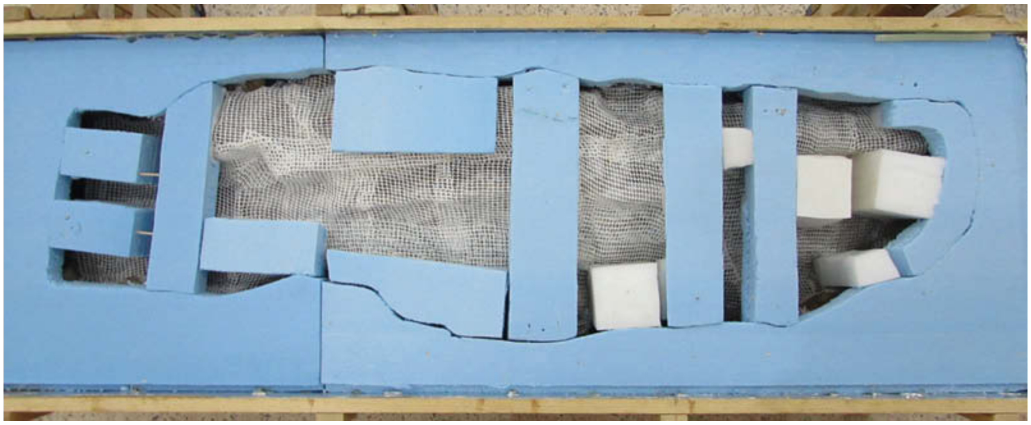

Fig. 10. The X-LITE support and foam base, built up on the reverse of the coffin (Courtesy of Lucy Skinner)

CDD was melted using a method developed at Abydos by treating an electric kettle like a double boiler and setting a heatproof glass jar inside containing CDD crystals (Skinner and Kariya 2017). CDD was employed in this case for its hydrophobic properties—it was melted and painted over the coffin base in a solid layer, forming a temporary barrier layer that prevented the water-based adhesive Lascaux 498HV from soaking into the wood, and also protected the coffin from small amounts of hot water used during application of the X-LITE sheet in the subsequent step.

Next, a 1:1 solution of Lascaux:water was used to adhere a lining layer of spider tissue (machine-made mulberry fiber tissue) over the entire surface, over the CDD. We found that overlapping small rectangles of tissue, about 8 x 5 cm, ensured that the tissue conformed well to the surface.

To make sure that the tissue layer was thick enough to cover the base of the coffin without developing holes, a second layer of tissue was applied using local wood glue. In this way, the adhesive was made to go further, and even after the CDD has sublimed, any PVAC adhesive (not conservation grade) has been kept out of direct contact with the coffin and body.

Over the smooth and soft tissue layer, we directly applied an X-LITE sheet to give structure and support to the base. X-LITE is a rigid bandage material used in orthopedics. It takes the form of a mesh coated in a thermoplastic material, and when heated it becomes plastic and moldable. A molded support for the coffin was applied by dipping strips of the X-LITE in boiling water, shaking off the excess water, and pressing the X-LITE onto the coffin to conform to its shape.

Finally, we built up the level on the back of the coffin to create a flat support (fig. 10) using blocks, cushions, and columns of Ethafoam and blue (Egyptian-sourced) Styrofoam, held in position with bamboo skewers and the weight of the coffin. The box was sealed by placing a wooden board over the foam mount. Once the block was rotated upright again, this board became the base of the mount.

3.3 REMOVAL OF BLOCK-LIFTING MATERIALS

After the coffin box had been reverted upright, we removed the lid and began to unscrew the sides of the box. With one long side of the box removed, we were able to commence cutting away the expanded foam from over and around the body using craft knives. It came away easily thanks to the aluminum foil barrier layer put in place before the foam was poured, and because all undercuts had been padded out and filled. The remaining sides of the box were removed and the body slowly revealed, bit-by-bit, and cleaned with brushes and puffers (fig. 11). The aims of the 2015 season achieved, we readied the burial for a further year of storage in the bio-archaeology magazine.

The wooden box used for the block-lift was redesigned and put back together, this time with a drop-down door, creating a side opening. This made it relatively easy to slide the mounted burial and

Fig. 11. The conserved body and coffin base (Courtesy of Islam Shaheen)

pack the body away at the end of the 2015 season, ready to be taken out again in 2016 for the next stage—the investigative part of the project.

3.4 CONSERVATION OF THE BODY, SANDY ENCASEMENT, AND COFFIN

Even though most sand had already been removed from the burial while it was still in the ground, there was still sand remaining that was removed using teaspoons whose handles had been bent to create scoops. Consolidation was kept to a minimum but was necessary for stabilizing the sandy shroud layer where it had cracked. As before, Paraloid B72 was used for this purpose.

4. ANALYSIS AND INTERPRETATION

The analysis and investigation phase mostly took place over two weeks in April and May 2016. Corina Rogge carried out analyses in the field using a Bruker Tracer III-V pXRF and portable Agilent Exoscan

Fig. 12. The thin drape of the textile and ties are visible (Courtesy of Lucy Skinner)

4100 FTIR. Islam Shaheen, imaging and documentation specialist from the Grand Egyptian Museum, was responsible for multispectral imaging, reflectance transformation imaging (RTI), and visible light photography. Salima Ikram joined us to assist in the bio-archaeological interpretation, both visually and through x-ray radiography, using a portable x-ray unit belonging to the Institute of Bioarchaeology. Mohamed Ibrahim and Lucy Skinner were present throughout to document and study the body and complete the conservation process.

4.1 TEXTILE SHROUD AND SKIN DOCUMENTATION

The body was faced toward the left side of the coffin and was originally covered in textile, about four layers thick. The way the textile drapes between the limbs and the shape of the textile folds discernable through the sandy shroud layer indicate that each limb was wrapped individually in wide strips of linen. The torso and head were similarly bound. A shroud was folded around the body and tied in place using rolled (folded?) linen straps, visible at the ankles, around the thighs (where it holds the arms in position at the side of the body), and probably in the neck area, although the textile and sandy shroud are not well preserved in this section (fig. 11). There is not much skin remaining, but that on the soles of the feet is so well preserved that it is possible to discern "toe prints."

4.2 BIO-ARCHAEOLOGICAL ANALYSIS (SKELETAL REMAINS AND ORGANIC MATERIALS)

Most muscle and flesh had decayed and disappeared, but there are muscle fibers in the thigh area that have a dark and almost woody appearance.

We are almost certain that the body belonged to a female for several reasons:

1. The burial goods (including the ivory clappers) that, as mentioned previously, are typically found in female graves
2. The long, braided hair with a beaded headband/fillet that was worn only by women (see section 3.5)
3. The fine features of the body and skeleton, and notably the absence of a pronounced brow ridge, the shape of the chin, and the small mastoid processes.

However, the only sure way to discern the sex of an individual when skin is not well preserved is to examine the skeleton. Unfortunately, the most diagnostic part of a skeleton for determining sex—the pelvis (White and Folkens 2005)—was not visible in this case because it is wrapped in textile.

In addition, we cannot be totally sure of the age of the individual because only a few of the bone epiphyses (the parts of long bones used to determine age by assessing the degree to which the epiphyses have fused) are visible. However, the femur and radius bones, as well as the iliac crest, are exposed, enabling Salima Ikram, upon examination of the skeleton and burial, to make an estimation of its age—tentatively suggesting 17 or 18 years old.

To permit further examination of the skeleton, and possibly discern details of the grave such as the location of beads concealed beneath textiles and bone in the hip region, we carried out x-ray radiographic imaging. This was facilitated through the transport to Abydos of a portable x-ray unit (Karmex Diagnostic X-ray Unit PX-20N [AC 115V 50/60HZ, 50−130 KVp 2-20mA]), belonging to the Institute of Bioarchaeology, and operated by Salima Ikram, with the films being developed in the darkroom of the dig house. The procedure involved placing the mounted coffin/body onto the floor of the bio-archaeology lab. Conventional AGFA Structurix x-ray film sheets, which are presealed within lightfast foil and lead wrapping were used. Each sheet of film was inserted successively underneath the body between the wooden base and the foam mount. The x-ray tube, mounted onto an A-frame, was positioned over the top of the body, and each sheet of film was exposed at 70Kv for 40 seconds. In thicker areas, the exposure time was lengthened to 55 seconds at 70Kv.

Fig. 13. The only area in which x-ray radiography can discern bone is the rib area. (Courtesy of Islam Shaheen)

Unfortunately, x-ray radiography of the burial was not helpful for discerning shape and features of the skeleton. The thick, radio-opaque layers of coffin and sand underneath the body almost completely obscured the bones in the x-ray images in almost all areas (fig. 13), and no great insights were offered.

Brown staining on the sides of the coffin is particularly concentrated in the central portion, the area corresponding with the abdomen, indicating that there were fluids emanating from the body as it decomposed, which soaked into the plaster and up the coffin sides. This, as well as the lack of large quantities of wrapping, suggest that the body was not eviscerated, desiccated, nor wrapped as one would expect had it been properly mummified. This is not unusual for the period (Ikram and Dodson 1998).

4.3 THE COFFIN

Neither the inside nor outside of the coffin was decorated with texts or figurative designs—or at least none have survived. However, the inside was coated in white plaster. XRF spectroscopy of the plaster indicates that it is calcium carbonate based, suggesting a predominantly lime- rather than gypsum-based plaster. The entire outside surface of the coffin was painted with a thick coating of red paint. Over the red paint was a liberally but patchily applied black coating. The red paint is rich in iron, suggesting that it is red ochre. Red is associated with solar deities and thus with rebirth and resurrection, which was the destiny that the deceased hoped to achieve.

Further confirmation is needed, but photomicrographs have been produced of the cross section of a tiny piece of wood found within a crumbing wall section of the coffin. This gives a preliminary identification of the wood as *Ficus sycomorus* (fig. 14), which is a typical wood used in ancient Egypt for coffin construction and could have been harvested locally.

4.4 BEADS

Found on either side of the body near the waist and the wrists were two strings of beads. One of these appears to pass underneath the body, maybe forming a girdle. Unfortunately, x-ray radiography

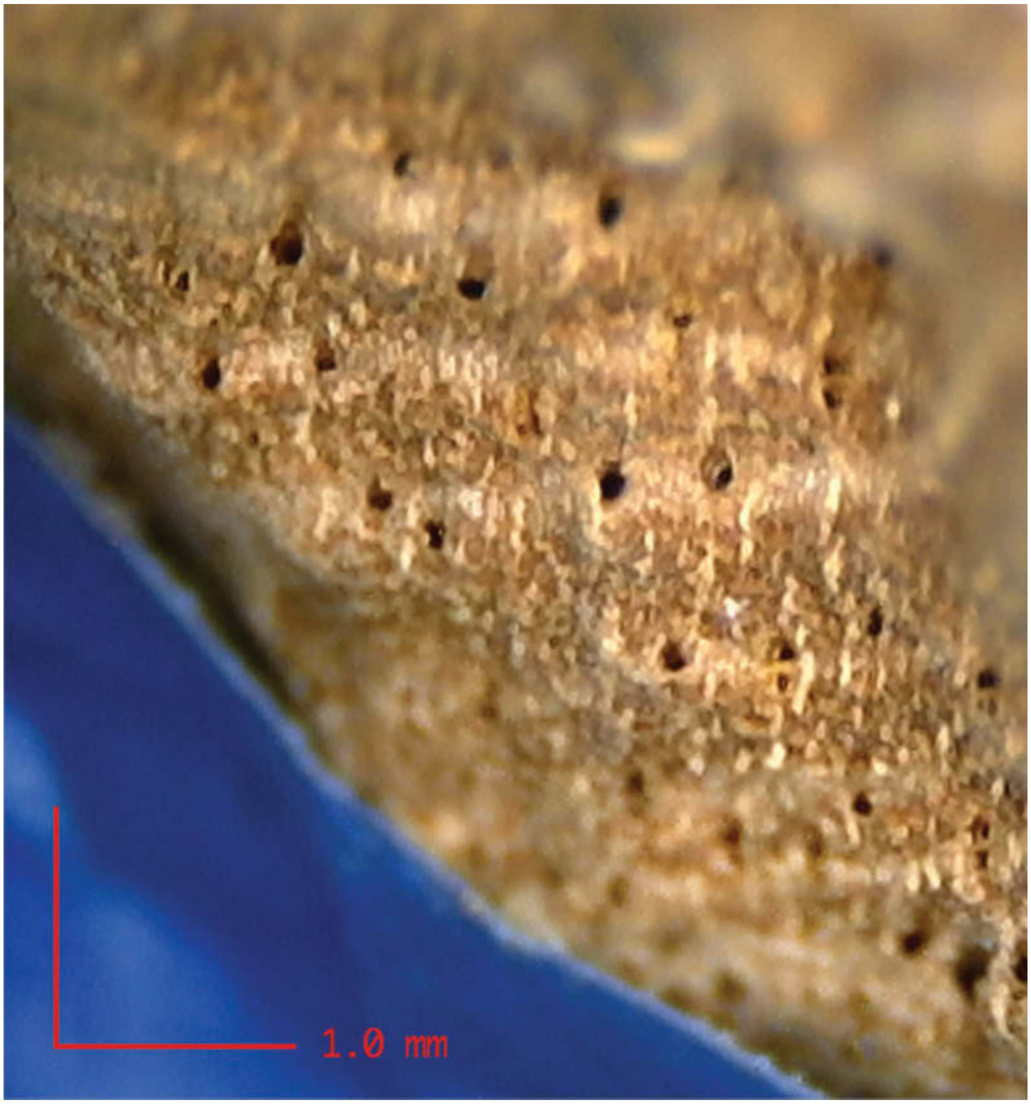

Fig. 14. Sycamore fig—the wood is diffuse porous, with few vessels per square millimeter, solitary, and in radial rows. Also diagnostic of sycamore fig are axial parenchyma in broad bands. (Courtesy of Lucy Skinner)

neither confirms nor denies the possibility, as it was not possible to discern whether this formed a continual string. The possible girdle string consists of small black beads interspersed with large red and white beads (fig.15). Some of the beads have been individually analyzed with XRF, the results of which suggest the following:

1. The black beads are made of faience, which is rich in iron, indicating that the colorant is iron oxide.
2. The large white beads are calcium rich but low in silicon, indicating that they are shell and not faience.
3. The red beads have not been analyzed, as none were found loose individually, but have the appearance of carnelian.

The other string appears to consist of black seeds strung on a thick vegetable fiber thread. XRF confirms this because there is no significant calcium or silicon in them, whereas analysis using diffuse reflectance FTIR indicates the presence of carbohydrates. At this time, the plant source of the seeds has not been identified.

Fig. 15. The girdle beads—red carnelian, shell, and black faience (Courtesy of Lucy Skinner)

4.5 BEADED HEADBAND

From close examination and photomicrographs, it is possible to see that the headband was constructed using a brick-stitch (also known as peyote-stitch) technique. This involves threading beads onto a thread and weaving them freehand using a fine needle-like tool. The pattern created is of colored beads in nested green, turquoise, and white diamond shapes, and in the middle is a blue cross-shape cutting through the center of a brown diamond. Rows of black, white, and green beads square up the pattern on the sides. RTI illuminates a slight variation in size of the different colored beads (white and light turquoise seem bigger than dark turquoise and brown), but generally they are about 1.5 mm in diameter (fig. 16). RTI also shows how the beads remain firmly stuck to the head. The headband does not form a complete loop around the head but ends on either side behind the ears, tapering to triangular points. Originally, the band must have been stitched to a textile or leather strap, tied at the back of the head, but no trace of this remains.

XRF analysis of detached individual beads from the headband detected silicon, potassium, and calcium, indicating that all colors are made from faience. This includes the white beads, which sets them in contrast to the white beads of the girdle, which are made of shell. As expected for faience objects, copper is the colorant present in blue and blue-green beads (fig. 17), while the black beads contain both copper and manganese. The white beads obtain their color from the faience itself.

4.6 HAIR

Almost as spectacular as the headband is the hairdo that it adorns. The deceased has fine dark black hair, which is plaited into small braids (approximately 0.5 cm in width), swept back from the face,

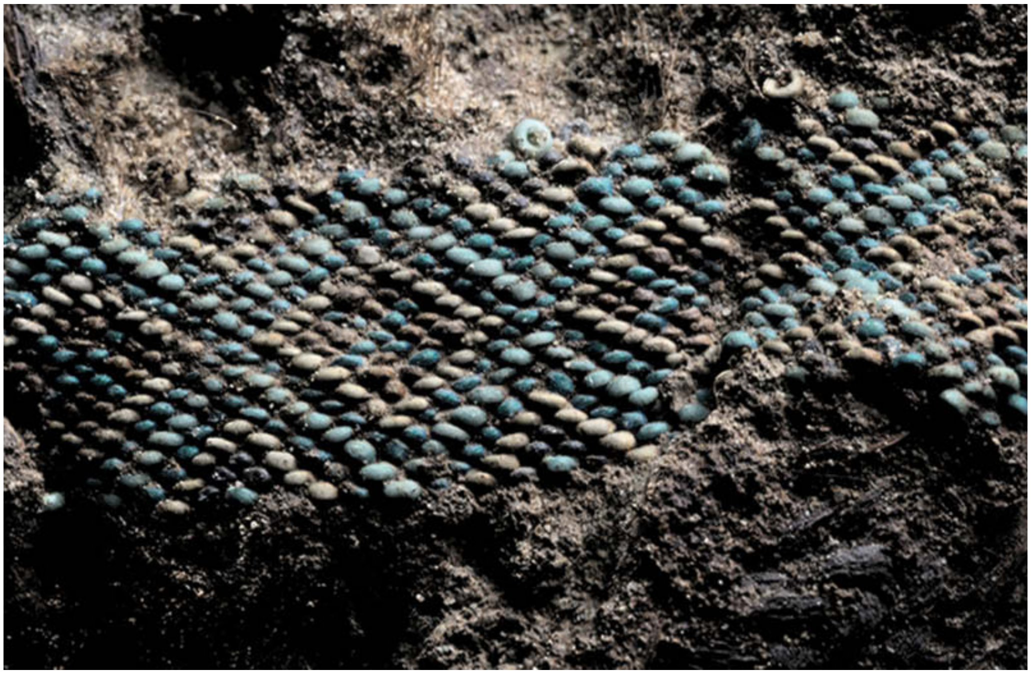

Fig. 16. RTI (diffuse gain) of headband beads (Courtesy of Islam Shaheen)

down the back and around the side of the head. Looking closely, it is possible to see that the hair closest to the skull, her natural hair, is lighter brown in color than the rest of the hair and that the dark braids are hair extensions. The extensions appear to be made from human hair. The tops of the hair extension strands are tightly bound together by a few hairs to prevent them from unraveling. The extensions are

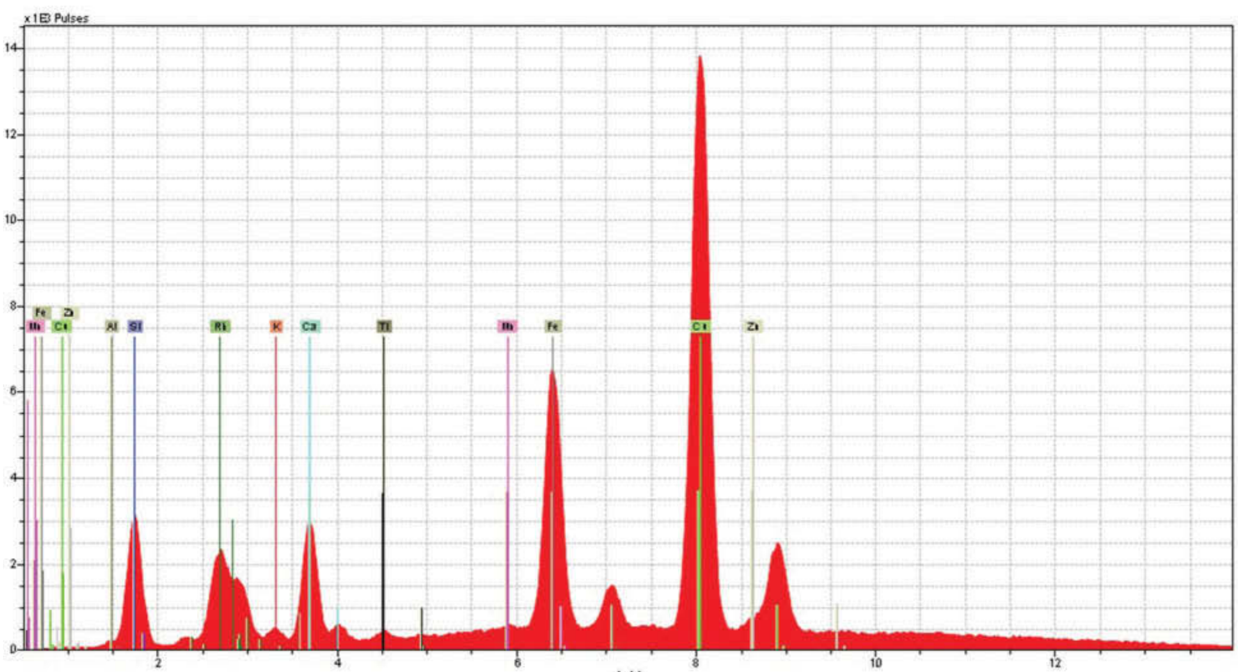

Fig. 17. XRF spectrum of blue faience bead. Silicon, calcium, and potassium suggest faience, with color provided by copper. (Courtesy of Corina Rogge)

Fig. 18. The natural hair and hair extensions are bound together and attached by incorporating natural hair into and around the bunches of hair extension. (Courtesy of Islam Shaheen)

held onto the head by incorporating her natural hair into the braids and wrapping unbraided strands over the top of bunches of the dark hair extension braids, holding them in position (fig. 18).

The hair extensions are beautifully preserved. They are incorporated close to the skull and extend around the side of the head, scoop over the shoulder, and come to an end, in a knot, against the chest (fig. 19). Clearly, someone carefully positioned the hair of the deceased before she was tied in linen and sealed inside the coffin.

Parallels to similarly well-adorned graves from this period are not known, although there are, of course, tomb paintings and coffins depicting young women with long, braided hair involved in funereal rituals. A fragment of a tomb relief held at the British Museum (EA1150) depicts a girl with long hair and a hair band (British Museum 2016).

4.7 RTI IMAGING

Macrophotography of two tiny beads in the shape of fish showed that they were clearly carved from stone and not faience objects as first suspected. The stone appears to be turquoise, but as this object is now in storage at Sohag, further analysis (using XRF) was not possible.

Fig. 19. Hair braids over the back of the neck and around shoulder (Courtesy of Lucy Skinner)

Images captured from RTI with specular enhancement by Islam Shaheen clearly show tool marks on two small fish beads and the steatite palette (fig. 20). The artifact, which we call a *palette*, is a curious object. How exactly its owner may have used it, since it is so small, and the striations on the sides do not conform to the palette interpretation.

4.8 FRUITS AND BERRIES

The berries originally inside the second basket have been identified as juniper (see fig. 2, center of image). One species of juniper grows in Egypt (Sinai), *Juniperus phoenicea*, and was probably a component of perfume, a spice, or used medicinally. The other organic material from the basket, which due to decomposition now looks like a flower bud, is actually a tuber from the sedge plant *Cyperus esculentus* and is known as tiger or chufa nut (see fig. 2). Tiger nuts are edible and very nutritious, and

Fig. 20. RTI specular enhancement of the steatite "palette" (Courtesy of Islam Shaheen)

they were ground up to produce a flour used in breads and cakes. They can also be pressed to release oil, which could be used as a base for perfume. Both juniper and tiger nuts have been found in Egyptian burials before, dating from the Predynastic period (Murray 2000).

4.9 RESINOUS MOUND

One of the most intriguing objects found in the burial was the unidentified orange-colored mound/lump from inside the larger basket. Diffuse reflectance FTIR spectroscopy suggests that it is a type of resin. Unfortunately, the spectral peaks are broad, and it has not been possible to determine which kind of resin it may be.

Finally, XRF of the black contents of one of the three calcite pots shows well-defined peaks for iron, lead, silicone, nickel, and zinc. These components indicate that it contains galena and perhaps some hematite, which are typical constituents of kohl used for eye makeup.

5. SUMMARY

This project is now at a stage where the coffin and body are stable and we have carried out every kind of analysis within our capabilities in the field. The investigation was nondestructive and took place in the magazine at Abydos. If able to remove samples and analyze these either in Cairo or abroad, then we would likely be able to make further interesting discoveries. In particular, we are interested in analyzing the resinous material; contents of the calcite vessels found in the grave; and the possible presence of any fats, oils, or waxes in the hair.

The lack of clarity in the images using x-ray radiography due to the thickness of the underlying coffin was quite disappointing. Future developments in technology and the availability of a portable CT scanner in Egypt, which may be brought to the site, would likely give better results and enable the confirmation of age and sex determinations of the body. The burial has been packed carefully, and in the future it may be revisited to prepare the assemblage for display in the as-yet unbuilt Sohag Museum. A lot of new information has been revealed about Middle Kingdom burial practices and destruction has been minimized through careful block-lifting and painstaking conservation treatment.

ACKNOWLEDGMENTS

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SOURCES OF MATERIALS

Conservare OH100
PROSOCO Inc.
3741 Greenway Cir.
Lawrence, KS 66046
800-255-4255
http://www.prosoco.com/products/conservare-oh100-consolidation-treatment

Cyclododecane
Kremer Pigments
247 West 29th St.
New York, NY 10001
212-219-2394
http://shop.kremerpigments.com/en/mediums-binders-und-glues/cyclododecane-volatile-binders/

GE STRUCTURIX AGFA industrial x-ray film, developer, and fixer fluid
Private contact through American University in Cairo.

Lascaux 498 HV, Paraloid B72 Methacrylate CO-polymer
Conservation Resources UK
15 Blacklands Way
Abingdon
Oxon OX14 1DY
http://www.conservation-resources.co.uk

Two-part liquid expanding urethane foam (marine foam)
U.S. Composites
6670 White Dr.
Palm Beach, FL 33407
561-588-1001
http://www.uscomposites.com/cinfo.htm

X-LITE
Allard International
Camp Scandinavia AB
Karbingatan 38
SE-254 67 Helsingborg
Sweden
+46 42 25 27 01
http://allardint.com/thermoplastic-materials/x-liter/x-liter-classic-sheets.html

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FACING THE PAST FOR ACTION IN THE FUTURE: CULTURAL SURVIVAL IN NATIVE AMERICA

KELLY McHUGH

This article attempts to generate awareness regarding the challenges that Native Nations in the United States face in protecting their cultural heritage. Cultural sites are vulnerable due to both man-made issues such as resource extraction, tourism, development, as well as natural disasters and forces of nature. Statutory obligations contained in federal law have not offered full protection due to a lack of true consultation and consent with tribes. Cultural institutions charged with the stewardship of Native American cultural patrimony should make consultation, collaboration, and consensus a priority, as collections are linked to the people and places from which they originate. While Native organizations are working to facilitate connection and raise awareness of these preservation and protection efforts, the conservation community has an obligation to do its part to ensure that the same effort generated globally and domestically is applied to the protection of Native American cultural heritage.

KEYWORDS: Consultation, Collaboration, Cultural heritage, Human rights, Sacred site, Cultural patrimony

1. CURRENT CLIMATE OF CULTURAL HERITAGE PROTECTION FOR NATIVE NATIONS

The devastation of both natural and man-made disasters in places like Iraq, Afghanistan, Haiti, Japan, Syria, and New Orleans mobilized the cultural heritage preservation community worldwide and generated international support. Media outlets provided a zoom lens for these tragedies, keeping them in the forefront of our minds. Organizations like UNESCO, the US State Department Cultural Heritage Center, the Smithsonian Institution, and the American Institute for Conservation are dedicated to protecting and preserving the world's cultural heritage and have been critical in protection, recovery, and preservation efforts. However, these preservation efforts have not been applied with same level of attention to cultural heritage vulnerabilities for Native Nations in the United States.

War, terrorism, and cultural disaster have affected Native people in our nation for over 500 years. Buildings are crumbling in our own backyard, sacred sites are compromised, and Native communities are struggling but determined to protect, recover, and preserve their cultural record. Native people feel a sense of urgency at the prospect of losing their cultural material or sacred sites. Organizations such as the Institute of Museum and Library Services (IMLS), the National Endowment for Humanities (NEH), and the National Trust for Historic Preservation support community preservation initiatives, but perhaps the greatest mobilization is happening within Native America itself through organizations like the Association for Tribal Archives, Libraries, and Museums (ATALM) (http://www.atalm.org) and the National Congress of American Indians (NCAI) (http://www.ncai.org).

This article aims to generate awareness and to challenge us as a profession to think about our current and future actions. Understanding the past and the social, historical and legal circumstances that have contributed to a serious lack of protection for Native American cultural sites, and for an imbalanced authority in the stewardship of cultural patrimony held in Museums, provides a foundation for creating a different future for cultural heritage preservation in Native America. A future that works with Native nations to develop policies, and utilizes collective knowledge for the benefit of these communities and what they value.

1.1 A MODEL OF CULTURAL LOSS: DAMMING THE LITTLE TENNESSEE RIVER

The Tennessee Valley Authority (TVA) is a federally owned corporation that was created in 1933 by a Congressional charter. The purpose of the TVA is to provide flood control, electricity generation, and economic development in the Tennessee Valley. This region of the country was particularly hard hit during the Great Depression, thus motivating the federal government to create an organization that could modernize the region's economy and society.

The project to find possible dam sites along the Little Tennessee River began in 1936. Sixty-nine locations were considered when the TVA settled on the Tellico Valley as the site in 1968. Tellico was slated to be a multipurpose project that would generate sufficient electric current to provide power to 20,000 homes, additionally serving as a flat-water recreation and flood control area. The economic motivation was to generate jobs and stimulate revenue for the region.

There were immediate attempts to block the project on the basis that it did not conform to the National Environmental Policy Act. This resulted in an injunction that remained until 1973, when the US District Court ruled in favor of the TVA, ruling it was in compliance (*Environmental Defense Fund, Inc. v. Tennessee Valley Authority 1972*).

A University of Tennessee scientist found a previously unknown species called the snail darter fish (*Percina tanasi*) in the waters of the Little Tennessee. Four months after its discovery, Congress passed the Endangered Species Act of 1973. Citizens appealed to the US Department of Interior in 1975 to list the snail darter as an endangered species, and the fish was added to the endangered species list on October 8, 1975 on the basis that it is genetically distinct and reproductively isolated. The existence of the dam would result in total destruction of the snail darter habitat.

The following two years saw a battle played out in the courts through a series of injunctions and appeals, environmental vs. economic. The case finally made its way to the Supreme Court in 1978, where justices upheld the injunction based on the designation of the snail darter as endangered. After the Supreme Court halted construction of the TVA's Tellico Dam under the Endangered Species Act in 1978, Tennessee Senator Howard Baker and Representative John Duncan quietly attached an appropriations rider overruling the Endangered Species Act and other laws preventing construction of the dam. President Jimmy Carter failed to veto the override and the Tellico Dam project was fully funded. This maneuver by the Congress bypassed the Supreme Court ruling to complete the project without a legislative hearing (Echo-Hawk 2013).

This legislation not only affected the survival of the snail darter fish; it had a tremendous impact on the farmers in the valley. They were forced to abandon their farms, some which had remained in families for generations. Some residents sold willingly while others were forced to go. The tensions of displacement remain palpable in the region and the controversy, as it is presently understood, relates mainly to the destruction of the farms and the snail darter's habitat. In 1979 the Little Tennessee River was impounded and Tellico Lake was born. Today, the remnants of the farms that once existed are only evidenced by grain silos extending out of the water (fig. 1) The beautiful custom-built homes and championship golf courses that hug the shoreline allow the residents of the development, known as Tellico Village, to enjoy themselves on the lake while boating, fishing, kayaking, or paddle-boarding.

Not as widely known is that by damming the Little Tennessee River, two Cherokee sacred capitals, known as Chota and Tenasi, would be flooded and destroyed. Tenasi and Chota were capitals of the Cherokee Nation as early as the 18th century. In the late 1700s, the capital moved from Tenasi to Great Tellico and then to Chota, which was partially destroyed in the Revolutionary War and never fully recovered (Trope 1995) (fig. 2). The former Chota and Tenasi sites are listed together on the National Register of Historic Places and were given archaeological site designation in 1972.

Fig. 1. Image of grain silos from a farm partially submerged by the Tellico Lake impoundment (Courtesy of http://bigdaddydavesbitsandpieces.blogspot.com/)

The Cherokee Nation mounted its own campaign to stop the damming of the river, filing a lawsuit in 1979 under the Indian Religious Freedom Act, claiming the land along the Little Tennessee River is a vital part of Cherokee religious practices (Benally and Goodman 2005). The case was dismissed and the appeals court affirmed the decision to allow construction of the dam. Since 1979 Chota and Tenasi have been mostly submerged by the Tellico Lake impoundment.

Fig. 2. Proposed rendering of Chota in the 18th century (Courtesy of Richard Thorton, http://www.examiner.com/article/chota-the-cherokee-town-of-refuge-under-a-tennessee-lake)

Fig. 3. Monument at Chota site (Courtesy of https://en.wikipedia.org/wiki/Chota_(Cherokee_town))

To address Cherokee concerns, the TVA funded an archaeological initiative run by the University of Tennessee, which worked to identify significant sites and in some cases move important historic structures. The TVA built the Cherokee a memorial at the Tanasi-Chota site and helped establish the Sequoyah Birthplace museum in Vonore (fig. 3). The grave of the chief Oconostota, which was uncovered in the 1969 excavations, was re-interred next to the monument. The Eastern Band of the Cherokee now manages the site.

The social remedy to this destruction is important to note, as it is part of a repeated American phenomenon. The TVA set up a memorial to the sacred capitals and Tellico Village acknowledged the Cherokee by giving the neighborhoods and golf courses Cherokee names. The courses are named Tanasi, Toqua, and the Links at Kahite, which the golf course website states, "are derived from the Native American Indians that once inhabited this area" (http://www.lakeside-realty.net/communities/tellico-village). This implies that Native Americans no longer inhabit the area and that somehow they disappeared or left of their own accord. Historical events such as the Trail of Tears or more contemporary events such as the destruction of these important Cherokee sites are not mentioned or acknowledged in the story. The practice of memorializing people and places that we as a society are responsible for destroying or nearly destroying negates our responsibility and denies the existence of people who are in fact still here.

In 2005 a bill was introduced to Congress to return 76 acres to the Eastern Band of the Cherokee, thus ostensibly returning their homelands to their control. The bill stipulates, however, that gambling operations cannot be established on the land and any shoreline development is subject to TVA approval (http://www.congress.gov/bill/114th-congress/house-bill/3599). This mandated oversight ultimately undermines Cherokee authority and control.

1.2 EMBEDDED SOCIAL AND POLITICAL PRACTICE

The example of the Tennessee Valley Authority's relationship with and impact on the Eastern Band of the Cherokee represents a scenario that is repeated throughout US history and continues to the present day. These factors involve:

Fig. 4. Images of neighborhood signs in Tellico Village (Courtesy of http://www.lakeside-realty.net/communities/tellico-village)

- A deliberate decision to favor resource development, logging, mining, and tourism over the preservation of sacred Native sites. This is a man-made disaster on the part of the US government that is both calculated and intentional.
- A fundamental lack of legal protection of sacred spaces for Native Americans.
- Entanglements in complicated negotiations with federal and state governments, private landowners, and/or corporations as Native nations fight to gain or regain control over important cultural places or retain their cultural heritage.
- A frequent necessity for Native people to align themselves with environmental movements in order to seek protection.

1.3 MAN-MADE DISASTERS

Damming rivers throughout the United States has caused tremendous economic and cultural loss for tribes, and Tellico Lake is just one example. Land management or resource development policies often take precedence over cultural preservation or the religious beliefs of Native Americans, who are deeply affected by these development decisions. Below are a few examples.

1.3.1 Black Hills

After a long period of intense conflict between the US government and Plains Indian Nations, the faces of Presidents Washington, Jefferson, Lincoln, and Roosevelt were carved into the Lakota's sacred Black Hills, thus creating Mt. Rushmore. The insult of the presence of Rushmore to some Lakota is related to the fact that it was built on land taken from them by the government. The Black Hills in particular are considered sacred ground and the monument celebrates the appropriation of Lakota land and loss of life.

1.3.2 San Francisco Peaks

The San Francisco Peaks are sacred to many tribes in Arizona, including the Navajo, Hopi, White Mountain Apache, Havasupai, and Hualapai. These tribes are challenging the National Forest Service's plans to clear-cut 74 acres to use reclaimed wastewater to make snow for the Arizona Snowbowl ski area. The belief is that the use of reclaimed wastewater for snowmaking will desecrate the sacred mountain, by according to Yavapai-Apache Nation Councilman, "killing the spiritual force within it" (Benally and Goodman 2005). In August 2008, the Ninth Circuit Court of Appeals rejected their claim under the Religious Freedom Restoration Act.

1.3.3 Medicine Bluffs

Medicine Bluffs in the Wichita Mountains of southwest Oklahoma is a holy place for the Comanche, who averted a near-man-made disaster in 2008 in protecting the sacred site. The Comanche have assembled at this traditional site for prayers, to gather medicinal and religious plants, and engage in intensely private spiritual experiences tied to this natural setting since time immemorial (Benally and Goodman 2005). The southern slope is the pilgrimage route where plants are gathered for religious and healing purposes and where sweat lodges are built. Having an unobstructed view of the bluffs from the southern approach is central to the spiritual experience. This site was listed on the National Register of Historic Places in 1974. The US Army established Fort Sill in this location in 1869 and planned to build a 43,000-square-foot training facility in an open field at the base of the southern approach to Medicine Bluffs, which would have obstructed the view needed by Comanche religious practitioners.

The judge on the case, recognizing his need for better understanding, walked the site with Comanche religious leaders. The ruling went in favor of the Comanche and is seen as a major victory in the preservation of Native American sacred sites (Benally and Goodman 2005).

2. THE PSYCHOLOGY OF FACING HISTORY

As conservators, we can be hyper-focused on objects or the materials used to construct them. We often believe our responsibility does not extend beyond our laboratories or museum walls. How or why would the preservation of these large geographic areas be our concern? They reside in the realm of other institutional organizations such as the US Forest Service, the National Park Service, or state governments. The answer lies in the fact that these sacred geographic sites fall into the same category as the beaded baby carrier, ceramic vessel, or feathered fan we see in our conservation labs. Cultural heritage is all-encompassing and interconnected, and the unifying element is the people to whom this cultural heritage belongs. Native people have a right to guide the stewardship of their cultural property. Distilled down to the essence, it is about human rights and cultural authority.

Why is so little known about the cultural struggle facing Native nations? There is a larger social narrative at play that is essential to understanding this, and we as caretakers of our nation's cultural heritage need to understand it as well. Walter Echo-Hawk, a prominent Native American rights lawyer and author of *In the Light of Justice: The Rise of Human Rights in Native America and the UN Declaration of the Rights of Indigenous Peoples* believes that for this understanding, we have to start at the beginning. America, the great democratic experiment, has human rights principles embedded in its founding documents, the Declaration of Independence and the US Constitution, which offer the greatest level of freedom in western civilization (Echo-Hawk 2013).

Echo-Hawk argues that this legacy has created an inflated self-image called American exceptionalism, which sees the American people as the most exceptional people on earth. This view is impossible to maintain when injustices against Native Americans have not been adequately addressed. Acknowledging these injustices mars the great American origin story, which focuses on a nation founded on the consent of the governed (Echo-Hawk 2013). Further, Echo-Hawk states that "we are overcome by anxiety and discomfort at the thought of making amends for collective wrongs committed against Indians, because that is how our nation was built. So facing our history calls our legitimacy into question." (Echo-Hawk 2013, 20) Until we are honest about the past, we cannot move forward. He sees two barriers:

1. This legacy challenges our self-image, core values, and origin myth, and we cannot face this without being overcome by paralyzing guilt.
2. Our legal system is capable of providing justice for wrongs against individual victims, but stops short of reparative justice for collective wrongs committed against groups of people, particularly when the offender is the United States of America (Echo-Hawk 2013).

3. FEDERAL LAW

Below is a summary of the major pieces of legislation that are often evoked in cases of cultural heritage protection. It is by no means a complete list and serves to simply articulate the possibilities and limitations of these pieces of legislation.

The **National Historic Preservation Act** of 1966 protects districts, sites, buildings and structures, and objects of significance in American history. The act measures the impact of all federally funded projects on historic properties. The most recent amendment, passed in 1992, increased protection for Native American and Native Hawaiian preservation efforts.

A limitation to this legislation is that to be considered for regulatory provisions, a site be registered on the National Register of Historic Places. The Department of the Interior is the agency that makes the determination as to what gets on the registry, and it has not always acted in the interest of Native America.

The **Religious Liberty Protection Act** of 2000 is rooted in prior legislation. The government outlawed traditional Indian religions in the 19th and 20th centuries as part of control and assimilation practices. Throughout the country, the government supported direct and indirect Christian missionaries who sought to convert and "civilize the Indians" (Trope 1995).

During the reservation era, traditional Native American religions were outlawed. Suzanne Harjo, a prominent Native American rights lawyer and activist, explains that people could not leave the reservation and travel to sacred places. Therefore, the government argued that the sacred sites were not being used and took it as permission to develop them (verbal communication 2016).

In 1934, the government recognized the right of free worship on Indian reservations but denied access to sacred places to practice religion. Sites outside of reservations on federal land were not protected against development.

The **American Indian Religious Freedom Act** passed in 1978 granted access to sites and freedom to worship through ceremonies and traditional rites.

An important Supreme Court ruling in 1988 known as the *Lying v. Northwest Indian Cemetery Protection Association* set an unfortunate precedent for future cases based on the claim of religious freedom. Members of the Yurok, Tolowa, and Karok tribes unsuccessfully attempted to use the First Amendment to prevent a road from being built by the US Forest Service through sacred land. The land that the road disrupted consisted of gathering sites for natural resources used in ceremonies and prayer. The Supreme Court ruled that this was not an adequate legal burden because the government was not coercing or punishing them for their religious beliefs. The effect of the Lying decision established that the American Indian Religious Freedom Act is not available as an alternative mechanism for judicial protection of sacred sites (Echo-Hawk 2013).

On June 25, 1997, in a 6-3 decision, the Supreme Court ruled in *Boerne v. Flores* (No. 95-2074) that Congress's enactment of the Religious Freedom Restoration Act exceeded its power under Section 5 of the Fourteenth Amendment and found the act unconstitutional. This brings us back to the Religious Liberty Protection Act, which is now often used by Native Nations in fighting for protection of sacred sites.

The **Native American Graves Protection and Repatriation Act** (NAGPRA) of 1990 states that if a burial site is found on federal land, tribes have the opportunity to intervene. Tribes or descendants will have ownership over human remains and associated cultural objects discovered or excavated on federal or tribal lands. However, NAGPRA does not empower tribes to absolutely bar disturbances of sites, which is a significant limitation, particularly where a site is considered to be an obstacle to development.

4. NATURAL DISASTERS

Climate change and development have exacerbated the effects of natural disasters on Native communities. Nowhere is this more evident than in the Arctic region. Melting ice is causing elevated sea levels and melting permafrost, threatening Native villages along the coast. President Obama, the first president to visit an Alaska Native village, established the White House Arctic Advisory council and budgeted $400 million to cover unique circumstances confronting vulnerable coastal communities. This

Fig. 5. Isle de Jean Charles, Louisiana (Courtesy of www.isledejeancharles.com)

includes relocation expenses for Alaska Native villages. This is part of a proposed $2 billion coastal climate resilience program, which remains to be passed by Congress (Mooney 2016).

Kivaline, Alaska serves as a powerful example of vulnerability, as the island is quickly becoming consumed by rising sea levels. The archaeological site of Walakpa, 12 miles south of Barrow, Alaska, is suffering from melting permafrost which is revealing objects and structures of well-preserved organic materials such as wood. A salvage archaeology project has been underway since early 2000 and serves as a good example of partnership between archaeologists and the people of North Slope Borough.

This crisis is also affecting a community in southwest Louisiana. The band of the Biloxi Chitimacha Choctaw tribe of Isle de Jean Charles has inhabited their barrier island since escaping from the Trail of Tears in 1830. They have lost 95% of their land mass to water as a result of pipeline development cutting channels through the wetlands and rising water due to climate change (fig. 5). The tribe is the first to receive a $48 million grant from the US Department of Housing and Urban Development for resettlement. The members of the tribe, considered climate refugees, are trying to raise an additional $50 million to fully fund the resettlement project. Many are looking to this project as a pilot for resettlement by other communities in the future.

5. AWARENESS INTO ACTION

The purpose of this article is to generate awareness regarding the cultural struggles affecting Native nations in the United States. Native history is American history and the same value, advocacy, and resources generated domestically and internationally should be applied to its preservation. But how do we turn this awareness into action? Echo-Hawk is urging Native nations to utilize the United Nations Declaration on Indigenous Rights as the legal framework in which to pursue cultural authority. The

Declaration was passed in 2007, the United States signed it in 2010 during the Obama administration, and Canada signed as a full supporter in May 2016. There is little doubt that the cultural heritage community will see this implemented by both countries more extensively in the future.

5.1 COLLABORATION AT NMAI

While action to preserve or protect cultural heritage through legal or large agency measures may be slow or daunting, there is something we as conservators can do to move equitable preservation efforts forward. This comes in the form of collaborative conservation practice. There has been a movement in conservation toward partnership and collaboration in some museums throughout the country. At the National Museum of the American Indian (NMAIC) Conservation Department, we are committed to and constantly evolving our collaborative conservation methodology (figs. 6, 7). With good intentions and patient partners and nearly two decades of experience, our collaborative stewardship practices have progressed. While we have not have achieved true and equal collaboration, we are moving closer to that model.

The collaborative conservation model allows for incorporation of different knowledge systems that converge to improve or correct misidentified or misinformed collection records, to inform proper handling, conservation, storage and display, and to provide access to collections, which can result in a number of outcomes that benefit source communities. It is not our duty alone to determine what is needed or gained by collaboration; this negates the idea of partnership. Engaging Native communities to assess and determine what is needed to increase cultural equity is essential.

Fig. 6. Mike Marshall and Steve Tamayo (Lakota) examine a child's elk tooth dress with previous Mellon Fellow Angela Duckwald (Courtesy of Kelly McHugh)

Fig. 7. Susan Heald, NMAI textile conservator, Deb McConnell (Hupa), Bob McConnell (Yurok), and Brianna Fraley (Tolowa) discuss basketry (Courtesy of Luba Nurse)

5.2 NATIVE ORGANIZATIONS

NAGPRA created a point of intersection between Native nations and museums and it can be said that the law inspired a cultural infrastructure that did not previously exist in tribal communities. There are now tribal historic preservation and cultural offices, museum studies programs are being taught in tribal colleges, and there has been tremendous growth in the number of tribal museums and cultural centers. This blossoming gave rise to the ATALM, which has grown exponentially over the years. A cultural infrastructure now exists in many Native nations with which to form partnerships.

5.3 FORMING PARTNERSHIPS

The School of Advanced Research (SAR) in Santa Fe, New Mexico has funded an initiative spearheaded by Conservator Landis Smith; Dr. Cynthia Chavez Lamar, Assistant Director for Collections at NMAI; and Brian Vallo, Indian Arts Research Center Director at SAR, which comprises a group of Native and non-Native museum professionals tasked to create a set of guidelines for collaborative collections care. The idea is that in order to have true collaboration, both parties need to come to the table with the same information. There is a set of guidelines for communities available on SAR's website (http://sarweb.org/guidelinesforcollaboration/) and another set for museums to be released in the near future. This not a "how to" on collaborating, but rather a resource to provide a structural framework to create informed and equal partners.

It is important for us to search for other models of collaboration. The NCAI has meeting each year at which tribal leaders throughout the United States gather to express their greatest concerns to the US government. Some of these concerns include international repatriation, the sale of sacred items at art auctions abroad, violence against women, illegal adoption of Native children, and climate change, among others. We in the cultural heritage community need to understand that we fit into this larger framework.

The Departments of Interior, Agriculture, Justice, and Defense have created an interagency Memorandum of Understanding to coordinate their efforts on the protection of Indian sacred sites (www.achp.gov/docs/SacredSites-MOU_121205.pdf). The Forest Service is now implementing forward-thinking practices regarding collaborative stewardship relating to access and use of lands and plants. They are forming significant partnerships with Native communities and are moving forward. Perhaps most importantly, these agencies are coordinating themselves, listening and translating what they are hearing into action.

Museums should not operate as silos. We have the opportunity to network ourselves, to listen and respond to the cultural heritage concerns of Native people. One idea is for us to hold "listening sessions" at ATALM meetings to understand the needs and concerns of Native nations. Disaster models in places such as Haiti, Iraq, and Syria can serve as guides, although the model of working with Native America will look differently, as collaboration will be guided by the communities themselves as sovereign nations.

6. CONCLUSION

This is indeed a movement that is gaining momentum; a collaborative framework is under construction. We have a responsibility to First Nations people to face our history, to act, to advocate, and to collaborate. Collaboration, as Jim Enote, Director of the A'shiwi A'wan Museum and Cultural Center at Zuni Pueblo states, "is a higher order and involves reaching out and enlightening on equal terms, to decentralize power and leadership and share in problem solving. We will not oppose each other; rather, we will enable one another and allow the places, objects and people to speak." (Enote, ATALM 2015) We have a tremendous opportunity to go forth with confidence that such a group of dedicated, responsible, conscientious, and resourceful members of the cultural heritage community can utilize our best skills and knowledge to benefit the members of our nation who were here first.

ACKNOWLEDGMENTS

I would like to acknowledge Kevin Gover and Jim Enote for their expert guidance throughout this project. I am grateful to Cynthia Chavez Lamar, Brian Vallo, Marian Kaminitz, Susan Heald, Emily Kaplan, Nancy Odegaard, Martina Dawley, Michele Austin-Dennehy, Ellen Pearlstein, Sanchita Balachandran, Jae Anderson, Teri Rofkar, Caitlin Mahony, Steve Tamayo, Gail Joice, and Nora and Eliza Naranjo-Morse for their commitment to collaboration. The following people have provided support, encouragement and editing assistance: Shelly Uhlir, Beth Holford, Diana Gabler, Anna Keruzec, Terry Snowball, and Elayne Silversmith. A special thank-you goes to Landis Smith for being a constant source of inspiration and support.

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NO MORE HOLIDAYS: A TIP FOR METAL COATING

TINA GESSLER AND STEVEN PINE

Transparent coatings on polished metals need to completely envelop the surface to provide sufficient protection from corrosion. It can be difficult to detect skips or thin spots in such a coating at the time of application since these coatings are thin, transparent, and nearly invisible when applied skillfully. It is impractical to attempt to assess the overall thoroughness of a coating using methods such as looking for iridescence or using a continuity meter. This tip will discuss an alternative method of coating testing using a small amount of fluorescent laser dye added to the coating material. With the addition of the dye, the integrity of the coating can be assessed in ultraviolet light, as skips or thin spots will not fluoresce. Specifics of using coumarin-based dye(s) with both cellulose nitrate and acrylic coating materials will be presented.

KEYWORDS: Lacquer, Silver coating, Coumarin, Laser dye, Cellulose nitrate, Acrylic

1. THE PROBLEM

Institutions with open exhibit environments, such as historic house museums and living history museums, are often unable to display silver objects within controlled cases for reasons of interpretive disruption or cost. Silver displayed without an environmental barrier tarnishes rapidly. Applying a protective inorganic coating is one viable option to preclude tarnish and reduce the need for polishing, which removes original material, increases handling, and requires extensive staff resources. A perfectly applied inorganic coating can last many years. But how to be sure the coating is perfectly applied? It is difficult to detect skips or thin spots by eye in a nearly invisible transparent coating. Iridescence can indicate a thin spot, but can also mean the coating is contaminated with grease, wax, etc. Using a continuity meter is a solid approach, but will only give information about one small area at a time.

2. THE SOLUTION

The objects conservation labs at the Museum of Fine Arts, Houston (MFAH) and the Colonial Williamsburg Foundation (CWF) have adopted an effective method for testing the integrity of clear coatings. A trace of fluorescent laser dye is added to the coating material so the completeness of the coating can be assessed in ultraviolet light, as holidays or thin spots will not fluoresce. In 1996, Steve Pine at MFAH began testing the laser dye Coumarin 1, also known as C1, as a marker in silver coatings following discussion with Kory Berrett and Richard Wolbers.

The C1 marker fluoresces blue-white, as can be seen in figures 1 and 2. As applied to silver, the thicker the coating, the whiter the fluorescence. This affords a somewhat subjective gauge of film thickness that can be helpful. It is important that the UV light source be strong enough to make the dye fluoresce brightly enough for you to assess the integrity of your coating. Longwave ultraviolet light at about 365 nm is ideal.

Initial tests to arrive at a suitable concentration of the UV marker in a variety of effective metal coatings led the MFAH staff to select Paraloid B-48N. MFAH conservators typically brush coat with six drops of 1% C1 in ethanol for each 300 mL of 7% Paraloid B-48N in toluene. The system has been successfully used on silver at MFAH since 1997. The coating is clear and essentially colorless in visible light and does not fail prematurely.

CWF started testing C1 in Agateen #27 cellulose nitrate-based lacquer in 2013. A slightly higher concentration of dye was found to be needed for spray applications to get sufficient fluorescence to assess the coating, with nine drops of 1% C1 in acetone for each 300 mL of 1:2 Agateen #27 lacquer:#1

Fig. 1. Coumarin 1-dosed (left) and undosed (right) Agateen #27 cellulose nitrate lacquer in visible light (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

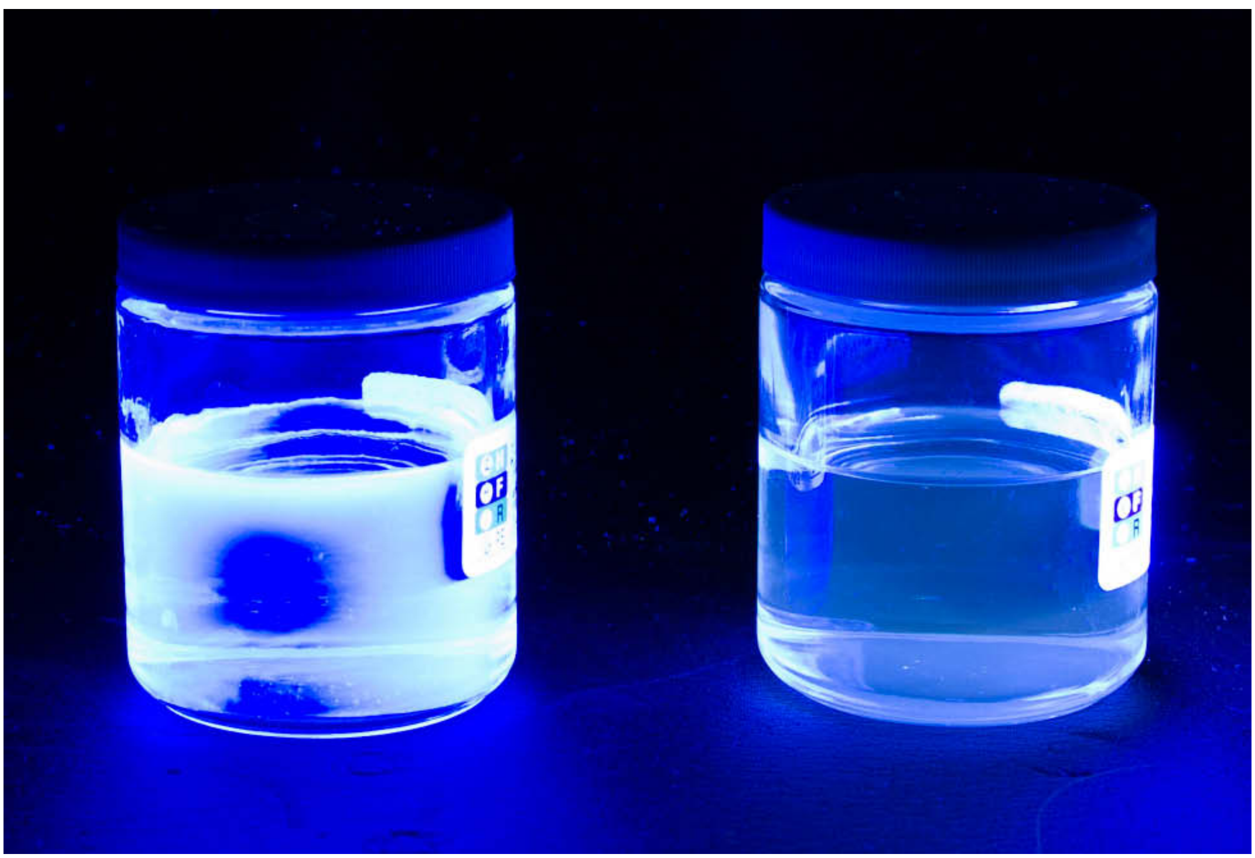

Fig. 2. Coumarin 1-dosed (left) and undosed (right) Agateen #27 cellulose nitrate lacquer in 365-nm longwave ultraviolet light (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

Fig. 3. Visible light image. Unknown Silversmith, *Salver,* ca. 1795, fused silver plate, 3.2 × 31 × 24.5 cm, Colonial Williamsburg Foundation, 1991-1234 (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

thinner providing good results (figs. 3, 4). In figure 4, gaps in the Agateen coating, marked by arrows, do not fluoresce and are readily identified even though they do not show in the visible light image.

You don't need a lot of materials to make this technique work. Most importantly, you need to test to get the right concentration of dye in the chosen lacquer and you need a UV light source strong enough to make a thin film fluoresce.

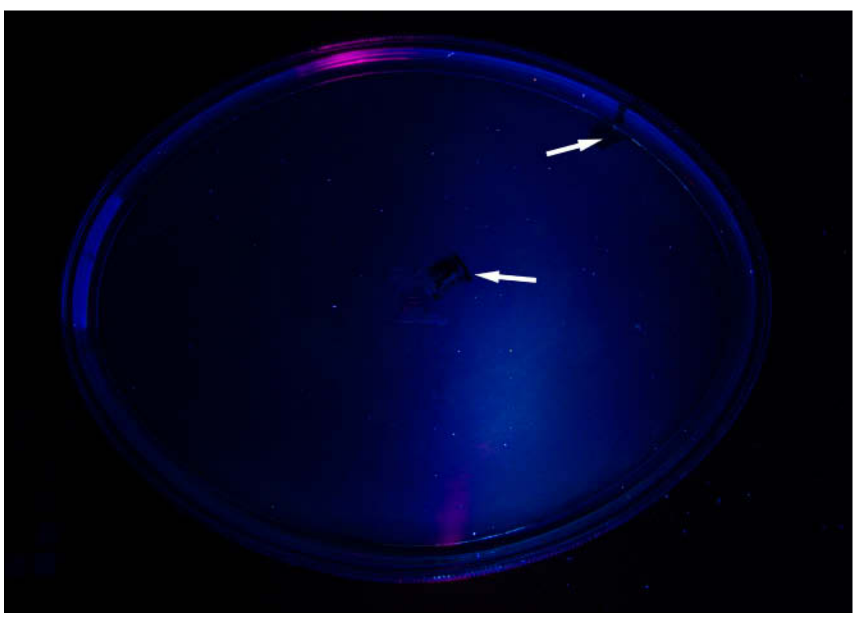

Fig. 4. 365-nm longwave ultraviolet light. Salver (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

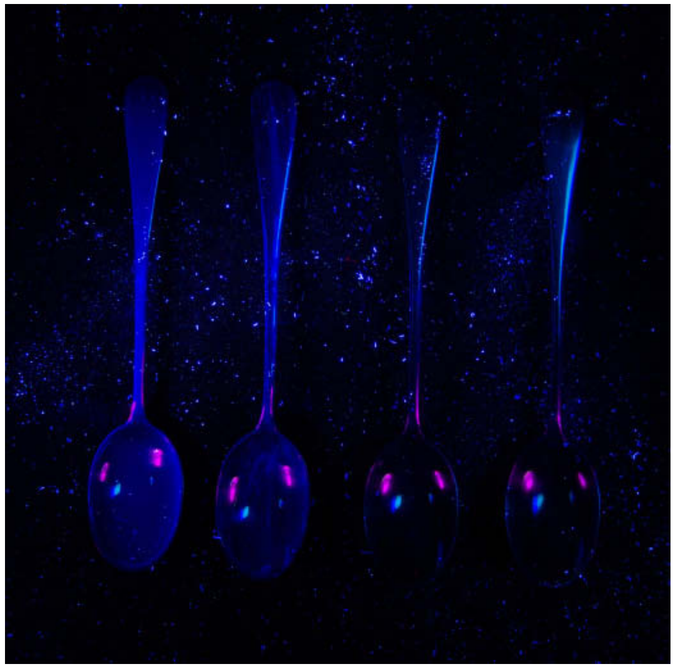

Fig. 5. Modern sterling silver spoons. April 21, 2015. Colonial Williamsburg Foundation study collection (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

3. FURTHER CONSIDERATIONS

There are many different coumarin-based dyes, some of which are fugitive. In this application, fugitive may be a good thing, since any unwanted color the dye imparts to the coating fades away. For Coumarin 1, the amino group is easily protonated and decoupled from the chromophore, leading to the disappearance of the absorption band at about 373 nm (Drexhage 1976). Practically, this means the fluorescence fades to negligible after about two months under normal laboratory conditions, as seen in figures 5 and 6. In figure 5 are four freshly lacquered spoons and the two furthest left have the C1 marker. Figure 6 shows the same spoons two months later when the fluorescence is nearly gone.

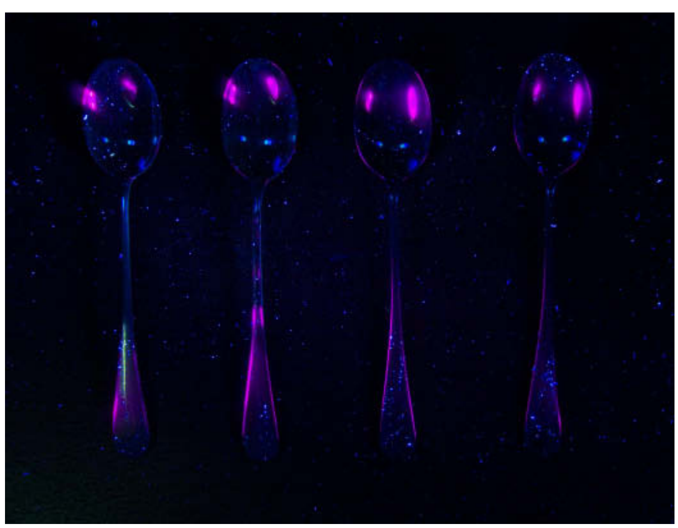

Fig. 6. Modern sterling silver spoons. June 1, 2015 (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

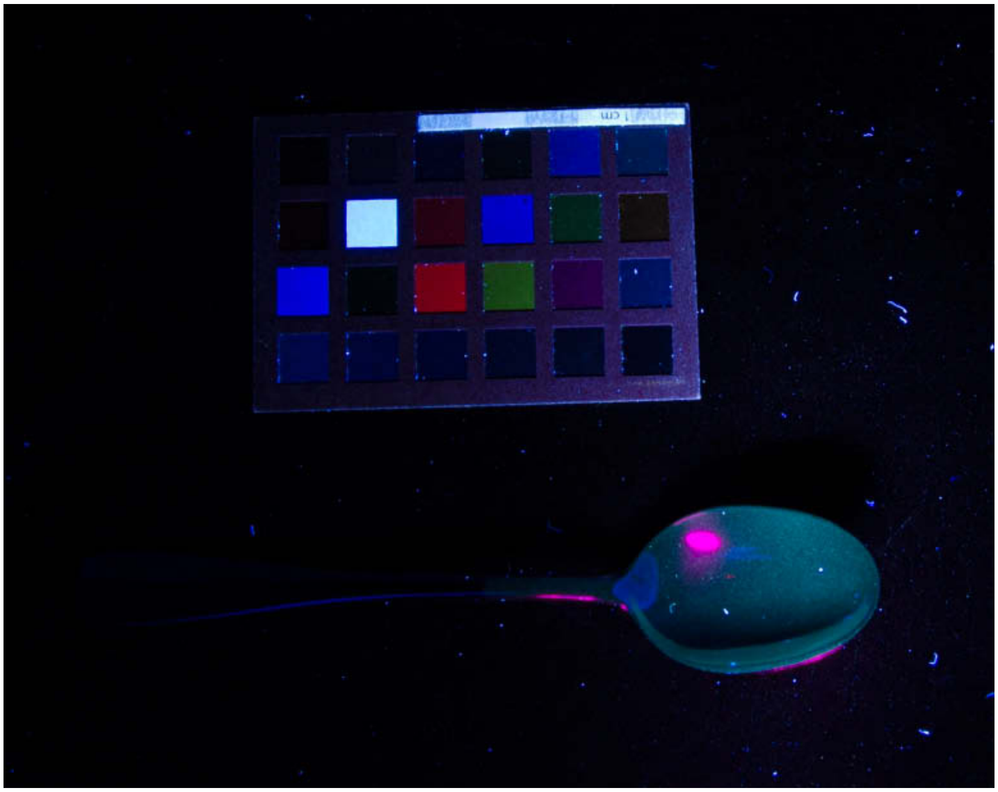

Fig. 7. Modern sterling silver spoon coated with C6-dosed Agateen on its right half only. Colonial Williamsburg Foundation study collection (Courtesy of The Colonial Williamsburg Foundation. Photograph by Tina Gessler)

In addition to C1, there are other dyes to consider whose green or yellow fluorescence might be easier to detect than the white fluorescence of C1. Coumarin 6 and Coumarin 7 both fluoresce green. The spoon in figure 7 was coated on its right half only with Coumarin 6 (C6)-dosed Agateen. C6 seems a good possibility for this application because its green fluorescence is more obvious than the blue-white of C1. Additionally, C6's fluorescence fades relatively rapidly over the course of a few days when exposed to ultraviolet light.

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Drexhage, K.H. 1976. Fluorescence efficiency of laser dyes. *Journal of Research of the National Bureau of Standards* 80A (3): 421–428.

SOURCES OF MATERIALS

Agateen #27 lacquer, #1 thinner
Agate Lacquer Tri-Nat LLC
824 South Ave.
Middlesex, NJ 08846
732-968-1080
http://www.agatelacquer.com/

Coumarin 1, Coumarin 6, Coumarin 7
Sigma Aldrich
3050 Spruce St.
St. Louis, MO 63103
800-521-8956
http://www.sigmaaldrich.com/

Paraloid B48N
Conservation Resources International, LLC
5532 Port Royal Rd.
Springfield, VA 22151
800-634-6932
http://www.conservationresources.com/

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DESICCANT TUBES FOR STORAGE OF UNSTABLE MATERIALS, OR CONFESSIONS OF A MICROCLIMATE DENIER

DENNIS PIECHOTA

This tip describes the construction and use of Tyvek tubes filled with activated regular density silica gel desiccant to maintain low relative humidity conditions within storage cases. Measuring 2 x 24 in., they are used to help achieve an in-case relative humidity of 15% or less for collections of unstable archaeological iron artifacts. The tubes are constructed of sheets of needle-punched Tyvek (Type 1622E) formed into tubes sealed with Tyvek tape. Custom-cut bag clasps allow resealable access through one end of the tube for refilling with reconditioned silica gel. Tyvek straps are attached to each end of the tubes to secure them to the sidewalls of the case in areas that will not interfere with access to the stored collections.

KEYWORDS: Silica gel, Desiccant, Museum storage, Unstable metal, Archaeological iron, Microclimate

1. OVERVIEW

At the Fiske Center for Archaeological Research of the University of Massachusetts–Boston (UMB), we actively excavate artifacts from historic sites around the United States and the world. This means that five archaeologists and graduate students from UMB and other universities recover large numbers of unstable ferrous artifacts during each excavation season. With only one conservator to treat these artifacts, we needed a place to store them at least temporarily under desiccating conditions.

The university-wide heating and cooling system exacerbates the well-known instability of archaeological iron. In the study/storage rooms, the relative humidity (RH) is often very high in the summer months when water is injected into the air-handling system to provide basic comfort cooling. In the north temperate climate of Boston we expect low relative humidity levels in heated rooms during the winter. But monitoring has shown that the relative humidity can spike up to 70% RH as moisture is sometimes injected during unexpectedly warm winter days (fig. 1).

2. DESICCANT TUBE DESIGN

My goal was to create a microenvironment where I could maintain relative humidity at or below 15% RH. To that end I dedicated a single museum storage cabinet: a Delta Designs DDLX-G cabinet with exterior dimensions of 147 cm wide x 200 cm high x 80 cm deep. The cabinet is fitted with four pull-out shelves and one fixed shelf, and has an internal air volume of approximately two cubic meters (fig. 2).

Typically we need all available shelf and drawer space for the collections, but just inside each sidewall there is a 2 in. (5 cm) wide space that is not used. So I designed 2 in. diameter Tyvek tubes to contain desiccant silica gel. I first tested attaching the tubes to the walls with adhesive-backed Velcro, but this method proved unreliable. The Velcro adhesive tended to separate from the cabinet sidewall or from the Tyvek tube. Instead, the four continuous stanchions built into the case to support the shelves and drawers were used to hang desiccant silica gel containers.

An effort was made to design custom desiccant packages that would be inexpensive and easy to construct, have secure closures, be archival, facilitate easy silica gel maintenance, and fit the available space. After a period of testing, the following tube construction materials (fig. 3) were selected: “soft” Tyvek (Type 1622E) sheeting, Lineco brand Tyvek tape with acrylic pressure-sensitive adhesive, desiccating silica gel (regular density, grade 3 on 8 mesh), and Clip-n-Seal brand bag closures.

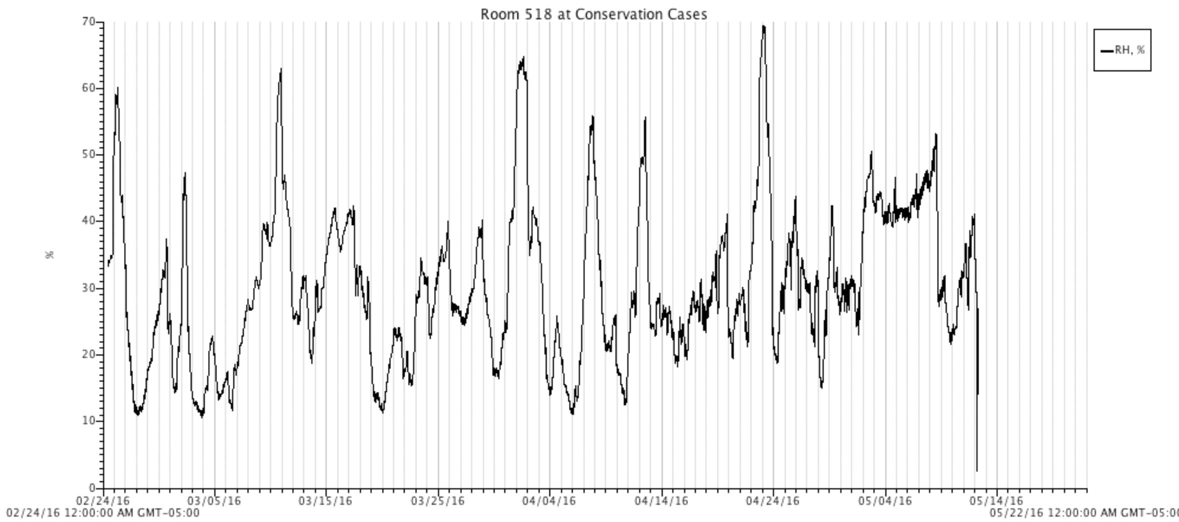

Fig. 1. Damaging relative humidity conditions during three months in the winter and spring due to comfort heating and cooling where moisture is injected into the air-handling system to cool during unexpectedly warm days (Courtesy of the author)

Fig. 2. The Delta Designs DDLX-G cabinet in which the desiccant tubes are installed (Courtesy of the author)

Fig. 3. Desiccant tube construction materials (Courtesy of the author)

Tubes were constructed using the following method:

1. Cut the Tyvek sheeting into an 8 ½ x 26 in. (22 x 66 cm) section.
2. Fold it lengthwise and make two consecutive ½ in. wide folds in the mating edges.
3. Seal the fold with a continuous length of Lineco Tyvek tape.
4. To form the straps, cut two 2 x 9 in. (5 x 23 cm) strips of Tyvek sheeting.
5. Triple-fold each strap lengthwise and staple each one near the ends of the tube.
6. Over the seam of the Tyvek tube, staple each strap in two points. This reinforces the tube seam and secures the straps in the form of a loop.
7. Seal one end of the tube by making two consecutive ½ in. wide folds and finish the tube by sealing with a length of Lineco Tyvek tape.
8. For the recloseable end of the tube, cut a Clip-n-Seal bag clip to 3½ in. (8.9 cm) and 4 in. (10.2 cm) lengths with the rod portion ½ in. (1.3 cm) longer than clamp portion to facilitate opening.
9. Apply labeling to identify the contents of the tubes.
10. At the fume hood, complete the tube by filling with approximately 900 g activated silica gel and close with the bag clip (fig. 4).

It is a good practice to periodically rescreen the silica gel with a #14 testing sieve or similar to remove the fine silica dust that can develop over time due to decrepitation.

Fig. 4. Completed desiccant tube filled with approximately 900 g activated silica gel (Courtesy of the author)

Within the cabinet, attach 10 in. (25.4 cm) miniature bungee cords to the cabinet stanchions. Their hooked ends conveniently grab the Tyvek tube handles and facilitate installation and removal (figs. 5a, 5b).

3. PERFORMANCE

The rate at which one will need to refill the desiccant tubes with fresh silica gel to maintain a relative humidity of 15% or less will vary greatly with each installation. The air volume of the case, the number and size of the tubes installed, the airtightness of the case, the access rate or use of the stored collections, and the room RH conditions will determine the annual silica gel replacement rate. Over the last two years at the UMB archaeology lab, I have needed to replace the desiccant twice annually. By

Fig. 5a. An overview of the opened cabinet showing five desiccant tubes installed along the sidewall; 5b. Detail of one desiccant tube installed using mini bungee cords attaching the straps to the cabinet stanchions (Courtesy of the author)

swapping out 10–12 tubes containing approximately 900 g each of silica gel, we have successfully maintained the target humidity in a Delta Designs DDLX-G case containing approximately two cubic meters of air volume. A datalogger with an LCD display (HOBO UX100-003) and visible through the glass door of the cabinet is used to monitor the case temperature and humidity. To speed the replacement process. A sufficient store of previously desiccated silica gel is kept on hand in a sealed metal container. The "spent" desiccant is then regenerated by heating to 180°C independent of the replacement process. While the maintenance of an artificially dry microenvironment in a temperate climate will always require vigilance and dedication, this method has gone a long way towards bringing routine to what was a dreaded chore.

SOURCES OF MATERIALS

Clip-n-Seal bag clips, Mini 10 in. bungee cords
Amazon.com
PO Box 81226
Seattle, WA 98108-1226
888-280-3321
https://www.amazon.com/

DuPont Tyvek Type 1622E
Material Concepts
11620 Caroline Rd.
Philadelphia, PA 19154-2116
800-372-3366
http://www.materialconcepts.com/

HOBO UX100-003 datalogger
Onset Corp.
470 MacArthur Blvd.
Bourne, MA 02532
508-759-9500
http://www.onsetcomp.com/

Lineco Tyvek Tape, 1 in. x 150 ft.
University Products
PO Box 101, 517 Main St.
Holyoke, MA 01041-0101
800-628-1912
https://www.universityproducts.com/

Silica gel, RD, Grade 03
Fisher Scientific
300 Industry Dr.
Pittsburgh, PA 15275
800-766-7000
https://www.fishersci.com/

Testing Sieve No. 14
Forestry Suppliers
205 W. Rankin St.
Jackson, MS 39201
800-647-5368
http://www.forestry-suppliers.com/

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TIPS FOR FEATHER FILLS

FRAN RITCHIE AND JULIA SYBALSKY

Preserved bird skins are notoriously thin and delicious to pests, making taxidermy bird mounts particularly vulnerable to feather loss. With few established techniques for replacing lost feathers, there is ample room for creative problem-solving by conservators working in this area. Treatments of two pieces of bird taxidermy will be discussed: an historic emperor penguin that suffered a probable pencil stab to the chest, and a bald eagle that lost its iconic white head feathers after a botched restoration. The case studies will illustrate two fill techniques—one involving the use of real, purchased feathers, and the other the fabrication of "conservation feathers." Although there were pros and cons to both techniques, one resulted in a more successful treatment for both birds. The tips provided in making these feather fills are useful for those charged with caring for natural science collections as well as ethnographic and historic collections that include feather clothing, ceremonial blankets, and other bird-related objects.

KEYWORDS: Taxidermy, Feathers, Natural science, Fills, Loss

1. INTRODUCTION

The conservation treatments of two historic bird taxidermy mounts provided the opportunity to test two different fill techniques: the fabrication and application of "conservation feathers" vs. the use of real, purchased feathers.

Conservation feathers were employed for the first treatment of an emperor penguin. Admiral Richard Byrd collected the specimen during an expedition to Antarctica in the early 20th century. The mounted penguin was then given to a member of the Rockefeller family and it is currently displayed at an elementary school. At an unknown date the specimen suffered a probable pencil stab to the chest, resulting in a 0.5 × 0.5 in. hole and feather loss in a prominent location. The damage was distracting and required repair.

The second treatment involved the use of real poultry feathers to create a fill for a mounted bald eagle that lost all of its iconic white head feathers after a botched "restoration." The eagle is on display at Stan Hywet Hall, the historic home of F.A. Sieberling, co-founder of the Goodyear Tire & Rubber Company. The original owners designed the interior at the turn of the 20th century when displaying a bald eagle was a sign of progress and patriotism. The unrepaired the feather loss, however, made the vulture-looking eagle confusing to guests and curators considered removing the original decor from public view.

2. CONSERVATION FEATHERS

The emperor penguin chest feathers are difficult to fill compared to feathers on other areas of the body. The feathers are small, narrow, bristly, and protrude from the body; they do not overlap with one another in the same manner as flight feathers on the wing. Craft feathers commercially available did not have the same characteristics as the chest feathers, leading conservators to replicate them using common conservation materials.

The process for creating conservation feathers is as follows:

1. Shave slivers of bamboo skewer for the shaft of the feather.
2. Line the center of a piece of spun bond polyester or Japanese tissue paper with heat-set BEVA 371 film.

3. Place bamboo sliver in the center of the BEVA 371 lining.
4. Adhere a second piece of spun bond polyester or Japanese tissue to the BEVA 371, thus encasing the sliver.
5. Trim spun bond polyester or Japanese tissue to create the feather vane (fig. 1).

The realistic-looking fabricated feathers could be shaped to mimic different types of feathers such as downy, contour, or flight. The spun bond polyester or Japanese tissue vanes could be toned using any method of coloring application, unlike real feathers that are not easily toned. The materials are easy to work with, but the process of creating the conservation feathers requires a fair amount of time. Conservators began filling the hole by heat-setting the feathers into place or dipping the ends in acrylic adhesive Lascaux 498HV.

However, the conservation feathers did not have the volume required to fill the loss and did not provide a way to blend fills into original feathers. Ultimately, small pieces of trimmed poultry feathers and feather vanes were inserted over the conservation feathers to provide the volume and camouflage required. Other areas of loss of flight feathers on the posterior of the penguin were also filled using trimmed poultry feathers. The feathers were tucked under the top layer of existing feathers, requiring no adhesive. Conservation feathers could be used in other situations, but for the penguin treatment, real feathers ultimately produced the best visual results.

Fig. 1. “Conservation feathers” created by heat setting spun bond polyester of various thicknesses lined with BEVA 371 film onto a sliver of bamboo skewer (Courtesy of the authors)

3. FEATHER PANEL FILLS

The bald eagle lost all its feathers on the neck and only a sparse amount of brittle feathers remained on the top of the head, requiring both large and small feather fills. Instead of adding many layers of feathers, the gap on the neck was filled first with polyester batting fiber fill that was shaped and secured with polyester thread until it was even with remaining body feathers. To fill the large remaining surface area, panels of feather fills were created to fit around the neck as follows:

1. Trim the vane end of poultry or game feathers to desired size to create small feathers. Trim the end of the shaft to thin the tip, if necessary.
2. Stretch nylon tulle into an embroidery hoop.
3. Tuck the end of a feather into the tulle. From the top of the tulle surface, insert the shaft into one hole of the tulle, skip two or three rows, and re-insert into another hole to "thread back" the end of the feather to the top surface. The feather is tucked into place, but will loosen if tulle is removed from the hoop (fig. 2).
4. Repeat step 3 until achieving a row of feathers of desired length. A few holes above the tip of the feather shafts, begin the next row of feathers. Position the next row to lie between the first row of feathers, creating a realistic overlapping pattern. For the bald eagle, feathers gradually decrease in size closer to the beak, requiring larger feathers for the first row and smaller feathers for the overlapping top rows.
5. Once all feathers are in position, carefully remove tulle from embroidery hoop. Trim excess tulle. Sandwich the ends of the feathers with two thin strips of spun bond polyester lined with BEVA 371. Heat-set the tips into place (fig. 3).

The bald eagle required seven panels of feather fills of varying sizes. The panels were attached to the thread-wrapped polyester batting on the neck by applying a layer of acrylic adhesive Lascaux 498HV to the spun bond polyester lining and pressing gently into place. Single feathers were also trimmed and

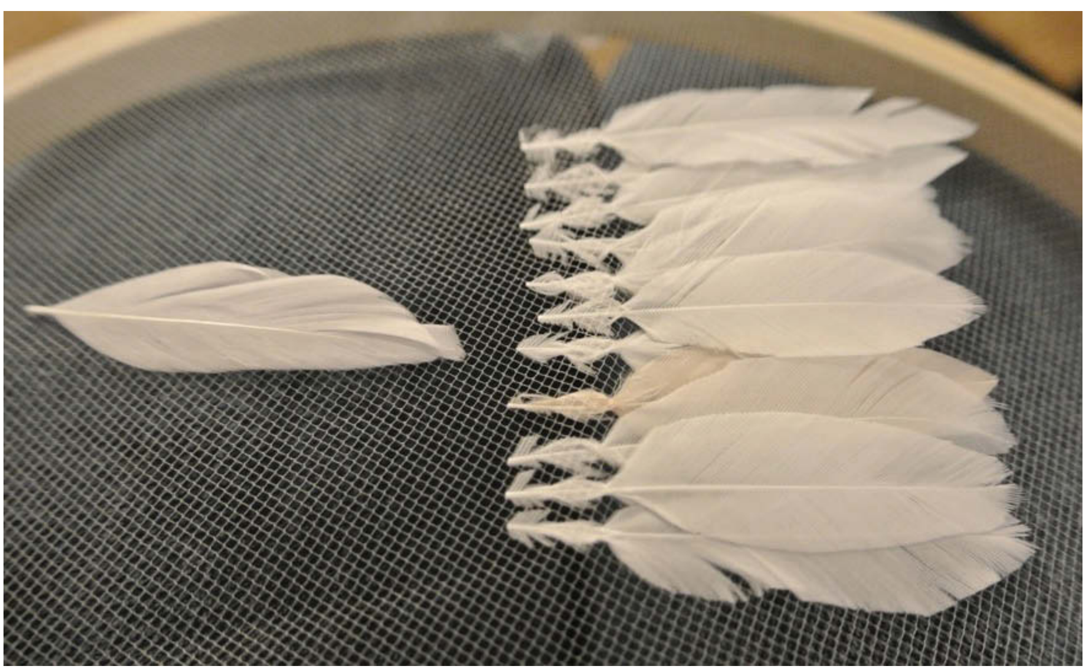

Fig. 2. Trimmed poultry feathers inserted into tulle that is stretched taut in an embroidery hoop (Courtesy of the authors)

Fig. 3. Completed feather fill panels, ready for application onto the taxidermy specimen (Courtesy of the authors)

added around existing feathers remaining on the top of the head. Where possible, these single feathers were tucked into place between feathers, but many were secured with a small amount of Lascaux 498HV on the tips of the shaft. The short time frame for completing the treatment did not facilitate meticulous trimming of feathers to match bald eagle feathers exactly; the fill is not scientifically accurate. However, the addition of the white head feathers drastically improved the overall appearance of the specimen and visitors once again recognize it as the iconic national bird.

4. COMMERCIAL FEATHERS

The real feathers used in conservation treatment were all purchased from reputable commercial craft sources. International, federal, and state laws protect many species of birds from hunting and collecting, including bald eagles under the Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668c). For these birds, it is illegal to possess even a single feather, since it is impossible to prove that the whole specimen was not harmed to obtain it. When completing feather fills, it is best to purchase poultry and game feathers. A variety of colors, shapes, and sizes are available at large craft stores such as Michael's. Be certain you are aware of laws surrounding the procurement of feathers if you wish to source them elsewhere. Consult the U.S. Fish and Wildlife service webpage (http://www.usfw.gov/) for federal laws and state websites pertaining to sporting licenses and collecting regulations for local laws.

5. CONCLUSION

Both conservation treatments successfully integrated purchased poultry and game feathers into different species of bird taxidermy. A technique of inserting vane fragments helped blend the gaping fill with surrounding feathers on the penguin, and creating panels of feathers efficiently covered the large surface area of loss on the bald eagle. Although the fabricated "conservation feathers" could have ideal applications during future treatments, the real feathers ultimately proved to be the best solution for the mounted penguin and bald eagle.

ACKNOWLEDGMENTS

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SOURCES OF MATERIALS

BEVA 371 film (ethylene vinyl acetate-based adhesive)
Conservator's Products Co. (CPC)
P.O. Box 601
Flanders, NJ 07836
201-927-4855
http://www.conservatorsproducts.com/

Craft poultry feathers by Creatology, Polyester batting (polyester fiber fill) by Loops & Threads
Michael's Craft Store
8000 Bent Branch Dr.
Irving, TX 75063
800-MICHAELS
http://www.michaels.com/

Lascaux 498HV, Spun bond polyester (spun bonded nylon, 0.4 oz./sq. yd.)
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
http://www.talasonline.com/

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work expands upon previous experiences preserving taxidermy collections across the United States, from Alaska and New York to Ohio and Wyoming. She is a graduate of the Art Conservation Program at the State University College at Buffalo and a Professional Associate member of AIC. Ritchie served as the Emerging Conservation Professionals Network Chair for the 2015–2016 term. She co-taught a graduate course with Julia Sybalsky on Conservation Strategies for Natural Science Collections at the Conservation Center of the Institute of Fine Arts, New York University in the fall of 2016. E-mail: franritchie@gmail.com

JULIA SYBALSKY is an Associate Conservator of Natural Science Collections at the AMNH, where she began working in January 2010. Her work supports the care of scientific collections and materials on exhibit, as well as the assessment of risks to collections and archive materials throughout the museum. Julia was an important contributor in the recently-completed renovation of dioramas in the Hall of North American Mammals and the Theodore Roosevelt Memorial Hall, and is involved in ongoing research into materials for the conservation of taxidermy collections. She is a graduate of the Conservation Center of the Institute of Fine Arts, New York University. Julia also co-taught a graduate course with Fran Ritchie on Conservation Strategies for Natural Science Collections at the Conservation Center in the fall of 2016. E-mail: jsybalsky@amnh.org

CORE-DRILL SAMPLING WITH THE SHERLINE MILLING MACHINE

ANTHONY SIGEL

Core samples are often needed for the analysis of ceramics, glazed and unglazed, high fired and low. Sampling of any kind is both unpleasant and challenging. To extract a sample containing a full stratigraphy can be difficult, and often the fracturing off of material adjacent to a chip or other damage with tools is difficult to control. The author has had success using diamond-coated core drills in a milling machine at slow speeds and describes the machine and its setup, explaining the techniques, fixtures, and special tools used. The importance of practice on nonart objects cannot be overstated. The pros and cons of destructive sampling and the prerequisites to be met before taking such an irreversible step are discussed.

KEYWORDS: Core drilling, Sampling, Ceramics, Milling machine

1. INTRODUCTION

This article discusses the use of a variable-speed, three-axis milling machine, such as the Sherline 5400 Deluxe Mill (fig. 1), manufactured by the Sherline Company, for taking ceramic core samples used for SEM and thin-section analysis. Core samples for thermoluminescence testing (TL) may be necessary for more vitrified wares and can also be obtained with these techniques but require additional safeguards against exposure to light to remove and store the sample.

2. ADVANTAGES AND DISADVANTAGES OF THE MACHINE

The drill head angle, speed, and movement can be controllable by the operator to a very fine degree: the number of revolutions per minute can be dialed down by rheostat to almost zero, the positioning of the X-Y support table and the speed at which the drill is lowered into the ceramic can be finely regulated, and the depth of the hole can be accurately measured and limited to 100th of a millimeter.

The machine's shape and size may limit the size or position of the object to be sampled. There is no direct pressure feedback from the handwheel as the drill bit is lowered, such as is found using a quill/lever-operated type of drill press machine. This can be largely compensated for in other ways, as will become clear later.

3. JUSTIFICATION FOR SAMPLING

Before contemplating irreversible, destructive sampling, it is important to ask and be able to answer in the affirmative these questions:

1. Is the research product to be gained worth the permanent alteration of the work(s) of art? Is the intellectual basis for the project sound, and is there a reasonable likelihood that the project will be successful?
2. Has the owner/curator given written permission for the sampling and are they fully aware of the resulting visual/physical change to the object? Have a test object on hand from which a practice sample has been taken to show the resulting appearance. Does the owner/curator expect aesthetic compensation of the sample hole, and to what degree?
3. Can the sample(s) be safely extracted, and will it provide enough material for an accurate analytical result?

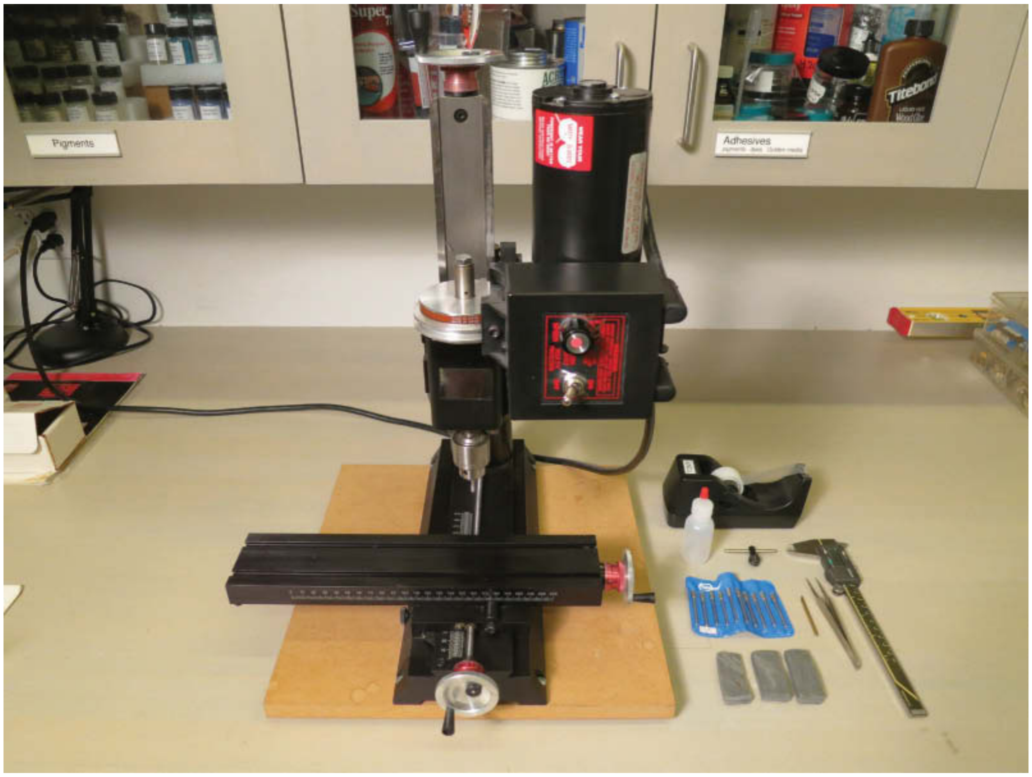

Fig. 1. Sherline 5400 mill with some of the tools needed for sampling (Courtesy of Anthony Sigel)

4. Is your scientific team fully committed? Has the necessary funding, instrument access time, and operator time been secured and scheduled, and are the analytical resources in place for successful interpretation of results, completion of the project, and its eventual publication if envisioned?

Only if all of these questions can be answered affirmatively should you proceed.

4. PRACTICE

When beginning to learn this (or any other sampling technique), practice on a similar-bodied modern cup, mug, or plate until you are comfortable with the drilling and sample extraction procedure.

5. EVALUATION OF SAMPLE SITES

Evaluate the object to choose the sample sites, preferably with the owner/curator and the scientist carrying out the analysis. Establish the sample location based on the glaze/interface/body components you want to study. Ensure that the area is representative, and that the interior diameter (ID) of the core drill you choose will provide enough coverage. Note that the size of the sample, or core, will match the inner diameter, or hole, of the core drill bit. The sampling procedure will leave a hole the size of the outer diameter (OD) of the core drill bit (fig. 2).

Look for the most inconspicuous places, but also those that will not create a structural weakness. Discuss the locations with colleagues/project advisors, then review them for approval with the owner/curator. Mark the location sites with fine tape pointers, and number each sample site.

Fig. 2. Digital calipers with diamond core drill sizes, 2.8-, 3-, and 4-mm OD—the most commonly used—and the resulting holes in a ceramic tile (Courtesy of Anthony Sigel)

5.1 DRILL SIZE SELECTION

Calculate the depth to be drilled, and measure the thickness of the object at the sample location with a digital caliper or other means. Subtract the hole depth from the overall thickness of the ceramic wall to ensure that there is no possibility of drilling all the way through. Sample extraction seems easiest if the hole depth is at least equal to, or slightly longer than, the ID of the core drill. It may be possible to drill a shallower hole, but the risk is greater of breaking off the core stalk above the bottom, possibly losing some of the strata in which you are interested. Example: the Metalliferous (Eurotool brand) DIB-503.00 diamond core drill bit has an OD of 3 mm and an ID of 1.75 mm. Therefore, an ideal drilling depth would be at least 2 mm.

6. DOCUMENTATION

Prepare all of your recordkeeping materials: camera, spreadsheet, labels, permanent pen, vials, and gelatin capsules. Take macro-photos to show the original surface appearance and location of the sample sites before sampling. Pull back to provide overall context information if needed. Prepare a spreadsheet or other means of capturing your sampling information. Without sample site photography, clear labeling, and tracking of samples, you may doom your analysis to incoherence.

7. SETUP: WORKSPACE

If you have an assortment of vessels/objects, group them into similar shapes and sizes to take advantage of like setups. Reserve adequate table space for this project, with a designated separate object storage, and keep your tools in a segregated area. Use a piece of mat board or Volara foam as an immediate "object-only" staging area, with tools and other hazardous items never allowed on it. Keep your workspace neat and uncluttered, and develop methodical and careful work habits.

Examine your hand tools and the drilling machine for projecting metal elements that could cause damage. Pad elements and projections that could come in contact with your objects. An ounce of prevention…never, ever rush or work in a hurry.

7.1 SETUP: MACHINE

Prepare a wood sampling platform—¾-in. plywood works well—and attach to the milling machine with the "T" nut hold-down clamps provided by the manufacturer. Cover the exposed fasteners with plastic caps or Plasticine to avoid damaging contact with the artifact. Gather the tools and materials needed, including safety glasses, a dropper bottle of water for lubricating the drill bit, Plasticine for object padding, and plastic wrap or Parafilm for protection and isolation from the Plasticine if needed. You can use a small jeweler's screwdriver to remove the core "plug" after drilling, but I prefer a purpose-made tool for this purpose, fabricated from brass tubing sized to fit the hole (fig. 3).

7.2 SECURING THE OBJECT

Devise a method of securing the object. The ceramic must be held firmly in a stable position and able to resist the downward pressure of the drilling without movement. A thin bed of Plasticine applied to the wood platform cushions the object, distributes the pressure over the slightly uneven rim, and absorbs vibration (fig. 4).

If the Plasticine is used below the object, additional clamping may not be needed, as the Plasticine is somewhat "tacky," especially on glazed ceramics. Avoid staining lower-fired ceramics by isolating the Plasticine with Parafilm or Cling Wrap (see fig. 13). Shapes such as closed vessels can be accommodated by cutting cradle shapes from blocks of wood and following the same steps for cushioning.

Fig. 3. Brass sample removal tool (Courtesy of Anthony Sigel)

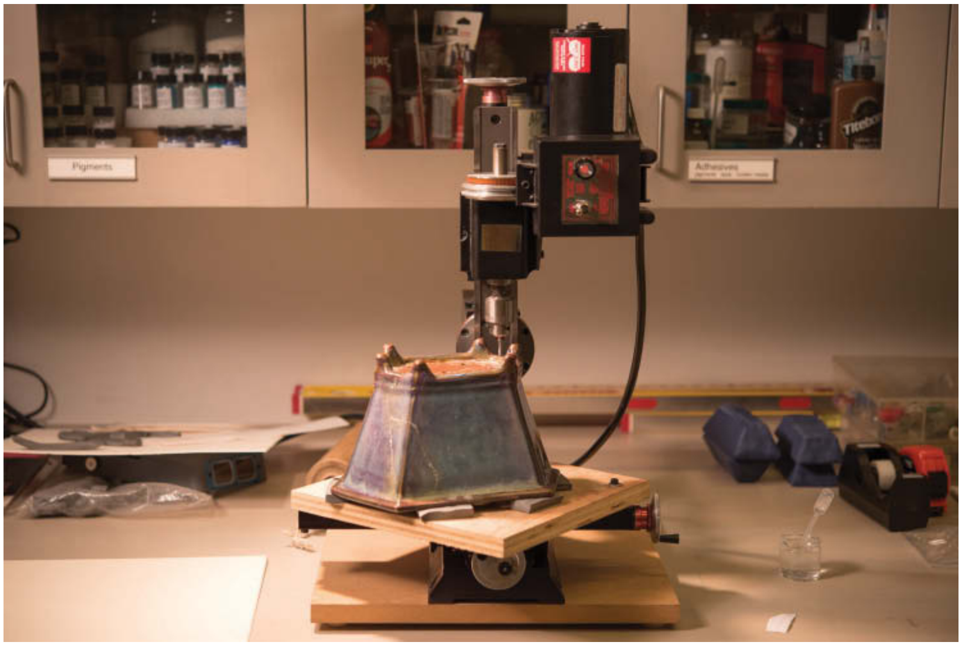

Fig. 4. Jun ware vessel is stable on its Plasticine bed and able to resist drilling pressure without movement. Chinese, *Elongated Hexagonal Flower Pot with Six Small Feet*, ca. 15th century, numbered Jun ware: light gray stoneware with variegated purple and blue glaze, 13.6 x 23.6 x 15.6 cm, Harvard Art Museums/Arthur M. Sackler Museum, 1942.185.33. Gift of Ernest B. and Helen Pratt Dane (Courtesy of Anthony Sigel)

7.3 PREPARING TO DRILL

Examine the drill bit. Is it the right size? Is the tip clean and in good condition (fig. 5)? Insert it fully into the drill chuck, tighten, turn on the machine, and be sure that the bit is running true and concentrically. Some core drills are fabricated from relatively soft hollow brass tubing—be sure not to crush the drill shaft. Others have a solid shaft, and the chuck may be firmly tightened.

Fig. 5. Verify that the bit is in good condition (Courtesy of Anthony Sigel)

Fig. 6. The paper acts as a spacer when "zeroing out" the handwheel (Courtesy of Elizabeth La Duc)

Check for clearances by rehearsing the procedure. Make sure that as the drill is lowered into the object, no part of the milling head or spinning drill chuck can strike the object. Be sure that there is adequate light, and wear safety glasses. You should be in a relaxed, concentrated state of mind, in as distraction free an environment as possible. Most of your feedback will be audible.

7.4 CALIBRATION

Center your drill over the sample site. Lower the bit slowly with the upper handwheel, trapping a slip of paper between the drill bit and the ceramic surface to act as a spacer, needed to "zero out" the depth calculation (fig. 6). Raise the bit just enough to remove the paper.

To calibrate the milling machine/drill, loosen the small black knob on the handwheel, which allows you to zero out the calibrated ring, and retighten the knob (fig. 7). Each complete clockwise revolution of the handwheel lowers the drill bit 1 mm; the scale on the ring is divided into 10ths and 100ths of a millimeter. Decide on your target depth—2.3 mm for example, which would be 2.3 full turns of the wheel. Write it down somewhere. Do a last check of everything: object stability, placement, clearances, and equipment.

8. DRILLING

With the dropper or squeeze bottle of water, make a small, penny-size puddle where the bit contacts the ceramic. The water will cool and lubricate the cut and clean the bit (fig. 8). If the object surface is level, surface tension will hold it there. If it is at an angle, you will need to make a small dam of Plasticine to keep it in contact with the bit. Refresh the water as needed to cool and lubricate the drill bit and flush away "drilling mud."

Turn on the drill at the lowest speed—virtually a crawl—and very slowly turn the handwheel clockwise, lowering the bit into the ceramic and establishing the hole. Use the lightest pressure—your guide will be the faint grinding sound. This is where practice on nonart ceramics will pay off. Depending on the vitrification of the ware, the drilling may be a very slow process, although you will be able to

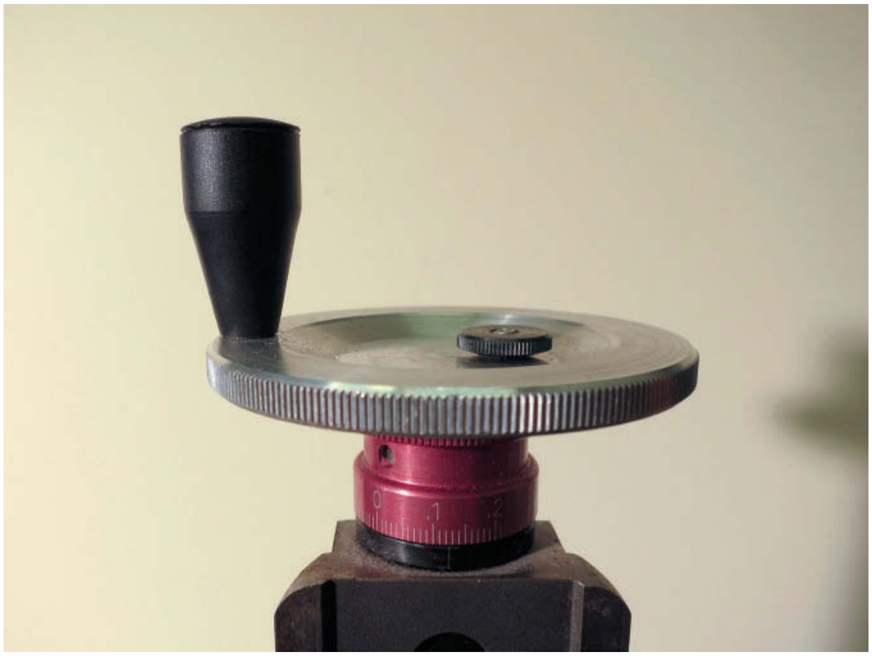

Fig. 7. Handwheel showing graduations and locking knob (Courtesy of Anthony Sigel)

increase the speed and pressure slightly after establishing the hole. Listen to the sound—it will be your guide as to how quickly to lower the spinning bit into the ceramic. Do not overdrive it!

Backing the drill bit out to check one's progress or to clear debris is generally not a good idea, as it can cause chipping or difficulty in reinsertion. When the target depth is reached, keep the drill running while turning the handwheel counterclockwise to raise the bit (fig. 9). With the bit up and out of the way, shut off the machine. Turning one of the lower handwheels, move the object a safe distance away from the drill bit. Remove the object. Flush the area with water to remove sludge from the channel, and clean and dry the surface with swabs.

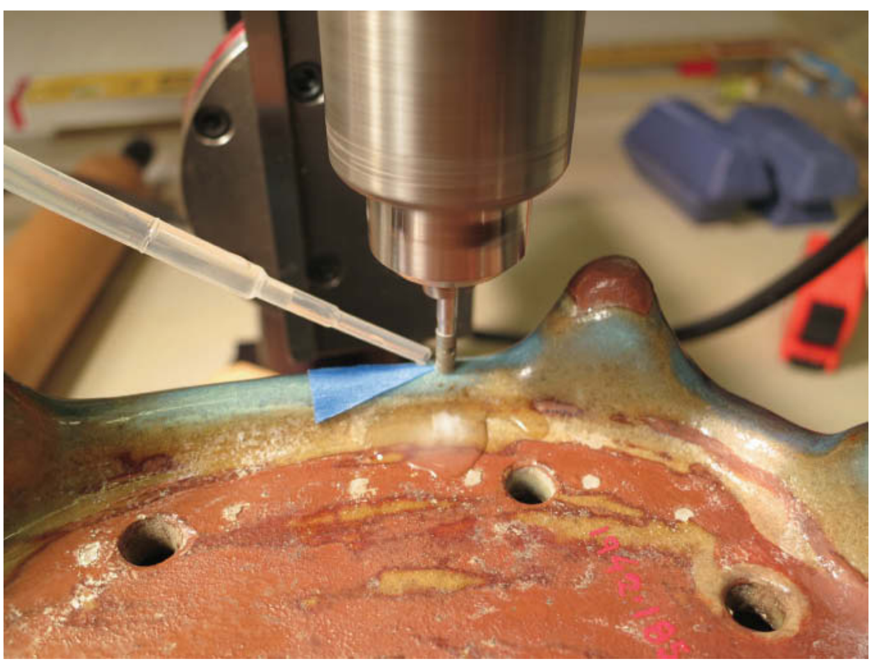

Fig. 8. Keep the bit lubricated with water (Courtesy of Elizabeth La Duc)

Fig. 9. Drilling completed (Courtesy of Elizabeth La Duc)

9. SAMPLE REMOVAL

To safely remove the core "plug," one needs to break the core off at its base by applying sideways pressure at the base of the core "plug." Use the tool fabricated from brass tubing, sized to fit the hole. The side of the tube, which is levered against the top edge of the hole and away from it, should be padded with a piece of tape to lower the risk of surface spalling. Levering the tool toward the hole will likely chip the core and break it well above its base, possibly losing the stratigraphy you seek.

First, cover the hole with a piece of 3M clear tape. This will stick to the core and prevent the core from flying across the room and ending up under a radiator. Push the core removal tool through the tape to the bottom of the drilled hole (fig. 10), then ease it out fractionally. Apply gentle sideways pressure away from the core, until you feel the core fracture, and voila! Lift the tape—your sample should come with it (fig. 11).

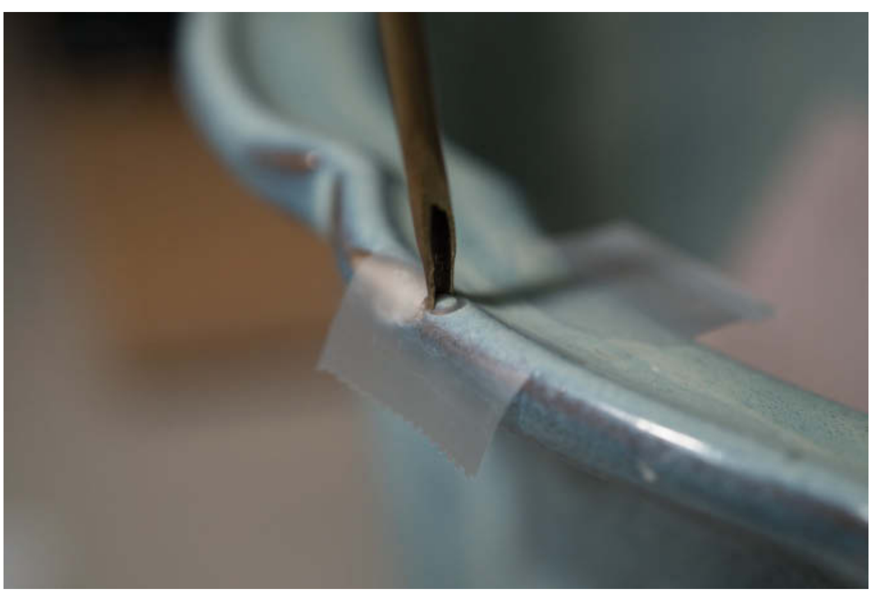

Fig. 10. Core removal tool inserted (Courtesy of Anthony Sigel)

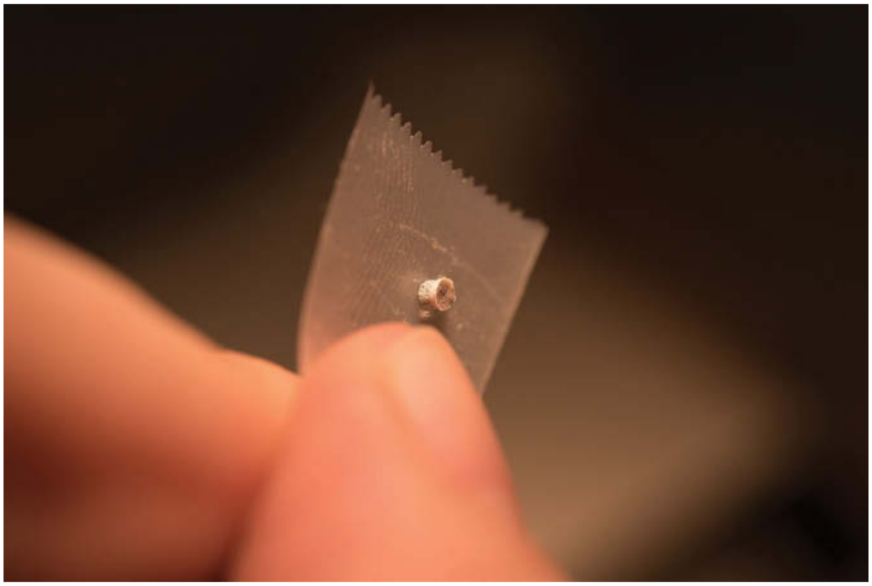

Fig. 11. Core removed—stuck to tape (Courtesy of Anthony Sigel)

Gently scrape the sample into a gelatin capsule or other container and label immediately. Place it in a properly labeled container and put in a safe place. Enter the sample number, description, accession number, and other data on the spreadsheet. Take the after photo if required. Splash your face with cool water. Sampling is a difficult, unpleasant thing to do, which permanently affects an object (fig. 12). Only do it when you really, really have to.

10. CASE STUDY: SHALLOW BOWL

Prepare the platform for a circular, shallow dish with a Plasticine bed and barrier film. The plywood platform allows for the attachment of stabilizing clamping cauls if needed to hold the dish in position (figs. 13, 14).

Fig. 12. Resulting 3-mm OD sample hole (Courtesy of Anthony Sigel)

Fig 13. Mounted plate with sample location pointers in blue tape. Chinese, *Imitation Celadon Bowl with Fish*, 14th century, 6 x 22 cm, Harvard Art Museums/Arthur M. Sackler Museum, 1932.63. Gift of H. Kevorkian (Courtesy of Anthony Sigel)

11. CASE STUDY: TALLER VESSEL

The Sherline machine allows the milling head to be swung off to the side to accommodate taller and differently shaped objects. A substantial counterweight must be added to the base (fig. 15). This vessel was sampled adjacent to a loss area that was to be filled and inpainted (figs. 16a–d).

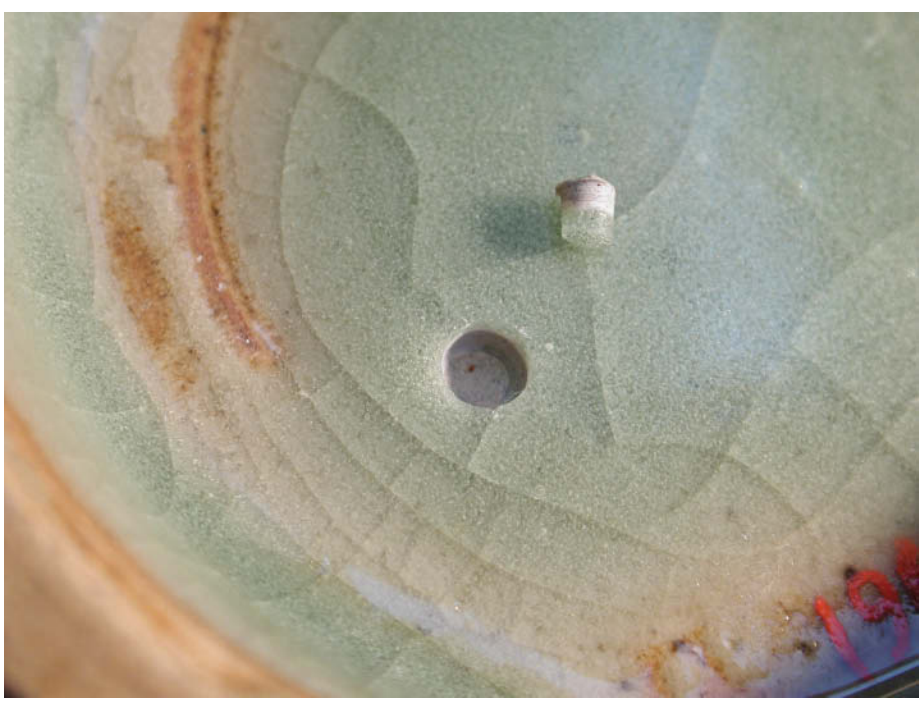

Fig. 14. Sample and hole after extraction (Courtesy of Anthony Sigel)

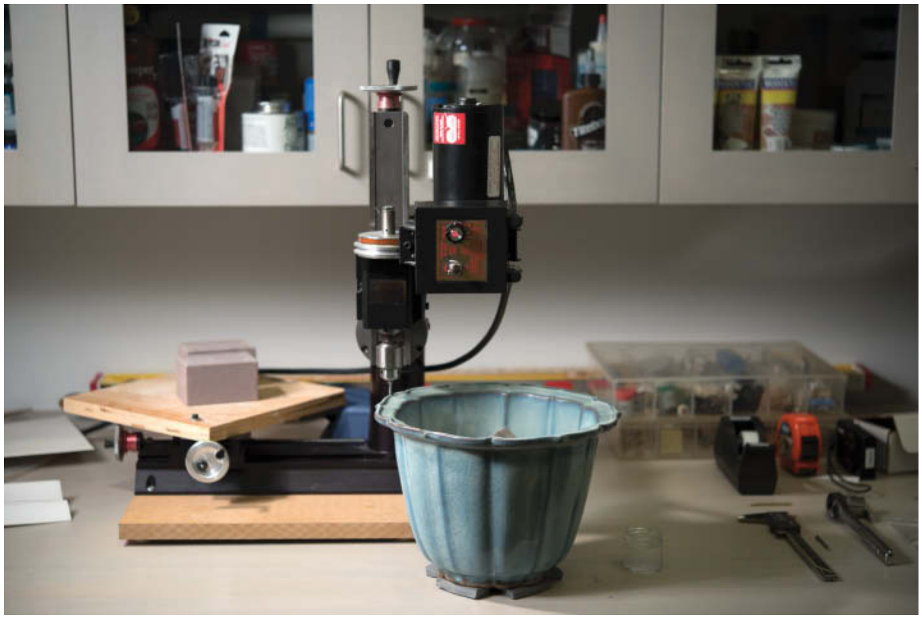

Fig. 15. Machine setup for off-axis sampling of larger Jun ware vessel. Chinese, *Lobed Flowerpot with Bracketed Foliate Rim*, 15th century, 17.9 × 26.2 × 26 cm, Harvard Art Museums/Arthur M. Sackler Museum, 1942.185.4. Gift of Ernest B. and Helen Pratt Dane (Courtesy of Anthony Sigel)

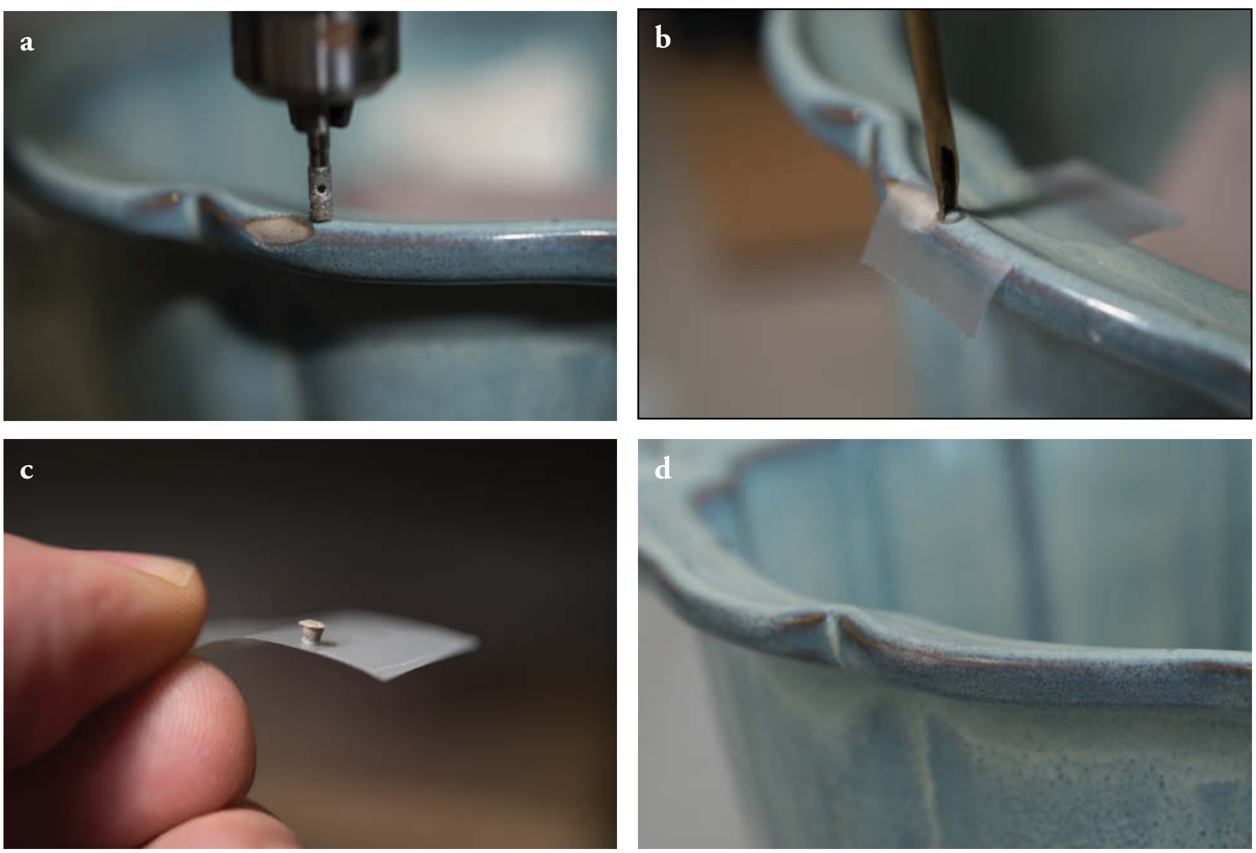

Fig. 16a. Preparing to sample adjacent to area of loss; 16b. Preparing to extract sample through tape; 16c. Successful sample extraction; 16d. Loss area after filling and inpainting by Straus Center Associate Conservator Susan Costello (Courtesy of Anthony Sigel)

12. AFTERWORD

These techniques have evolved in our lab in an effort to develop and refine safe and effective sampling methodologies, and are by no means ideal. We are extremely interested in learning how other practitioners solve these problems and look forward to hearing more about smaller-diameter, thinner-walled diamond drills, and machines that might combine a lever-operated drill head (quill type) with the micrometer-like precision and rheostat speed control offered by the Sherline machine.

SOURCES OF MATERIALS

Diamond core drills
Metalliferous
34 W. 46th St., 3rd Fl.
New York, NY 10036
212-944-0909
http://www.metalliferous.com/Diamond-Core/products/464/
Suppliers of good-quality, perforated thin wall core drills with solid shanks; 2.5-, 3-, 3.5-, and 4-mm OD are available. Our lab has found the 3-mm OD to be a good balance of outer hole diameter/sample size.

Mylar sheet, Volara polyethylene foam
University Products
PO Box 101
517 Main St.
Holyoke, MA 01041-0101
800-628-1912
https://www.universityproducts.com

Newplast (formerly Harbutts) Plasticine
Conservation Resources International LLC
5532 Port Royal Rd.
Springfield, VA 22151
703-321-7730
www.conservationresources.com

Sherline milling machine and accessories
Sherline Products Inc.
3235 Executive Ridge
Vista, CA 92081-8527
800-541-0735
http://sherline.com/product/5400a5410a-deluxe-mill-package/

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AVOIDING MISTAKES: HOW NOT TO LOSE THINGS

ANTHONY SIGEL

Disassembly of objects with many pieces can be difficult to keep track of. To avoid losses, print out an image of the disassembly layout to store the pieces on. If one goes astray, it will be immediately noticeable.

KEYWORDS: Mistake, Accident, Loss

1. INTRODUCTION

1.1 A DISASTROUS MISTAKE

Some years ago, I was treating an Islamic plate (fig. 1). Restored multiple times, it contained reused sherds, manufactured replacement sherds, plaster fills, and overpaint.

The orange-brown stains were partially dissolved shellac adhesive, absorbed into the fritware body and deteriorated glaze during a previous disassembly. After disassembly, each sherd was wrapped in lens tissue and poulticed with a solvent gel—some only one to two times, others as many as four to five times—to remove as much staining as possible (fig. 2).

Keeping track of everything became more difficult than a typical treatment in which all elements are subjected to the same processes at the same time. The numerous changes of poultice happened over the course of several weeks. Only at the end of the lengthy process did I discover that I had lost a sherd (fig. 3). It had no doubt stuck to the bottom of some toweling and was inadvertently tossed in the garbage at some point in the process. Even though all of the residue-encrusted tissue was saved, bagged, and labeled from each poultice session, the sherd was gone. A lengthy exploration of our dumpster yielded nothing.

1.2 A NEW PROCEDURE WAS CREATED

I was horrified by this mistake and resolved to change my working process to ensure that it could not occur again. I now photograph sherd groups after disassembly and directly print them out on a laser printer slightly over life size (fig. 4). Taped together and to a mounting board, it provides a storage location for all sherds, and if one is missing it can be instantly and easily detected (fig. 5). If a lengthy, messy cleaning procedure is envisioned, covering the printout with a sheet of Mylar will preserve it and allow easy cleaning.

All of our Fellows are now taught this procedure (fig. 6). Interestingly, when the plate was reconstructed, it became apparent that it was a badly warped and shattered kiln "waster," probably recovered from a kiln site discard pile and restored for the trade in the late 19th to early 20th century (fig. 7).

This method has utility beyond ceramics treatment, indeed any disassembly of an object with multiple pieces or fragments that could be misplaced. The image can also be used to make notes for each fragment or group, recording the cleaning process, interesting features, or treatment progress, and retained in the treatment file.

The takeaway: It is only by acknowledging and sharing our mistakes that we can learn from them and find solutions to do things better in the future.

Fig. 1. Before treatment. Syrian, *Laqabi plate with Hare*, ca. 12th to 13th century, fritware, 3.5 x 23 cm, Harvard Art Museums/Arthur M. Sackler Museum, 1934.48 (Courtesy of Anthony Sigel)

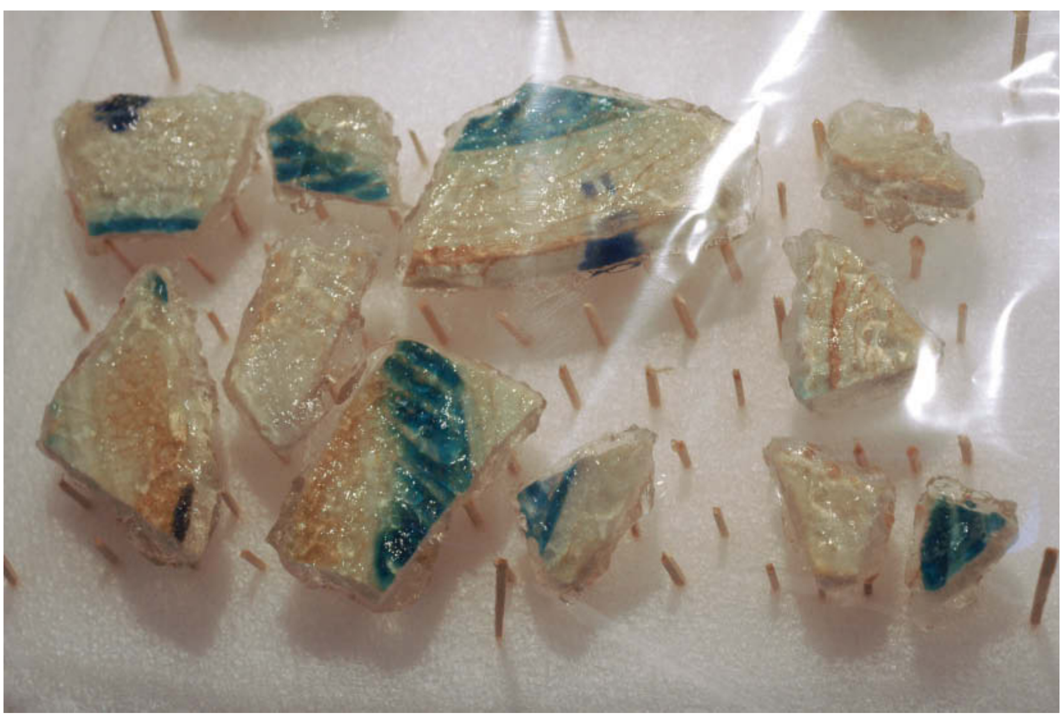

Fig. 2. Tissue-wrapped sherds during cleaning (Courtesy of Anthony Sigel)

Fig. 3. Disaster: a new, missing sherd (arrow) (Courtesy of Anthony Sigel)

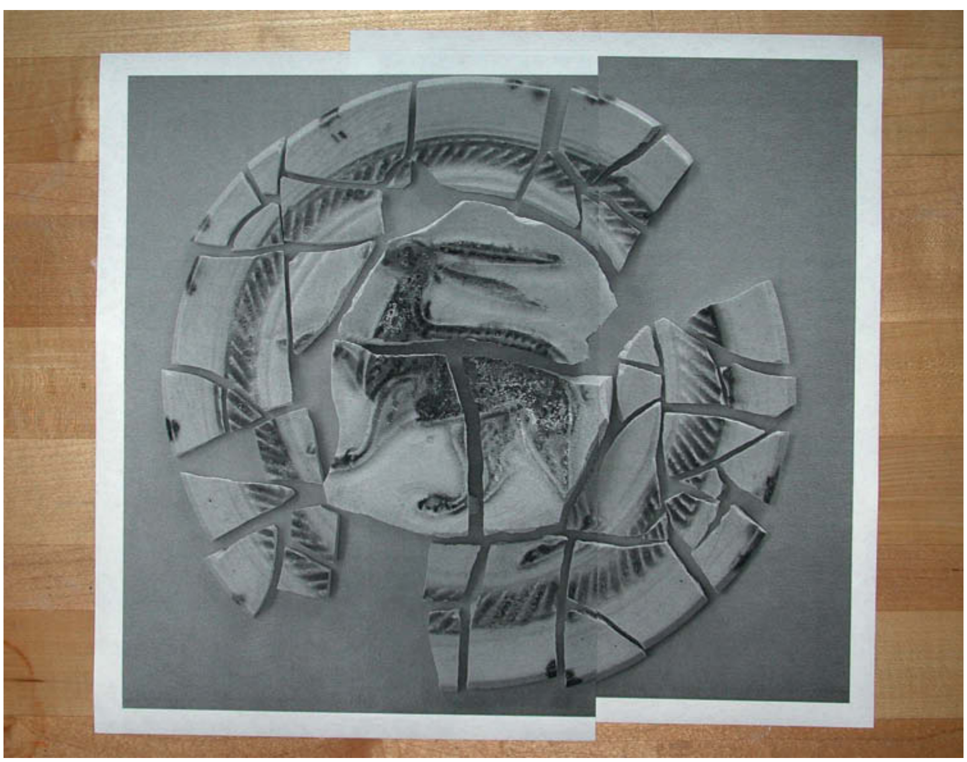

Fig. 4. Quick laser-printed photo of sherd layout (Courtesy of Anthony Sigel)

Fig. 5. Sherd layout photo in use (Courtesy of Anthony Sigel)

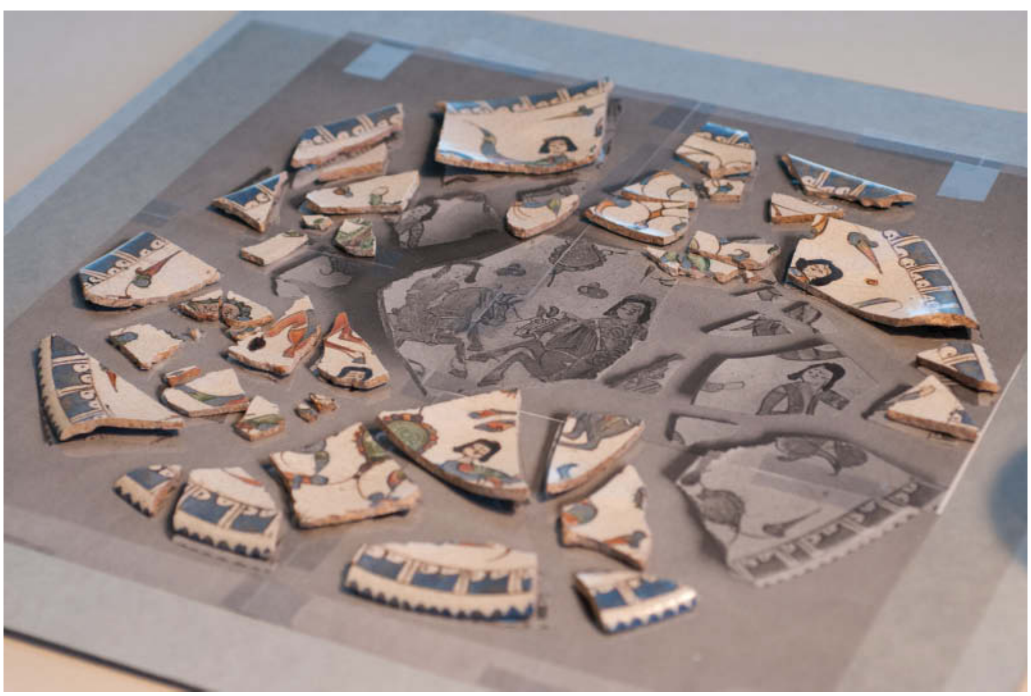

Fig. 6. During treatment image showing Mylar overlay by Jess Chloros, 2008 Straus Center Objects Lab Fellow. Persian, *Mina'i Bowl with Horsemen*, ca. 1200 to 1250, fritware with overglaze painted decoration in mina'i technique, 8.7 × 22.2 × 22.2 cm, Harvard Art Museums/Arthur M. Sackler Museum, 1936.34. Sarah C. Sears Collection (Courtesy of Anthony Sigel)

Fig. 7. Reconstructed plate showing original warping and losses (Courtesy of Anthony Sigel)

ACKNOWLEDGMENTS

I am grateful to former Straus Center for Conservation Director Henry Lie and all of my current and former colleagues in the Straus Center for teaching me and creating an environment where both successes and failures can be acknowledged.

SOURCES OF MATERIALS

Mylar sheet
University Products
PO Box 101
517 Main St.
Holyoke, MA 01041-0101
800-628-1912
https://www.universityproducts.com

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