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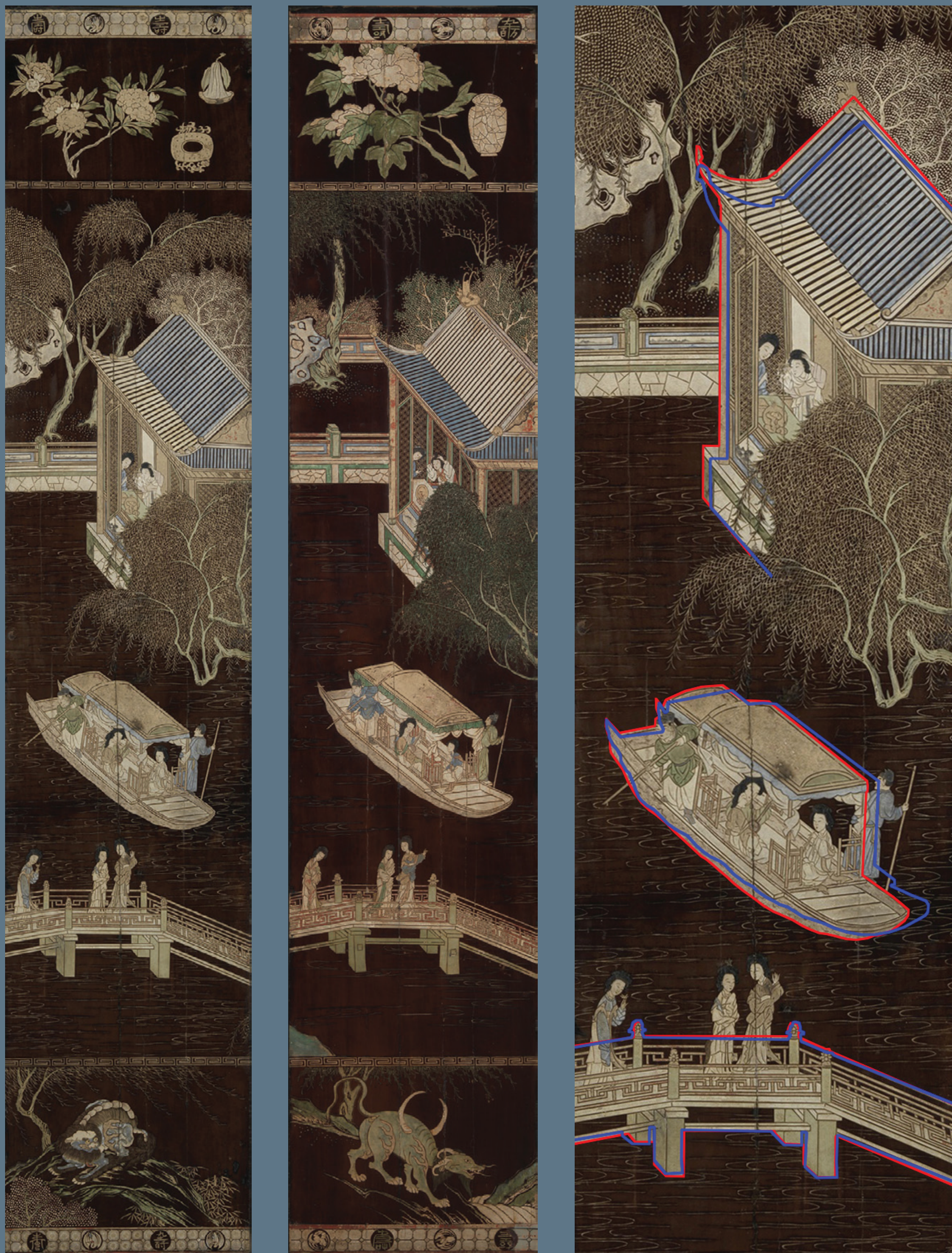

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POSTPRINTS OF THE WOODEN ARTIFACTS GROUP SESSION
ANNUAL MEETING

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AMANDA SALMON AND DEBORAH HUDSON

Embers in the Ashes: Challenges Encountered During the Restoration of Fire-Damaged Woodwork in a Historic House Museum

ABSTRACT—This article shares lessons learned from a restoration project following a 2009 fire at Craigflower Manor National Historic Site in the town of View Royal, near Victoria, British Columbia, Canada. It describes the unusual cause of the fire and focuses on the trial use of commercial dry ice blasting services to treat fire-damaged interior woodwork. The suitability of the technique for use within heritage interiors is considered. Complications that resulted from the insufficient capture of primary waste are discussed. Oversights are examined within the context of the exceptional circumstances of disaster recovery with the intention of informing best practices.

1. INTRODUCTION

Following a devastating fire in 2009 that seriously damaged the interior of Craigflower Manor National Historic Site near Victoria, British Columbia, the heritage farmhouse museum underwent a major restoration that provided a vital learning experience for heritage professionals involved in the project. Challenges encountered throughout the course of the restoration were numerous, often complex, and sometimes unanticipated. Shortly after the disaster, the site operators, TLC The Land Conservancy of British Columbia (TLC), contacted the Canadian Conservation Institute (CCI) to consult on the possible use of commercial media blasting with dry ice (solid carbon dioxide) for the restoration of fire-damaged interior woodwork. Since CCI had no practical experience with the technique at the time, it could not provide any immediate comments on its suitability. A CCI site visit was conducted as a learning opportunity to observe and assess the trial use of dry ice blasting to treat fire-damaged architectural woodwork, and to provide recommendations for additional treatment of damaged wooden elements. The advantages and the drawbacks of the commercial blasting process were observed when it was used to remove charred material from the substructure of the building's sole staircase. Complications arising from the insufficient capture of primary waste warrant an examination of the suitability of the technique for use within historic interiors. The aim of this account and critical analysis is to share insights, and successes and failures of the project, to inform best practices in the recovery of fire-damaged heritage interiors.

2. BACKGROUND

Built between 1853 and 1856, Craigflower Manor is one of the oldest remaining farmhouses in British Columbia and is designated as both a Provincial and National Historic Site (fig. 1). The Manor was built as part of Craigflower Farm by the Puget's Sound Agricultural Company, a subsidiary of the Hudson's Bay Company (HBC). The site represents the efforts of the HBC,

Fig. 1. Craigflower Manor National Historic Site (Courtesy of Deborah Hudson)

under its obligations to Britain, to establish a colonial settlement on Vancouver Island. At the height of its operation, Craigflower Farm was home to 76 people and included several homes and outbuildings housing various business operations. One of the farm's last remaining buildings, Craigflower Manor is the only late Georgian style building in British Columbia modeled on a Scottish manor house, and it is particularly significant as a representation of the early adaptation by settlers to the use of local building materials (Canada's Historic Places 2016). Native wood species are used prominently throughout the interior, which features extensive Douglas fir millwork and a finely crafted central staircase with a distinctive arbutus balustrade.

Craigflower Manor was purchased by the Province of British Columbia in 1965, restored under the direction of the well-known local architect Peter Cotton from 1967–68, and opened to the public as a museum in 1969 (Cotton 1970). In 2002, the Province began the process of devolving its heritage properties, and in 2003, TLC—a not-for-profit organization modeled after the National Trust—signed a 15-year agreement with the Province to manage and operate the site.

3. THE FIRE AT CRAIGFLOWER MANOR

On January 23, 2009, the interior of Craigflower Manor was severely damaged by a fire likely caused by an electric heater that had been installed sometime after the Cotton restoration in 1968. The heater had been mounted within a wall that defined a closet beneath the building's central dog-leg staircase (fig. 2). The site had recently closed for the evening, and no staff were present when the incident occurred. Firefighters from View Royal arrived on the scene first, within 4 minutes of the alarm, and were quickly joined by firefighters from the neighboring municipalities of Colwood and Esquimalt. After another 12 minutes, they were able to extinguish the fire, saving the building from any major structural damage (Hatherly 2009). The firefighters had been alerted to the emergency quickly because the main fire panel was located within the same small closet where the blaze ignited, and a signal was sent directly to the fire station as the panel itself was consumed by the fire.

Although the 1850s building would not have met contemporary construction codes for fire-protection standards, its massive square-log construction, the thickness of its lath and plaster walls, and the thickness and high grade of the wood used to construct the staircase were all factors that helped to contain the fire in its initial stage. As the firefighters entered the building through the kitchen door, a fireball erupted from inside the closet, fed by the sudden addition of more oxygen to the building. It billowed into the kitchen and at the same time coursed through the central hall and traveled up the staircase to the upper level. At the end of its path, the fire and smoke were somewhat relieved by a small open hatch to the attic. It was unusual that the hatch had been left open, but the fire inspector considered it a fortunate coincidence under the circumstances. If the fire had not been put out quickly, however, this

Fig. 2. The site of ignition under the central staircase of Craigflower Manor (Courtesy of Deborah Hudson)

coincidence would have turned to an unfortunate one, and would have ultimately hastened the destruction of the building. As is the case with many historic houses, the Manor did not have a fire suppression system.

Upon gaining entrance to the building, the firefighters used thermal imaging cameras to detect sources of heat through the smoke. Identifying a strong heat signature beyond the kitchen in the closet beneath the staircase, they immediately sprayed a mist of water above the source of the fire to reduce the ambient temperature. This action prevented the fire from reaching the point of flashover, the moment at which all combustible materials ignite within a structure fire. Additional bursts of water succeeded in extinguishing the fire at its source (Hatherly 2009). As the closet was close to where the firefighters entered the building, there was relatively little water damage associated with the event. Firefighters punched two large holes in walls along the path of the fire to make certain that the fire had not spread into the fabric of the building. Fortunately, the fire had not penetrated the structure beyond the interior surfaces.

According to the fire inspector who assessed the site following the disaster, the blaze was probably caused by an electric heater that had "gradually heated and ignited the brittle wood inside a wall" (Petrescu 2009). The fire inspector later explained to TLC staff that the heater beneath the staircase had likely been overworking due to capacity and placement issues, exacerbated by an abnormally cold winter in Victoria. The inspector did not, however, believe that the heater was the direct source of ignition. Instead, he concluded that the continuous heating of the small area over a prolonged period of many years had likely desiccated adjacent wood members, creating "pyrophoric" conditions under which the wood finally combusted. This phenomenon is termed *long-term, low-temperature ignition* or *delayed ignition* in current literature. The theory asserts that wood's combustion temperature may be lowered by protracted exposure to relatively low temperatures such as those created by common heating sources. In conjunction with other complex physical and chemical variables, it is theorized that long-term heating can create conditions favorable for spontaneous ignition (Babrauskas 2001). Several hundred fire inspection reports spanning over a century detail incidents involving the combustion of wood in close proximity to heating sources but without indication of direct ignition (Babrauskas 2001). There appears to be a lack of understanding regarding the exact physical and chemical mechanisms of this phenomenon. Although beyond the scope of this article, this lesser-known hazard of delayed ignition initiated by common residential heating sources bears further examination as a potential risk to heritage properties.

4. DAMAGE

There was a broad range in the severity of damage to the interior of Craigflower Manor as a result of the fire. Due to the localized nature of the fire ball, the most serious damage occurred at the ignition site and directly along its path (fig. 3). The substructure and superstructure of the staircase, and the upper sections of the walls, wooden doors, casings and jambs located on the first and second floors, suffered the most direct damage. This damage was characterized by both catastrophic and superficial charring. The transparent coatings and painted finishes on the millwork in close proximity to the path of the fire exhibited charring, blistering, and localized losses (fig. 4). There was also extensive indirect damage throughout the interior characterized by a fine deposit of soot and ash on virtually all exposed surfaces in the house, including all of the artifacts.

The poor condition of the central staircase was of particular concern for several reasons: it was considered to be one of the main character-defining architectural features of the building, it was the only means of access to the second floor, and it had suffered extensive damage due to its proximity to the area of ignition. Catastrophic charring reduced the thickness of most of the wooden members composing the substructure of the staircase by up to 50%, with total loss in some areas. Structurally damaged members included support posts, stringers, treads, risers, cleats, nosings, hand rails, and balusters (fig. 5).

Fig. 3. Example of the extensive damage to millwork caused by the fire (Courtesy of Deborah Hudson)

5. INITIAL RECOVERY

Once the firefighters had completed their investigation and staff were allowed full access to the Manor, a temporary wooden support structure was erected beneath the staircase for reinforcement and to ensure safe access to the second floor (fig. 6). Within the first days after the fire, local conservators provided recommendations for triage. TLC contacted a commercial disaster restoration company known to have previous experience working for museums. During a site meeting with the company, dry ice blasting was promoted as a highly controlled and effective method for removing charred material and damaged finishes. It was at this point in the recovery process that TLC contacted CCI to consult on the proposed use of dry ice blasting. A CCI site visit was arranged to investigate the technique and provide further treatment advice for the damaged woodwork.

Fig. 4. Example of the charred and blistered finish on the staircase caused by the fire (© Government of Canada, Canadian Conservation Institute. CCI 100841-0029)

Fig. 5. The central hall and staircase of Craigflower Manor after the fire (Courtesy of Deborah Hudson)

Fig. 6. The auxiliary support installed to support the damaged staircase (© Government of Canada, Canadian Conservation Institute. CCI 100841-0025)

6. DRY ICE BLASTING IN COMMERCIAL RESTORATION AND CONSERVATION

Dry ice blasting technology entered the industrial market in the late 1980s and has been explored by both heritage conservation professionals and commercial disaster restoration companies as a method to remove unwanted materials from targeted surfaces. The technique has been widely used by restoration companies for a variety of services, including decontamination of specialized equipment, mold remediation, and fire restoration. The most common commercial technique employs pelletized carbon dioxide as blasting media, propelled by high velocity airflow. The effect of the propelled particle on the surface is multiple. The kinetic energy transferred from the accelerated particle to the surface assists in dislodging the coating or contaminant. The thermal shock created by the significant temperature differential between the particle and the surface causes the treated material to shrink and become embrittled, enabling the particle impact to fracture the superstrate. Finally, the solid phase carbon dioxide particle sublimates on impact, rapidly expanding in the gas phase to help lift the disrupted contaminant. As with any type of media blasting application, the targeted contaminant is considered the primary waste, whereas the blasting media is referred to as the secondary waste. One of the advantages of dry ice blasting in comparison with traditional abrasive blasting techniques is that no secondary waste contamination occurs due to the sublimation of the blasting media.

Dry ice blasting technology ranges from equipment that produces a more aggressive effect using pellets, and higher pressure and media volumes, to units capable of more refined removal of contaminants using shaved media often called *snow* or *dust*, and lower pressure and media volume ranges. Within the conservation community, solid carbon dioxide cleaning methods have been investigated for the disruption of soiling layers, coatings, and other contaminants from both organic and inorganic substrates with varying results (Odegaard 2015; van der Molen et. al. 2015). The challenge of controlling the swift reduction of the superstrate has been noted (van der Molen et. al. 2015). Conservators have reported some promising results using shaved, solid-phase carbon dioxide snow for the treatment of soot-covered objects, including paper and books (Silverman 2006; Silverman and Irwin 2009).

7. DRY ICE BLASTING TRIAL AT CRAIGFLOWER MANOR

The dry ice blasting technique was described to TLC as being highly controlled and was characterized as having the ability to remove the print from a cigarette without damaging the paper. As it was explained, the method sounded promising for a variety of treatment applications at Craigflower Manor, including the controlled removal of soot deposits and blistered finishes from fire-damaged woodwork without damage to intact, underlying layers. Use of the technique was also promoted for the removal of catastrophic charring from wooden elements while retaining undamaged wood. Consequently, it was considered for the remediation of the staircase substructure where the stringers, support posts, and the undersides of treads and risers were severely charred.

TLC engaged the restoration company to test the dry ice blasting at Craigflower Manor, this to coincide with the CCI site visit. The charred underside of the staircase was selected as the initial interior test site for the treatment. Subcontractors hired by the restoration company arrived on-site the day before the testing to begin preparations for the blasting trial. This included the construction of a temporary enclosure to isolate the area immediately surrounding the proposed blasting site under the staircase with the intention of containing the dust generated by the procedure. The restoration company was asked to avoid the use of nails or screws when securing the isolation tent within the historic structure to protect its interior surfaces. A misunderstanding of the purpose of this request resulted in the construction of the lumber framing for the initial iteration of the isolation tent using only tape to join the framing members together. The resultant framing began to slowly collapse soon after it had been erected. A "pressure-fit" enclosure to contain the blasting site was eventually created with polyethylene sheeting hung with the use of telescopic poles and wood battens to clamp the plastic tightly against interior surfaces at its perimeter. Large vertical zippers were installed in the plastic sheeting to facilitate walk-through ability at key access points. Wood framing was also cut to fit snugly within doorways to secure plastic sheeting, creating secondary isolation barriers to adjacent rooms outside the enclosure. Concerns regarding the effectiveness of the isolation structures, as well as the installation of a dust extraction system, were discussed prior to testing the ice blasting in situ.

On the second day of the CCI site visit, a dry ice blasting operator subcontracted by the restoration company arrived to perform the work, beginning with a demonstration, as requested earlier by TLC. The technician first tested the Cold Jet Aero 75 dry ice blasting machine outside the farmhouse on a salvaged, charred wood member (fig. 7). The most commonly used pressure and volume setting (1 lb./min. at 40 psi) was demonstrated first. The blasting stream was observed to have a poorly controlled "chipping" effect, and portions of charred material were rapidly dislodged from the surface along with some fragments of sound wood. Consequently, this initial setting was judged to be too aggressive. The lowest pressure and media volume possible without constricting the flow of the media (1/2 lb./min. at 30 psi) was demonstrated next. This setting was observed to be less aggressive, producing an acceptable level of control in reducing the char to the pyrolysis front where sound wood was exposed (King, pers. comm.; Salmon 2009).

At the minimum setting, the dry ice pellet blasting had a level of control that prevented the unnecessary loss of undamaged wood that might be more difficult to avoid using traditional hand or power tools. This characteristic was considered useful for the treatment of the charred staircase substructure, where access to the complex stair assembly with hand tools would have been more challenging. The blasting did, however, have the effect on the surface of removing some of the softer, earlywood cells preferentially to the denser latewood cells, resulting in a slightly ridged surface. It should be noted that the ridged surface produced by the dry ice blasting would influence future treatment. A gap-filling adhesive would likely be required should bonding to new material be proposed. Although more interventive, the blasted surface could be further prepared with hand tools to reduce the ridges of latewood to create a flat gluing surface.

Unfortunately, the dry ice blasting equipment used in the trial at Craigflower Manor did not appear to be capable of the necessary control required for more refined removal of soot or damaged coatings from structurally sound millwork. It was agreed that the blasting should only be used on the most severely charred material, and that it was too aggressive to be used on blistered finishes and superficially charred or soot-damaged

Fig. 7. Testing on a charred wood member removed from the Manor demonstrating the effect of the dry ice blasting (© Government of Canada, Canadian Conservation Institute. CCI 100841-0040)

millwork elsewhere in the interior. Further testing was then conducted in situ on a small area of the charred treads and risers beneath the staircase by the blasting technician and an assistant from the restoration company, whereas the other parties remained on the property but outside the building due to health and safety concerns. Although in situ testing could not be observed directly by TLC and CCI for this reason, upon reentry and inspection of the results, the effect produced on the tested surfaces was considered acceptable.

The exposed areas of the charred underside of the staircase were treated with the dry ice blasting procedure at the lower setting of ½ lb./min. of media volume flow rate and a pressure of 30 psi. After the char had been removed from the underside of the stairs and the area was inspected, the temporary staircase support was dismantled to allow full access to the rest of the damaged substructure. The blasting process took under an hour to complete (fig. 8). After blasting had ceased and reentry was permitted, it was immediately evident that although removal of the charred material to expose sound wood had been successful, engineering controls provided to capture the primary waste had been ineffective and had failed to capture the generated dust. The air outside the enclosure and beyond the immediate blasting site was thick with suspended particulate matter. Airborne debris had escaped from the tent and infiltrated surrounding areas. The black dust was actively depositing on all neighboring surfaces, in some areas up to several millimeters thick (fig. 9). It appeared that the dust had escaped not only through breaches in the enclosure but also through losses in the staircase and gaps in the walls and floors, accumulating thickly in immediately adjacent rooms. It also became apparent that the only form of dust extraction ultimately employed was an industrial high-efficiency particulate air (HEPA) vacuum held by the assistant. The

Fig. 8. Staircase substructure after dry ice blasting treatment (© Government of Canada, Canadian Conservation Institute. CCI 100841-0053)

unforeseen negative impact of the resulting dust on the heritage interior and the collection was disheartening for all parties present at the site.

Immediately after the blasting concluded, appropriate personal protective equipment was procured by TLC, and dust removal was conducted by CCI and TLC using the restoration company's industrial HEPA vacuums. Virtually every exposed horizontal surface in close proximity to the blasting area required vacuuming. The dust had even penetrated beyond blocked doors into adjacent rooms. Cleaning began with the floor at the edges of the deposition to avoid stepping on the fine black dust to prevent driving it into the surface. Artifacts on open exhibit in adjacent rooms were all vacuumed without handling for the same reason. It took three people a day and a half to remove the majority of the dust from the most severely affected surfaces. Although damage from the dry ice blasting was not permanent, valuable time and energy were lost to the unanticipated undertaking of additional cleaning.

8. RESULTS OF WOODWORK RESTORATION

Following the site visit and dry ice blasting trial, CCI supplied TLC with a report providing recommendations for further treatment of the damaged woodwork. It called for an engineering report for the staircase and provided several options of varying degrees of intervention for its stabilization. It also provided guidance for the careful documentation, removal, and replacement of catastrophically charred millwork according to original specifications. It offered options for the consolidation of superficially charred substrates, various cleaning methods for soot-damaged surfaces, and recovery of original finishes (Salmon 2009). The recommendations provided by CCI supported the successful grant application for the funding of the Craigflower Manor restoration project.

Following the dry ice blasting, a structural engineer assessed the staircase. It was determined that although the capacity of the stair treads was significantly reduced, the remaining sections had the capacity to withstand the code-prescribed loads. The greater structural engineering concern was that the load-bearing capacity of the stringer adjacent to the main interior wall had been compromised by severe loss. A central support was added mid-span and concealed within the main interior wall to handle loading. The engineer also indicated that the post supporting the beam at the half-landing had been severely damaged and was no longer capable of bearing the prescribed load. However, once damaged material was selectively removed to reveal the assembly, it was found that the beam at the half-landing had the support of another uncompromised post. Further support was eventually provided to the beam with the restoration of the adjacent door jamb framing to pre-fire dimensions.

Since the prospect of using dry ice blasting for more refined treatment of the damaged millwork surfaces was abandoned early, more established techniques were pursued instead. Destroyed millwork was carefully removed with hand tools and replicated according to original dimensions and profiles. Replacement elements were installed to fill losses, and a trusted local carpenter skillfully scarfed and laminated new wood to existing sound wood while retaining as much original material as possible (fig. 10). Original fasteners and hardware were salvaged and reintegrated. Some areas of localized charring on woodwork for which consolidation had been recommended were removed instead, and no loss compensation occurred in response to the pressures of time and funding. As a result, certain areas of the woodwork, such as some of the damaged balusters, now have a permanently distorted appearance. Although visually incongruous, they may be considered to have interpretative value as an indication to visitors of the effects of the fire on the building.

Wherever possible, the original varnishes on affected millwork were preserved. In areas where the millwork had suffered blistering and localized losses in the upper varnish layers, damaged top layers were mechanically removed to reveal the

Fig. 9. The staircase handrail after the fire (a) and after contamination of primary waste from the dry ice blasting treatment (b) (Courtesy of Deborah Hudson)

earlier layer beneath. A reversible transparent coating was applied where necessary to harmonize the appearance of the extant transparent finishes. New sections of millwork were intentionally stained and finished to blend but not to match with adjacent original surfaces. Losses in the blistered brown paint layer applied during the 1967 restoration to the interior surface of the original front door and transom, and the window frames in the kitchen, revealed an underlying faux-grained oak surface. Although it was decided from the outset of the restoration project to return the interior to the aesthetic of the 1967 restoration, it was hoped at the time that additional funding would be obtained in the future to further investigate the original finishes and potentially reveal the original faux-grained layer. The Craigflower Manor restoration project took 4 years to reach completion and was considered successful. Best practices always remained the goal; however, the usual restraints on time and funding inevitably resulted in some difficult decisions and compromise.

9. ANALYSIS OF DRY ICE BLASTING TRIAL OVERSIGHTS

The restoration project that followed the fire at Craigflower Manor accomplished the goal of repairing the damaged interior according to high professional and ethical standards. Restoration of the National Historic Site was guided by professional museum, conservation, and built heritage restoration standards, including those from *Standards and Guidelines for the Conservation of Historic Places in Canada* (Parks Canada 2010). The interior was returned to the aesthetic of the earlier 1967 restoration while preserving character-defining elements and original materials that were considered to be in salvageable condition. The project team consistently sought the advice of specialists to ensure that a high standard of work was established and executed. However, as one of the treatments undertaken during the project that produced mixed results, the dry ice blasting trial at Craigflower Manor requires further examination. An analysis of the circumstances leading to the unsatisfactory outcome of localized recontamination is

Fig. 10. Replacement millwork surrounding the entrance to the larder (a) and replacement spindles and handrail components installed in the balustrade before finishing (b) (Courtesy of Deborah Hudson)

presented to serve as a reference for others who might consider use of the technique for similar scenarios.

9.1. RISK ASSESSMENT

Initial testing of the dry ice blasting procedure was conducted outdoors on a sunny day, and the volume of dust generated by the blasting tests was not entirely visible in the bright light and quickly dissipated in the breeze (King, pers. comm.). When the second test was conducted under the staircase, lighting conditions were again poor, although in this instance quite dark as the fire had decommissioned the electrical lighting in the Manor. A temporary electrical supply brought in from the other side of the building allowed for only limited lighting. Again, the amount of dust generated was not readily apparent. The pressure and turbulence created by the blasting may have also pushed the accumulated dust through breaches in the enclosure from the outset of the trial. The inspection of in situ testing did not venture beyond the isolation tent, and the overall effect on adjacent surroundings was not perceived. Additionally, a tendency to focus on the details of the effectiveness of the treatment at the expense of its broader consequences led to an oversimplified assessment of the treatment's risks. Greater attention was paid to the effect of the procedure on the surface rather than to the effect on the heritage environment, as it was assumed that protection of the interior had already been achieved by the isolation enclosure. The obligation to protect and retain original materials in a damaged heritage property brings with it the requirement for greater control of the effects on the environment than is necessary in more common residential and commercial recovery endeavors where damaged material may be considered replaceable.

9.2. ENGINEERING CONTROLS

In the case of the dry ice blasting treatment at Craigflower Manor, engineering controls were clearly inadequate to contain the primary waste. Given the sensitive property environment, the chosen removal technique, and the nature of the contaminant, a full abatement-level enclosure with an industrial ventilation system was warranted. Access doors were not baffled; the floors and ceilings were not tarped; and joints, entryways, and losses in the staircase itself were not well sealed. The floors and ceilings of the historic house exhibited small gaps that are common in heritage structures, and it is speculated that if these losses had been sealed, dust containment would have been improved. Small losses in the staircase structure caused by the fire were also missed during the sealing process, and they acted as breaches in the enclosure as well. Although the wood batten framing held the protective plastic sheeting firmly against interior surfaces, this method did not provide the airtight seal required to prevent leakage at the joints. The application of tape to artifact surfaces is usually avoided in conservation practices to prevent contamination by adhesive residues and physical damage to the surface during release. Upon weighing the risks of potentially creating localized damage to the interior surfaces, with the need to create a fully sealed enclosure to protect the heritage interior, taping at all attachment points would have been warranted in this case. It appeared that the only extraction device ultimately used during the blasting process was an industrial HEPA vacuum held by the assistant in an attempt to capture the resultant dust. An industrial negative air ventilation and exhaust system would have been required to properly extract the dust from the enclosure and the building.

Even after consideration of the deficiencies already mentioned, the large volume and relatively wide disbursement of primary waste from the isolation enclosure remained surprising. Research on the health effects of dry ice blasting conducted by Clark Seif Clark (CSC), an American environmental consulting firm, may shed light on this inconsistency. A study requested by an Arizona-based restoration firm, and led by CSC industrial hygienist and indoor air quality expert Derrick Denis, was undertaken to determine how best to protect personnel performing dry ice blasting operations. CSC technicians monitored carbon dioxide levels during a real-life blasting operation. They discovered that the amount of carbon dioxide gas generated during the procedure rose quickly to concerning levels that could adversely impact the health of the operators if left unmitigated. The study also hypothesized that, upon sublimation of the blasting media, the rapid expansion of carbon dioxide gas in an enclosed space has the potential to create pockets of positive pressure that could have a considerable effect on net pressure. If unaccounted for in the ventilation strategy, the resultant increase in pressure could also impact the integrity of enclosures and create the potential for localized containment breaches (Denis, pers. comm.; Denis et. al. 2010). It is estimated that 1 lb. of dry ice expands upon sublimation to create up to 8 cf. of carbon dioxide gas at ambient conditions. An estimated 15 lb. of solid carbon dioxide was used during the dry ice blasting trial at Craigflower Manor. The resultant volume of carbon dioxide gas created in the enclosed space during the ice blasting process at the Manor may therefore be estimated to have been up to 130 cf. within 30 minutes. The air pressure within the enclosure would have been even further increased due to the delivery of the blasting media by compressed air. The research conducted by CSC seems to explain the discrepancy noted at Craigflower Manor, between the relatively minimal apparent disbursement of dust observed in the testing of the blasting process conducted outdoors and the dramatic effects of the technique's application indoors within the confined space of the containment enclosure.

10. RECOMMENDATIONS

The exercise of oversight analysis brings forward recommendations for those who may be faced with similar situations in the future. Conditions such as personnel availabilities, external pressures to act quickly as a result of competing authorities and stakeholder priorities, and the unfamiliar and taxing nature of disaster recovery itself can impact informed decision making. It is hoped that that the provision of both technical and administrative recommendations will assist in the implementation of educated treatment choices and promote successful outcomes for future projects involving the restoration of fire-damaged heritage interiors.

10.1. CONTROL OF CONTRACTOR ACTIVITIES

The reality of museum and historic site budget constraints often forces organizations to look beyond the conservation community to commercial enterprises for specialized treatment services. However, even those contractors experienced in the disaster recovery of heritage properties require comprehensive guidance from heritage professionals. Referral processes and thorough vetting of prospective service providers must still be bolstered by informed management of on-site activities, and reinforcement of the unique sensitivities of heritage properties, to prevent further damage to cultural property. For instance, project staff should be well educated in the specific type of work being conducted on-site by contractors and in the local and national regulations applicable to such activities. Requisite site orientations for all contractors stressing the significance and vulnerabilities of the heritage property should be strongly considered. In the case of Craigflower Manor, this step was taken with the primary contractor but not with the subcontractors. Reference materials such as *Working with Contractors* (Museum and Galleries Commission 1998) provide excellent guidance on the subject.

10.2. DRY ICE BLASTING STANDARDS AND REGULATIONS

The establishment of comprehensive regulations specific to dry ice blasting engineering controls is critical for the protection of both the local and broader environment, as well as for the safety of workers. The technique is often promoted as an environmentally sustainable process with no waste generation. This is only true as far as secondary waste material is concerned. Dry ice blasting conforms to the US Food and Drug Administration, and the US Environmental Protection Agency regulations regarding hazardous substances since carbon dioxide sublimates, and so is not considered a hazardous material requiring regulated waste disposal. However, when dry ice is employed as blasting media, and particularly when the technique is applied to fire-damaged surfaces, several health and safety issues arise.

As demonstrated by the situation at Craigflower Manor, the disbursement of the primary waste from the dry ice blasting process requires strict attention. Unfortunately, many jurisdictions do not have specific legislation pertaining to indoor air quality. In the absence of legislation, the "general duty clause" applies in Canada. This clause is common to all Canadian occupational health and safety legislation and requires the employer to provide a safe and healthy workplace. However, explicit regional regulations are less common, and most standards outlined in legislation are aimed at ensuring the comfort of workers rather than protection from specific health hazards (CCOHS 2016). Both the Occupational Health and Safety Administration (OSHA) and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) provide guidelines for indoor air quality (ASHRAE Standard 62.1; ASHRAE 2011), and the control of airborne dust (OSHA 29 CFR 1910.94; OSHA 1999). Indoor dry ice blasting projects should follow these standards in addition to regional regulations governing indoor air quality. These more specific guidelines are provided for the protection of the health of workers and the environment, offering supplementary guidance for containment and extraction controls.

Given the similarity of dry ice blasting to traditional abrasive blasting methods used for the remediation of contaminated surfaces, it would be prudent to assume existing standards for containment and extraction established for these applications. The American National Standards Institute (ANSI) provides applicable guidelines in its publication, *Abrasive Blasting Operations- Ventilation and Safe Practices for Fixed Location Enclosures* (ANSI/AIHA/ASSE Z9.4; ANSI 2011). Furthermore, dry ice blasting operators should strongly consider the adoption of hazardous material abatement-level standards and regulations for engineering controls until specific controls for dry ice blasting are regulated. These measures are recommended particularly for the removal of combustion products during fire restoration, where particulate matter may be toxic or considered an explosive dust. As a corollary, the adoption of abatement-level engineering controls would provide a high level of protection for heritage interiors.

Appropriate engineering controls for dry ice blasting operations conducted in heritage interiors might include temporary enclosures constructed of puncture- and tear-resistant material such as woven polypropylene containment tarps covering all sides of the structure, including floor and ceiling surfaces. Two thicknesses of sheeting material with offset joints should be considered, or the construction of a full, secondary isolation structure just beyond the primary structure. All seams, overlaps, and attachment points to the structure should be sealed with heavy-duty tape. Other controls for abatement enclosures include baffled air inlets and doors, or airlocks at access points (OSHA 29 CFR, 1926.1101; OSHA 2011). The optimal choice for extraction would be a negative air pressure system using industrial air movers and a filtered exhaust system diverted to the exterior of the building. Air intake and exhaust velocity ratios should be set according to the nature of the contaminant and monitored periodically to ensure the correct level of output (ANSI/AIHA Z9.9; ANSI 2010). Output calculations must also account for an inevitable drop in airflow as captured particulate loads the filters of the exhaust system (Denis. pers. comm.). Ventilation system designs should encourage laminar flow rather than turbulence by correctly positioning blasting operators in relation to air inlets and exhaust devices. For those contemplating the use of dry ice blasting within interior spaces, consider employing a specialized professional such as an industrial hygienist to calculate the required airflow necessary to protect both workers and the local environment, and to recommend an appropriate ventilation and exhaust system.

In the absence of specific guidelines governing the control of dry ice blasting, abatement-level ventilation strategies should be considered. However, further study and guidance is still required to account for the unique safety, containment, and extraction issues encountered with the dry ice blasting technique. Changes to localized and net pressure within temporary enclosures due to the positive pressure caused by both the additional volume of carbon dioxide gas and the compressed air carrying the blasting media, must be accounted for when determining appropriate ventilation system output. Further investigation is also essential to assess the risk to workers' health from the displacement of oxygen by carbon dioxide gas upon sublimation. The danger of cognitive impairment or asphyxiation to dry ice blasting operators working within confined spaces can be significant and must be addressed and mitigated by the ventilation strategy. Until guidelines or regulations specific to dry ice blasting are created and imposed, references such as the safety tip sheet "Dry Ice Blasting," created by the Infrastructure Health and Safety Association (IHSA), provide a useful overview of both health hazard and containment issues (IHSA 2016).

Finally, it is anticipated that the publication of the proposed standard, *IAQA/ASHRAE/RIA 6000P: Standards for Fire Restoration*, developed jointly by ASHRAE, the Indoor Air Quality Association (IAQA), and the Restoration Industry Association (RIA), will fill the urgent need for guidance in this area. The proposed guidelines are intended to address environmental and safety issues related to fire restoration and "will be adopted and specified within the fire restoration industry, the insurance industry, and related parties" (IAQA 2016). These standards will also "provide a basis to determine how to perform restoration services of properties and contents, and how to determine services have been successful" (IAQA 2016). It is very encouraging to see both a recognition of a lack of guidance and corrective action by the restoration industry and standardization authorities in this regard.

10.3. Combined treatment approaches for fire-damaged interiors

Based on the experience at Craigflower Manor, it is recommended that bulk removal of charred material within a historic structure damaged by fire should be undertaken first by traditional means using relatively dustless techniques employing chisels, scrapers, and other appropriate hand tools. After bulk removal, more refined reduction by carbon dioxide snow cleaning, as opposed to more aggressive pellet blasting, could follow to address hard-to-reach areas and expose sound wood in a controlled manner with minimal loss. Dry ice blasting has the potential to be an effective means of reducing charred material within a historic structure. The blasting technique is unparalleled at reaching the otherwise inaccessible areas around joints and complex assemblies common to timber frame construction. The sublimation of the blasting media avoids contamination by secondary waste. The technique itself should not be dismissed but rather further investigated and refined to capitalize on its advantages. The use of more precisely controlled and less aggressive equipment with carbon dioxide snow rather than pellets is considered a better option for treatment of heritage interior elements; however, abatement-level engineering controls are strongly advised. Adequate technical expertise, ample experience, and knowledge of standards for containment and portable extraction scenarios are requisite. Had the isolation tent been sealed and exhausted properly, the results of the dry ice blasting treatment during the restoration of Craigflower Manor would have been quite different.

10.4. Salvage and recovery planning

The importance of an up-to-date salvage and recovery plan as an integral part of an overall disaster plan cannot be overemphasized. Proposed treatments and service providers must be thoroughly and thoughtfully examined before initiating service. Potential resources should be investigated and relationships established before the pressures of the salvage and recovery process affect decision making. Alongside significant artifacts, character-defining spaces, features, and finishes of heritage interiors should be identified in advance and designated for priority treatment as part of a disaster planning process. Although implementation may understandably diverge from plans at certain times during recovery processes due to unforeseen circumstances, the existence of a formal strategy will undoubtedly assist in the management of outcomes.

10.5. Transparency

Project post-mortems and the dissemination of unsatisfactory outcomes are becoming common practice in industry as companies and institutions strive for transparency and innovation. Often culminating in statements called *failure reports*, these exercises recognize the value of objective analysis of undesirable results to improve best practices (Engineers Without Borders 2011). It has long been acknowledged that there is a tendency toward reticence to share undesirable results in the heritage community (Baril 1998). This hesitance must be overcome by those who have experienced adverse situations, in the interest of promoting precision and progress for the development of both treatment methodologies and overall preservation strategies.

11. CONCLUSION

Examination of the Craigflower Manor restoration has led to a more complete understanding of the broad range of challenges that can arise during the recovery period following a disaster at a heritage property. Although the restoration was not without fault and sometimes constrained from achieving the ultimate goals set by best practices, the restoration team maintained high aspirations and many positive results arose from the process. Staff and volunteers showed great professional dedication, resilience, and determination in responding to the direct and indirect challenges presented as a result of the fire. Local professional conservators and skilled craftspeople had the opportunity to hone and apply and their skills toward the restoration of a National Historic Site, and to educate, train, and share their expertise with others. In a broader sense, several beneficial partnerships were initiated or strengthened. The interest and support of the local community in the restoration project underscored an attachment to Craigflower Manor as an important and meaningful local historic landmark.

Examination of the dry ice blasting treatment at Craigflower Manor reveals that the technique must be carefully controlled if considered for the treatment of fire-damaged woodwork within heritage interiors. Strict supervision and informed management of contractor activities is crucial. The application of appropriate engineering controls is essential, not only to protect workers' health but also to contain primary waste and avoid recontamination of the site. Rigorous risk assessment practices must be applied jointly by both service providers and heritage professionals to ensure that treatments do not adversely impact the broader interior environment. It is hoped that the dissemination of the Craigflower Manor restoration project results for the treatment of its fire-damaged woodwork will help to inform colleagues faced with similar situations in the future of the important issues considered here.

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CAMILLE MYERS BREEZE AND MELISSA H. CARR

A Ghost of the Civil War: A Man, a Flag, and a Frame

ABSTRACT—In January 2014, a tattered flag encased in an elaborately carved frame was found in the basement of Lowell Memorial Auditorium in Massachusetts. The flag and frame had sustained damage from use, time, neglect, previous mounting campaigns, and souvenir hunters. Camille Myers Breeze treated the flag, and wooden artifacts conservator Melissa Carr treated the frame. Members of the board of the Greater Lowell Veterans Council collaborated with insight and decisiveness about levels of restoration. The result was the rediscovery of a legacy of preservation, respect, and civic pride for a man and the flag for which and with which he died.

1. INTRODUCTION

For decades, staffers walked through the basement of the Lowell Memorial Auditorium in Massachusetts and never noticed the big, dirty frame propped against a piano.[1] Then in January 2014, two employees stopped, looked, and called the Greater Lowell Veterans Council to tell them that they had found something extraordinary—a tattered flag encased in an elaborately carved wood frame (fig. 1).

Fig. 1. Flag and frame as found in the basement of the Lowell Memorial Auditorium, 2014 (Courtesy of Richard Howe)

There is no record of when the framed flag was taken off of display, but it was likely due to the tattered and broken appearance, as well as the thick layer of soot covering all of the components. The location where it had hung was confirmed when holes in the marble wall of the auditorium's Hall of Flags were found that correspond exactly to the hardware on the back of the frame. It spent decades across from the auditorium's main doors, with their large transom lights, and directly over a forced air return.

Over the course of the fall and winter of 2014–15, wooden artifacts conservator Melissa Carr and textile conservator Camille Myers Breeze performed their respective treatments, touching base with each other to ensure that the conserved and mounted flag would fit back into the original frame. Each woman also began the journey of discovering the story of the man responsible for return of the flag to Lowell.

2. THE MAN

Lowell city historians Eileen Loucraft and Richard Howe had uncovered most of what we now know about Solon Perkins (fig. 2), based on the inscription on the inner frame, which reads:

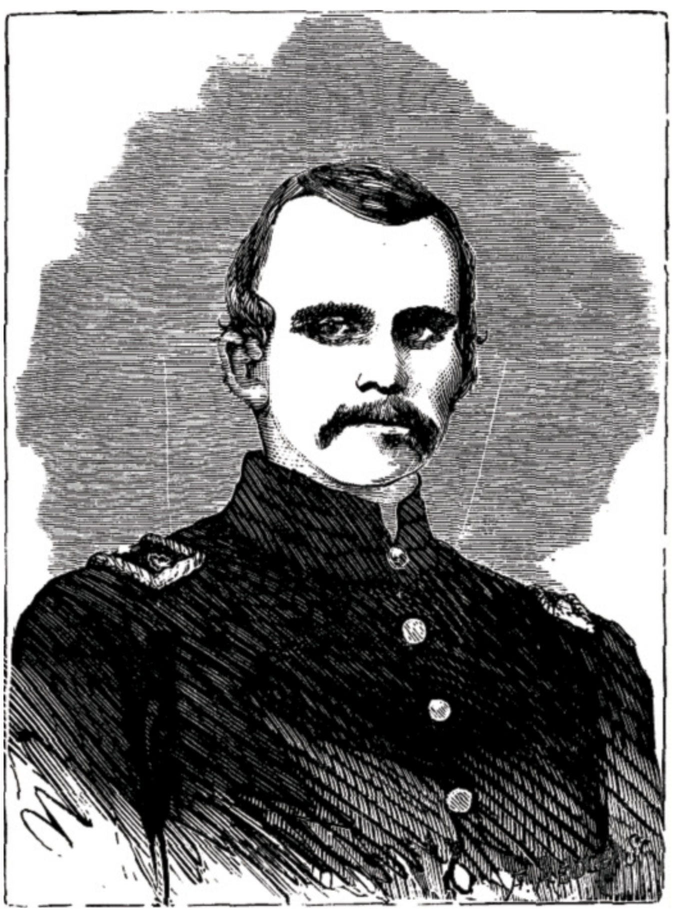

Fig. 2. Solon Perkins (C. Cowley, *Illustrated History of Lowell*, Lee & Shepard, 1868)

"Under this flag at Clinton Louisiana June 3rd 1863 Solon A. Perkins was Killed." Born in Lancaster, New Hampshire, on December 6, 1836, Perkins and his family relocated to Lowell when he was just 4 years old. According to Howe's Blog, after graduating from Lowell High School, Perkins "immediately became engaged in the world of international business, working for several years in Buenos Aires and for several more in Valparaiso, Mexico. In these places, he became fluent in both Spanish and French, skills that became invaluable during his military service in Louisiana" (Howe Jan. 18, 2014, "Solon Perkins: 1836-1863").

The Perkins flag, as it is known, is one of two Cavalry guidons referred to in a letter written by Major General Benjamin F. Butler of the 8th Massachusetts Volunteer Militia. Reprinted in the Lowell *Daily Sun* on December 15, 1894, Butler's letter says, "The two sashes in this box belonged to two of the bravest cavalry officers I ever knew . . . The larger one belonged to Capt. Solon Perkins 1st lieutenant of the second company, Mass. unattached cavalry, who was killed near Port Hudson, La., in June 1863. Both were dear friends, and better or braver men never lived" (Howe Jan. 19, 2014, "Civ. War S. Perkins Saga Cont.").

The newspaper article goes on to say that Butler's letter and the Perkins flag were "to be put in Memorial Hall." Twenty-one years after the date of the article, a devastating fire hit Lowell Memorial Hall, taking with it many relics of Lowell history. Fortunately, prior to her death in 1896, Mrs. Perkins had gifted the flag to Charles L. Knapp, a Lowell banker and philanthropist. It is possible that Mrs. Perkins gave him the flag because she felt that he would keep it and do her son honor in a public way. According to Knapp's wife Mary Sawyer Knapp, it was they who "carefully preserved [the flag] by mounting under glass in a beautifully hand-carved frame." Mrs. Knapp donated the flag to the new Lowell Memorial Auditorium in 1929, constructed 7 years prior. The flag was installed at the auditorium on November 12, 1929 (Howe Jan. 19, 2014, "More on the Civ. War Flag Mystery").

3. THE FLAG

The approach for conserving the Perkins flag was developed over the course of discussions with Jack Mitchell, Bob Marshall, and other members of the Greater Lowell Veterans Council. At every juncture, decisions were made expeditiously and with great thought. When asked whether they wanted to compensate for missing parts of the flag, including the two tips, they decided that the story of the flag was better told with the colors of the missing areas restored (fig. 3).

The flag was glued and stitched to a brittle sheet of cardboard prior to 1929. The stripes were easily released by cutting the stitches, but the canton was heavily adhered. For ease of handling, the cardboard was broken along existing tears in the flag, and the canton and stripes were separated. At this point, all available surfaces were lightly cleaned with chamois, which was

Fig. 3. Bob Marshall and Camille Myers Breeze removing the Perkins flag from the frame

found to be less abrasive than vulcanized rubber or a cosmetic sponge, followed by low-suction vacuuming.

The canton was carefully released from the cardboard with a combination of ethanol, a heated spatula, and mechanical action. After adhesive and paper residue was sufficiently reduced, a large number of gold painted silk star fragments remained more or less in the location where they had been glued 100 years earlier. To consolidate them before they disintegrated further, "star dummies" were created.

The star dummies were made of a combination of BEVA gel, water, ochre acrylic paint, and Jacquard antique gold Pearl Ex pigment, mixed until the color was an adequate match. This thermoplastic paste was painted onto synthetic taffeta, allowed to dry, and cut into the shape of the flag's stars.[2] Using a tacking iron, a star dummy was adhered behind each of the flag's 34 fragmented stars. After conferring again with the Greater Lowell Veterans Council, it was decided that the star dummies should be left intact rather than cutting away any unused portion of each star. The star dummies were lightly tacked with an iron to a sheer blue taffeta underlay, and stronger areas of the canton were hand stitched with fine polyester thread (fig. 4).

An aluminum solid-support panel was obtained that fit exactly within the flag's inner frame. The panel was covered with 1/4-in. Polyfelt followed by beige cotton poplin. Over this mounting surface, a ghost image of the flag's missing areas was created using three colors of synthetic taffeta. Rather than hot cutting the edges of the taffeta, which produced an uneven beaded edge, a 1/16-in. line of 2.5-mil BEVA film was used to prevent unraveling. The striped portion of the flag was lightly stitched to the panel before the canton portion was incorporated.

An overlay of undyed silk Crepeline was chosen as a barrier between the flag and a sheet of UV-filtering acrylic. Before application, the flag was covered with a piece of tissue paper and then the Crepeline was rolled onto a tube. Starting at one end,

Fig. 4. Comparison of the canton after removal from the cardboard (left) and after stabilization with star dummies (right).

the flag was carefully checked for particulate matter and any fragments of silk were straightened before the silk Crepeline was unrolled and the tissue was slid out from beneath. When this delicate process was complete, fine polyester thread was used to stitch around the perimeter of the flag, encapsulating it between the Crepeline and the panel.

Rather than wrap the edges of the silk Crepeline overlay around to the back of the panel to be stapled or sewn, which would subject them to contact with the antique wood frame, another strategy was employed. A 1/8-in. strip of 2.5-mil BEVA film was adhered to the outer edge of the panel's face, and the Crepeline was lightly tacked down. The silk could then be trimmed with a scissor without fear of unraveling.

A 1/8-in.-thick sheet of UV-filtering acrylic was pre-drilled around the perimeter with enough holes to accomplish a pressure mount.[3] The acrylic was placed over the flag, and screws were sent into the top of the panel. We had anticipated that these screws would be visible when the inner frame was placed over the flag, as the frame has a very narrow lip. So a 1-in. window mat was created out of Larson-Juhl Artique mat board with a linen texture. The mat was adhered to the top of the acrylic face with 3M double-sided #415 tape, masking the screws (fig. 5). Although the mat will get soiled over time because it is not protected by the acrylic, this was an inexpensive way to maintain the highest standards in the integration of the mount and the historic frame.

Fig. 5. Flag after pressure mounting and before final framing.

4. THE FRAME

The decoration on the white oak outer frame includes the company banner, an eagle in the upper right corner, something missing in the upper left corner, a saber belt and buckle, a saber, a rifle, the list of towns where Perkins' company fought (both before and after he died), a Cavalry Corps badge, and the dates

Fig. 6. Frame before treatment

of the war (1861–1865). On the painted and gilded inner frame is the inscription of Perkins' date and place of death (fig. 6).

When the frame arrived for treatment it was a filthy broken mess. Parts were missing from the rifle and the sword, the finish was discolored and stained, the paint was flaking, and the gilded lettering was almost unreadable. Treatment began with the replacement of the missing portions of the carvings on the outer frame.

After some Internet research and crowd-sourcing, it was determined that the rifle was not a rifle at all but a full-scale replica of a Joslyn .52 caliber carbine, made in Stonington, Connecticut, in either 1862 or 1864. The original carver almost certainly had an actual example of the carbine in front of him to copy. For the conservation treatment, multiple photographs from several angles sufficed. Interested readers can query "Joslyn .52 caliber carbine" and find images that correspond to the carving.

On the carbine, the trigger and trigger guard were reduced to stubs, and the sight and hammer were missing entirely. After modeling the parts in white pine to resolve design and fabrication questions, the pieces were reproduced in white oak. The trigger and trigger guard elements were reattached with small pegs at the connecting points. The sight and hammer were reattached directly with fish glue (fig. 7).

After more Internet research, it was determined that the saber was a replica of a typical Civil War—era saber, with the original having a brass hilt and leather wrapped around the handle. Again, interested readers can query "Civil War saber" and find images that correspond to the carving.

Fig. 7. Carbine carving with replacements

Fig. 8. Saber carving with replacements

Four stubs were all that remained of the carving of the original hilt. After much trial and error in white pine to get the compound curves and negative spaces right, the missing parts of the hilt were fabricated in white oak and reattached with small pegs at all of the connecting points (fig. 8).

Re-creating the missing parts of the carbine and saber hilt required no speculation; the photographs provided the necessary information. The one area of missing carving that was not replaced was in the upper left corner, where a broken stub protruded slightly. There was no photograph for what would have been there and the decision was made not to guess. The stub was left in place and the area cleaned and filled so that it would not distract.

Before the replacement carvings were toned, the outer frame was cleaned. The soot and dirt mostly washed off with a 2% solution of triammonium citrate, pH 8.0, and the streaks and stains went with them. After cleaning, the replacement carvings were toned to blend with Golden Fluid Acrylics and tinted shellac.

Whereas the outer frame was disfigured by dirt and missing carvings, the inner frame was disfigured by dirt and severely flaking paint on two of the four sides. Before addressing either, several cross sections were taken to determine if the frame had been repainted and if that might be a factor with the flaking paint. The cross sections revealed that the entire inner frame had been prepared with the same ground layers and then the green or gold applied over them, with no additional paint layers or coatings after that.

A cursory examination of the back of the frame provided the explanation for why the paint was flaking so badly on two sides only. The wood on the left (facing) and top was vertical grain, whereas the wood on the right and bottom was face grain. Paint holds better on vertical grain than on face grain, hence the failure on the right and bottom.

The flaking paint and gilding were set down with Lascaux Medium for Consolidation, after which the surfaces were dry-cleaned with erasers and wet-cleaned with a 2% solution of triammonium citrate, pH 7.5 (fig. 9). Some streaking and blanching resulted, but that was corrected with the application of a 5% solution of Paraloid B-72 in ShellSol A100. Paint losses were compensated with Golden Fluid Acrylics.

Finally, the two frames were reassembled and the back built out to accept the thickness of the flag in its acrylic casing.

5. CONCLUSION

Solon Perkins died in Clinton, Louisiana, a town that appears about halfway through the list on the right side of the frame. The Greater Lowell Veterans Council, 152 years after Perkins

Fig. 9. Inner frame inscription during cleaning

died, took it as their duty to restore the flag and frame to its rightful condition (fig. 10) and return it to the Lowell Memorial Auditorium Hall of Flags. It hangs between plaques listing the soldiers from Lowell who died in the American Civil War and tells an enduring, entirely current story of love and respect.

Fig. 10. Lowell Memorial Auditorium Hall of Flags, 2015

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SOURCES OF MATERIALS

Aluminum solid-support panel and UV-filtering acrylic
SmallCorp.
19 Butternut St.
Greenfield, MA 01301
413-772-0889
www.smallcorp.com

BEVA gel and BEVA film
Conservator's Products Company
PO Box 601
Flanders, NJ 07836
973-927-4855
www.conservators-products.com

Crepeline, Paraloid B-72, and Lascaux consolidation medium
Talas
330 Morgan Ave.
Brooklyn, NY 11211
212-219-0770
www.talasonline.com

Golden Fluid Acrylics and Jacquard antique gold Pearl Ex pigment are available from art supply stores.

Gütermann Skala polyester threads
Testfabrics Inc.
415 Delaware Ave.
West Pittston, PA 18643
570-603-0432
www.testfabrics.com

Larson-Juhl Artique mat board is available through Larson-Juhl and your local framer.

Polyfelt (1/4 and 1/8 in. thick)
University Products Inc.
517 Main St.
Holyoke, MA 01040
800-628-1912
www.universityproducts.com

ShellSol A100 is available from
Conservation Support Systems
PO Box 91746
Santa Barbara, CA 93190
800-482-6299
www.conservationsupportsystems.com

Superba cotton poplin
Philips-Boyne Corp.
135 Rome St.
Farmingdale, NY 11735
631-775-1230
www.philipsboyne.com

Triammonium citrate and diammonium citrate
Sigma-Aldrich
PO Box 14508
St. Louis, MO 63178
800-325-3010
www.sigmaaldrich.com

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ENDNOTES

1. A video of the flag being removed from the storage room can be viewed in "From Ragged Glory, a Piece of Lowell Civil War History Unfurled," published by Grant Welker in the Lowell *Sun* on January 24, 2014. A video of the rededicated flag being unveiled with the help of the conservators may also be viewed in "Civil War—Era Flag Takes Its Rightful Place in Lowell Memorial Auditorium," published in the Lowell *Sun* on June 1, 2015
2. Although the exact formula used for the Perkins star dummies was not recorded, several versions of this mixture have proven successful in other conservation applications.
3. The knowledgeable staff at SmallCorp advised on how close a hole can be safely drilled to the edge of the acrylic. They likewise determined how many holes were necessary to accomplish the pressure mount.

CHRISTINA HAGELSKAMP

Aspects of the Manufacture of Chinese *Kuancai* Lacquer Screens

ABSTRACT—In this article, three case studies of *kuancai* lacquer screens from the Kangxi period (1662–1722) are presented: two intact 12-panel folding screens and a large set of panels that have been integrated into a 17th-century Dutch interior. Examination and analysis yielded new information about construction and material composition, including variations in joinery of the individual panels, the choice of materials used for their ground and lacquer layers, as well as techniques for transferring designs.

1. INTRODUCTION

> *I've loved Chinese screens since I was eighteen years old . . . I nearly fainted with joy when, entering a Chinese shop, I saw a Coromandel for the first time.* Coco Chanel

The *kuancai* (款彩) lacquer technique, in the western world customarily referred to as Coromandel or Bantam lacquer (Piert-Borgers 2000b) emerged at the end of the Ming dynasty (1368–1644) and is unique to China. Its earliest mention in Chinese literature is found in the *Xiushi lu*, "On Lacquering," a treatise written at the end of the 16th century to promote the lacquer arts (Frick 2015). *Kuancai* is most famously used on large-scale folding screens, which were at the peak of their popularity during the Kangxi period (1662–1722). At present, the earliest screen with a confirmed date was produced in 1659, at the end of the Shunzhi reign (Garner 1979).

Kuancai can be translated as "cut color," referring to the decoration process in which designs are carved into a black lacquered surface, much like a wood cut. The technique is also called *ke hui* (刻灰), "carved ash," or *diao tian* (雕填), "bold carving and filling," in China (Zhang 2010). The resulting recesses are subsequently coated with paints in a great variety of colors, as well as gold leaf. The large surfaces of folding screens provided an ideal canvas for displaying the multitude of bold and colorful motifs created in this technique. Screens were decorated with scenes and symbols that represent longevity, wealth, fertility, and happiness, strongly inspired by increasingly accessible block prints. Folding screens served as a popular gift for significant birthdays, retirements, or promotions of high-ranking military or government officials, which is occasionally documented by commemorating inscriptions on one of the sides.

With the rise of international sea trade and the passionate interest in all lacquer goods and exotic imagery in the western world, the lavishly decorated screens became an instantly popular export article. In addition, the large screens became an ideal source for repurposing, especially in the late 17th and early 18th centuries, when architectural paneling and furniture were embellished and "exotified" with decorative fragments from individual panels (Campen 2009; Piert-Borgers 2000a).

This article presents a comparative study of the materials and techniques used for manufacture of *kuancai* lacquer screens from the Kangxi period, focusing on three objects: a Dutch period room, the so-called Leeuwarden Lacquer Room (BK-16709), lined with segments from several screens, and an intact 12-panel folding screen (BK-1959-99), both from the collection of the Rijksmuseum Amsterdam (RMA), as well as a 12-panel folding screen from the collection of the Metropolitan Museum of Art (MMA; 09.6a-l) (fig. 1).

2. OBJECTS

Kangxi screens commonly consist of an even number of panels, usually 12, and can reach heights of up to 10 ft. Individual panels are approximately 20 in. wide, for a total length of around 20 ft. per screen. In general, the decoration on both sides of a screen consists of a central scene continuing over 10 panels and a wide border with individual vignettes, both framed by narrow decorative bands. Popular designs used in the large central field were palace scenes, flora and fauna, depictions of immortals and scholars, and scenic landscapes. The wide borders were generally decorated with a great variety of small scenes, mythical creatures, and symbolic objects, whereas the narrow bands most often show repetitive designs such as alternating dragons or flower blossoms, geometric patterns, and encircled Chinese *shou* (longevity) characters or cranes. Especially rich screens show similar large central scenes on both sides, although the majority have one less lavishly decorated side, commonly seen as the reverse, sometimes with inscriptions or small depictions of fauna and flora framed in cartouches. Few examples show no decoration at

Fig. 1. Top: Period room, H. 202¼ in., L. 120½ in., W. 116⅜ in., Leeuwarden, Netherlands, before 1695, Rijksmuseum Amsterdam (BK-16709). Left: Folding screen, H. 126⅜ in. × L. 245¾ in., China, 17th century, Rijksmuseum Amsterdam (BK-1959-99). Right: Folding screen, H 116 in. × L 242⅞ in., Guangzhou, China, 1689, Metropolitan Museum of Art (09.6a-l).

all on the rear surfaces or only surrounding borders while leaving the central field empty.

The MMA screen (09.6a-l) includes a palace scene on one side and elaborate inscriptions on the other, identifying it not only as an object made for the Chinese domestic market but also as a birthday present for a government official from Guangxi Province. The text includes, on the right, a poem to honor the screen's recipient and his achievements, and on the left a list of contributors to this sumptuous gift. Also included are the year of the occasion (1689), as well as the name and seal of the poet.

A unique inscription is found on the border of the outer left front panel, on the side with the palace scene, naming the lacquer artist and his workshop in Foshan, a district near modern Guangzhou, making this the only known screen that can be attributed firmly to a specific studio and place.

The front's palace scene is based on the subject of "Guo Ziyi's banquet." Guo Ziyi (697–781) became a famous general during the Tang dynasty and was later immortalized in Chinese mythology as the god of wealth and happiness. The screen's broad border depicts cartouches with the "Hundred Antiquities," including landscapes and still lives. The narrow band around the center field consists of opposing dragons, while the outer band is executed with a stylized lotus pattern.

Around the inscription on the back of the screen, cartouches containing depictions of people, birds, and flowers are placed in the broad border along the sides and top, whereas mythical creatures are represented along the bottom. Here, the center field is framed with a narrow band of variations on the *shou* character against a hexagon-pattern background, with the outermost border again consisting of a series of stylized lotuses.

The screen remained in China until the 1880s, when it was acquired by German military attaché Baron Speck von Sternburg, who subsequently brought it to the German Embassy in Washington, DC, where he was appointed ambassador in 1903 (American Art Association 1909).

The RMA screen is exceptional in terms of its rich decoration on both sides, as well as its height of 10½ ft. Under the central field, the individual panels are embellished with a pierced feature in form of a stylized *lingzhi* fungus, as well as a pierced and gilded apron placed between each pair of legs. On the front, the large central field depicts a hunting scene with Dutch merchants, and the reverse contains a depiction of the so-called "Hundred Birds" against a gilded background.

The subject of the hunting scene has been used on other screens, with great consistency in the overall composition, and even the expressions of individual figures.[1] The scene is framed by a band of opposing dragons with the broad border showing gilded fan-shape cartouches containing flowers and birds along the top of every panel. Floral vignettes are depicted along the sides and the Hundred Antiquities along the bottom. The narrow outer band shows alternating medallions with cranes and the *shou* character against a hexagon-pattern background.

The Hundred Birds on the reverse are framed with flowers and opposing cranes against a similar background. The broad border shows rectangular cartouches with landscapes on a gilded background along the top, whereas depictions of the Hundred Antiquities are found on the sides and bottom. The narrow outer band is executed with a stylized lotus pattern. One element of the bottom band of decorations that stands out is a stylized split peach stone, representing longevity. An inscription along its rim refers to *Xiwangmu*, Queen Mother of the West, a deity who in Chinese mythology is the keeper of the peaches of immortality.[2] Both this inscription and the fact that the screen was located in China until its purchase by a French art collector in 1906 suggest that it was made for the domestic market, probably in the last quarter of the 17th century.

The Leeuwarden Lacquer Room was created in the northern Dutch province of Friesland at the end of the 17th century (Dorscheid et al. 2015; Haan 2009). Its walls were lined with panels originating from three screens, created by separating the front and back of each panel. In its current configuration, the room consists of three paneled walls, with the two long sides depicting nearly identical palace scenes. This passage is based on the subject of "Spring Morning in Han Palace." It is framed with a meander band, with depictions of the Hundred Antiquities decorating the top, whereas mythical creatures are depicted along the bottom and two dragons decorate the sides. The narrow outer band shows alternating medallions of cranes and the *shou* character against a hexagon background pattern. The shorter wall includes panels from the back of the original screens, with individual panoramas of the "Views on West Lake." Like the palace scene, it is framed with a meander band, and depictions of the Hundred Antiquities and floral still lives in the broad border. The outermost border again consists of a series of stylized lotuses.

Comparison of distinctive features, such as knots in the exposed wood and details in the design, yielded sufficient evidence to reconstruct the original configuration of all three screens, confirming that each was decorated with an identical palace scene on the front and individual panoramas on the back (Hagelskamp 2015). The closely matching palace scenes suggest that the screens were made in a series, presumably for the export market.

3. DECORATION TECHNIQUE

Kuancai lacquer screens are made of a wooden substrate onto which several preparatory ground layers and finishing lacquer layers are applied. The ground layers, mostly with a coarse structure at first and a finer consistency toward the top, and with admixtures of unwoven fibers in the lower layers, compensate irregularities in the wood. By sanding each layer, a smooth substrate is created for the application of several layers of lacquer. Generally, the lacquer's working properties were modified by adding drying oils. Not only did this increase the final gloss while avoiding time-consuming polishing, it probably also slowed down the curing process to facilitate the later incising of the lacquer surface.

Kuancai lacquer workshops used the popular designs of broadly disseminated block prints as their creative source, something that is not seen on such scale on other styles of Chinese lacquer work. It seems likely that the popular designs were transferred by gluing sketches or prints on paper onto the prepared lacquer surfaces, similar to current practice (Changbei 2014; Zhang 2010). To create the design, outlines are incised through the lacquer into the upper ground layers and excess material is removed. The resulting recesses are thinly painted or gilded. If paper was indeed applied, it would be removed to reveal the pristine black lacquer surface.

The original appearance of a *kuancai* lacquer screen would have been characterized by a high-gloss black lacquer background with a recessed decoration, illuminated with bright but predominately matte paints and accents in gold leaf. The painted and gilded recessed areas created a three-dimensional appearance that was emphasized by the juxtaposition of reflective and matte surfaces, and accentuated by applying washes and glazes within the painted decoration. However, those nuances rarely survived. The degradation of the lacquered and painted surfaces results in a diminished gloss and color and the development of craquelure. In addition to dirt accretions, wear, and losses in both the lacquer and painted surfaces, many examples of *kuancai* lacquer screens have suffered from manifold restoration campaigns, which were executed without knowledge of the original techniques used and often altered a screen's appearance by the wholesale application of varnishes and paints that resulted in uniformly glossy surface and a limited color pallet.

3.1. CONSTRUCTION

Screen panels are assembled from several vertical planks of wood, with the outer ones extending to create the feet, and with rails placed across the top and between the feet. Bamboo dowels are inserted to join all of these members (fig. 2). On closer examination of all three objects, differences in their construction became evident. In the case of the MMA screen, the mitered top rail is joined to two of the vertical planks with vertically oriented tenons. On both sides of the shaped bottom rails, horizontal tenons are inserted into the outer planks, in addition to a tongue-and-groove joint running along both sides and the top edge.

No tenons were found in the RMA screen, as both the bottom rail and the mitered top rail are joined to the vertical planks using only bamboo dowels. The additional pierced and gilded aprons placed below the bottom rails are inserted into a tongue and groove running along the sides and top edge, identical to the red painted rail on the MMA screen. However, and very different from the MMA screen, as reinforcement, two cross-rails were inserted into thin channels cut into the upper and lower half of each panel (fig. 3). Since the lacquer panels of the RMA's Leeuwarden Room were reduced in height, thinned down to about 7-mm-thick sheets and then cradled from the back, it was not possible to determine their complete array of

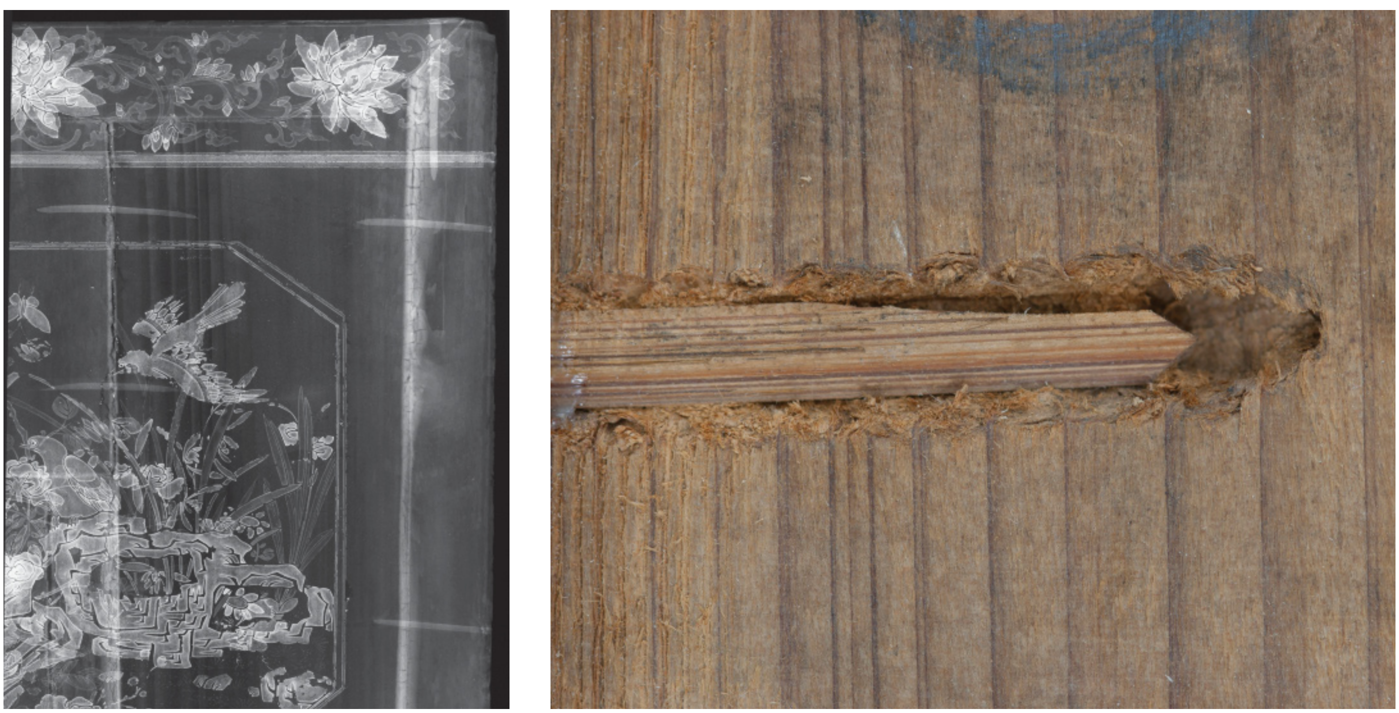
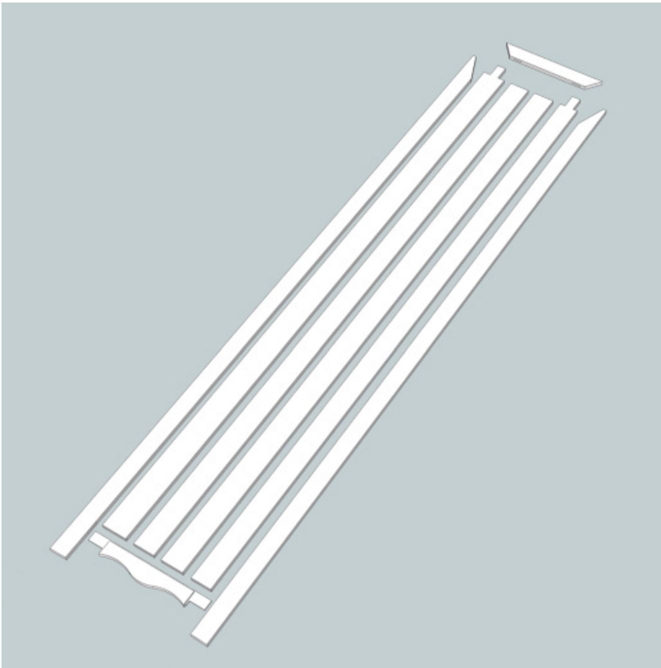


Fig. 2. Left: Screen (09.6a-l), detail of a digitally enhanced x-ray radiograph showing dowels are used to join the top rail and vertical planks. Right: Leeuwarden Room (BK-16709), detail with the remaining half of a bisected dowel on the back of one of the split panels.



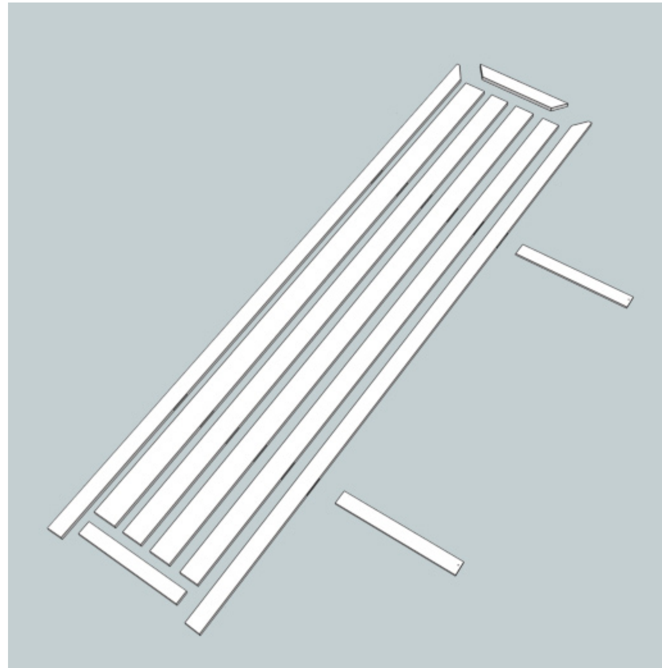


Fig. 3. Construction sketches illustrating the two styles of joinery found on the three objects. All three also incorporate dowels to join the individual members. Left: The system of mortise-and-tenon joints on screen (09.6a-l). Right: A pair of inserted cross-rails found on both Rijksmuseum objects.

original joinery. The exposed rear surfaces, though, aside from traces of dowels used to join the vertical planks, did show inserted cross-rails on all panels as described on the RMA screen (fig. 4). Other examples of this type of structural feature subsequently found on several screens suggest that this technique was used more commonly than initially expected.

A related method of stabilizing panels was found on several other screens, among which is an example from the Philadelphia

Fig. 4. Left: Screen (BK-1959-99), detail of a digitally enhanced x-ray radiograph showing a cut internal channel and an inserted rail, both running the entire width of the panel. Right: End grain of inserted rail (BK-1959-99).

Fig. 5. Screen (09.6a-l), details of original pin-and-loop hinging mechanism.

Museum of Art (Screen 1921-19-1). Here, sliding dovetails have been introduced across the entire width of each panel. This approach, however, resulted in cracks along the exterior seams, and therefore the "blindly" inserted cross-members might represent an innovation whereby the structure is reinforced without compromising the lacquered surfaces.

The individual screen panels were originally assembled with a pin-and-loop system. On many screens, including the RMA objects, the hardware has not been preserved and often is replaced with modern, western-style hinges. The MMA screen, however, still bears all of its original brass hinges. Except on the outer ends, each panel has two pins on one side edge and two pairs of loops on the other, into which the pins of the adjacent panel are inserted (fig. 5). To facilitate assembly, the upper pins are longer than the lower ones, which allowed inserting the top pin first, followed by the bottom one.

3.2. MATERIAL COMPOSITION

For the identification of materials used on the *kuancai* objects, optical microscopy (OM), polarized light microscopy (PLM), Fourier transform infrared spectroscopy (FTIR), X-ray fluorescence (XRF) and pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) were applied. A selection of analytical results from all three objects are listed in table 1.

The results of microscopic wood identification of the MMA and RMA objects coincide with microscopic and macroscopic observations on several screens, suggesting that coniferous species of relatively low density have been consistently used for *kuancai* screens. Surely, economic factors played an important role, but using lightweight wood also facilitated the moving and assembling of the large panels.

Comparison of the ground preparation of all three objects revealed differences regarding their layering: only on the panels

Table 1. Analytical Data of the Three *Kuancai* Lacquer Objects

	Screen MMA 09.6	**Leeuwarden Room RMA, BK-16709, Panel B.03 and C.09**	**Screen RMA BK-1959-99**
Wood	*Pinaceae* Fir (*Abies* sp.)	*Cupressaceae*	Coniferous
Fiber	Ramie (*Boehmeria nivea*)	Hemp *(Cannabis satavia)*	Not analyzed
Ground Layer	Siliceous materials (kaolin, gypsum) Proteinaceous binder	Siliceous materials Proteinaceous binder Starch	Siliceous materials Proteinaceous binder Blood[3]
Lacquer Layer	*Laccol* (from *Toxicodendron succedaneum*) in all three layers Drying oil, possibly heated	*Urushiol* (from *Toxicodendron vernicifluum*) Tung oil	*Urushiol* (from *Toxicodendron vernicifluum*) Possibly oil

Note: Most of the analytical examination shown in the table was carried out prior to the conservation treatment of the respective objects by Adriana Rizzo, associate scientist at the MMA, and Henk van Keulen, conservation scientist at the Dutch Cultural Heritage Agency (RCE).

from the Leeuwarden room, the top and bottom rails have been covered with textile to reinforce joints and minimize cracking of the lacquer surface at their seams. The stratigraphy of the applied ground layers shows that all three objects include unwoven fibers, identified as Ramie on the MMA screen and Hemp on the panels of the Leeuwarden room. On the latter, they have been applied on top of the coarse ground, whereas the fibers on the two intact screens have been applied directly onto the wood substrate. The room panels differ also in their subsequent layer sequence: on top of the coarse and fibrous layer, three coatings of a finer ground, separated by two thin paper layers, have been applied. The preparation on the two intact screens is less complex and consists of a coarse and a fine ground on top of the fiber layer (fig. 6).

The lacquer surfaces of the three objects display distinct characteristics. The RMA room and screen both show a thin (20–30 μm), discolored lacquer layer with the lighter ground partly shining through, creating a patchy, brownish appearance. The lacquer buildup on the MMA screen is significantly thicker (~170 μm) and has retained an even black appearance. A prepared cross section shows visible separation lines, suggesting that the thick coating has been applied at least in three stages (see fig. 6).

Py-GC/MS analysis identified the inclusion of a drying oil in all three lacquer samples. Urushiol, the main polymeric constituent of exudate from *Toxicodendron vernicifluum* trees native to China, Japan, and Korea, was detected on both objects from the RMA. Laccol, from *Toxicodendron succedaneum* trees native to Vietnam and in the late 19th century also introduced in Taiwan, was identified in all three layers on the MMA screen. Apart from the inter-Asian trade of raw lacquer materials, laccol lacquer could well have been obtained directly from South China, as the trees had likely spread from neighboring Vietnam (Wan et al. 2007). Possibly related to this suggestion is the result of recent comparative analysis revealing that laccol lacquer has been used not only on Chinese export lacquer ware with gold decoration but also on *kuancai* screens (Miklin-Kniefacz et al. 2015; Petisca et al. 2011; Piert-Borgers 2000b; Schilling et. al. 2014). The known origin of the MMA screen (Guangzhou) reconfirms the use of laccol lacquer in South China while also demonstrating its application in products made for the Chinese domestic market.

3.3. Decorative Techniques

When studying the decoration, it becomes obvious that the craftsmen responsible for the carved design used a range of differently shaped knifes, chisels, and gravers. Additionally, it is apparent that the designs were laid out and incised both free-hand and with the aid of drawing utensils, such as rulers and compasses. On the MMA screen, the majority of the straight lines were inscribed with the use of rulers, revealed by stepped or overshot scribe lines. Most of the designs, however, including geometric patterns such as circles and hexagons, are cut out free-hand, as is evident from the irregular nature of the outlines.

The RMA screen and especially its Leeuwarden panels show a more frequent use of drawing utensils. Traces of incisions made using rulers and curved templates are still visible as scribe lines that overshot the intended layout (fig. 7). Mistakes were also found in the design of the crane medallions of the narrow outer bands: incisions using a compass, recognizable by the center puncture hole, were accidently repeated on the rear, where later the lotus banding was carved out (Hagelskamp, 2015).

The unique opportunity of comparing corresponding panels from the three closely related screens incorporated in the Leeuwarden room revealed interesting details regarding the possible use of paper transfers. The primary layout of the palace

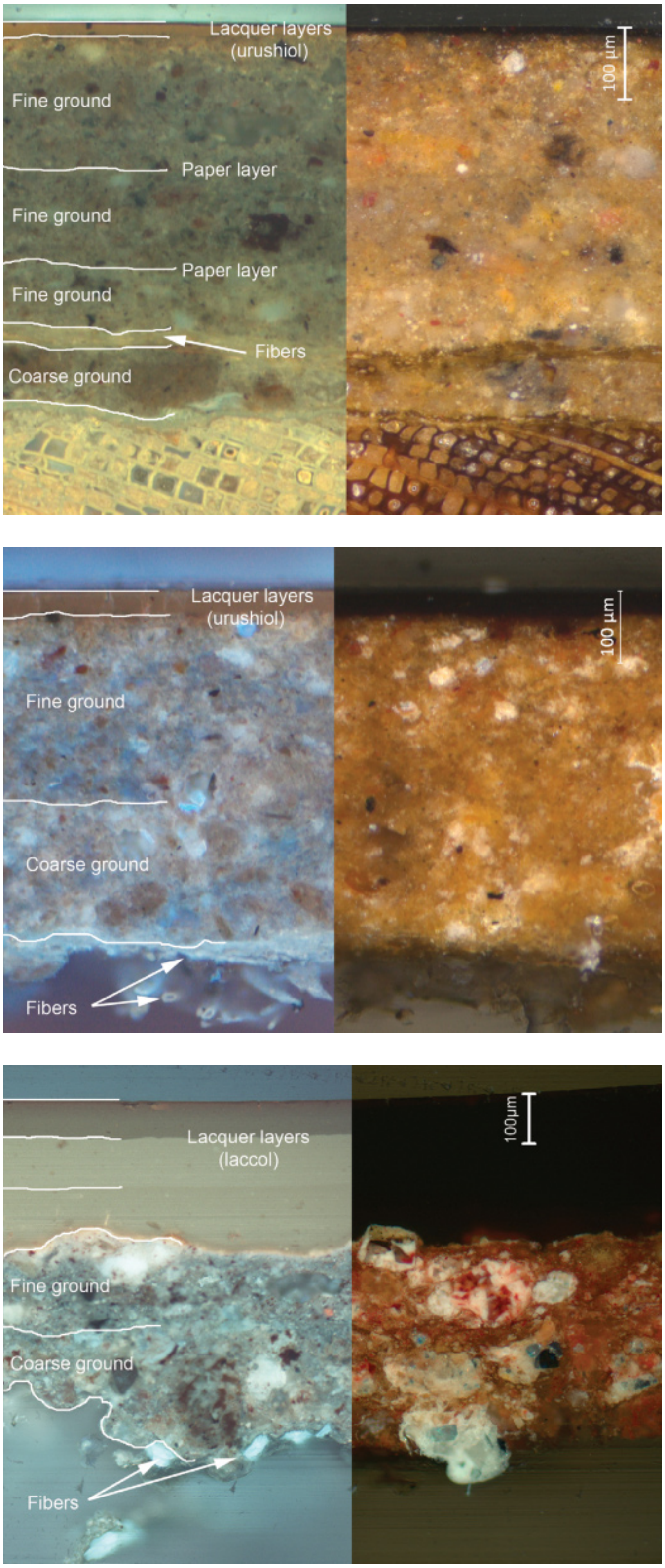


Fig. 6. Composite micrographs of cross sections of prepared samples from BK-16709 (top), BK-1959-99 (center), 09.6a-l (bottom), under visible and ultra-violet light.

scenes is all but identical, suggesting the preparation of a template that was used on all three screens. Variations in how these compositions were filled out, however, indicates that this phase was executed more freely, without the need to make all details identical. Minor differences were also found in the relative positioning of individual design elements, suggesting that these were created in contained and manageable units (fig. 8). More secondary parts, such as rock formations and trees surrounding the architecture, vary considerably and indicate that these were sketched and carved out individually.

4. CONCLUSION

The examination of three *kuancai* lacquer objects from the Kangxi period aimed to reveal both common practices and variations regarding construction, material choices, and composition, as well as decorative techniques. While two folding screens were destined for the domestic market, a set of three screens were produced for export and ultimately incorporated into the wall paneling for a 17th-century Dutch interior. The study illustrates the application of diverse construction methods, varieties in the material choice, and stratigraphy of both ground and lacquer layers. Observations regarding the transfer and execution of the design illustrate the implementation of both freehand cutting and guidance with drawing utensils, as well as suggestions about the use of templates for reproduction. Hopefully,

Fig. 7. Leeuwarden Room (BK-16709), detail of panel C.05 showing the design laid out with rulers and curved templates and illustrating overshot scribe lines.

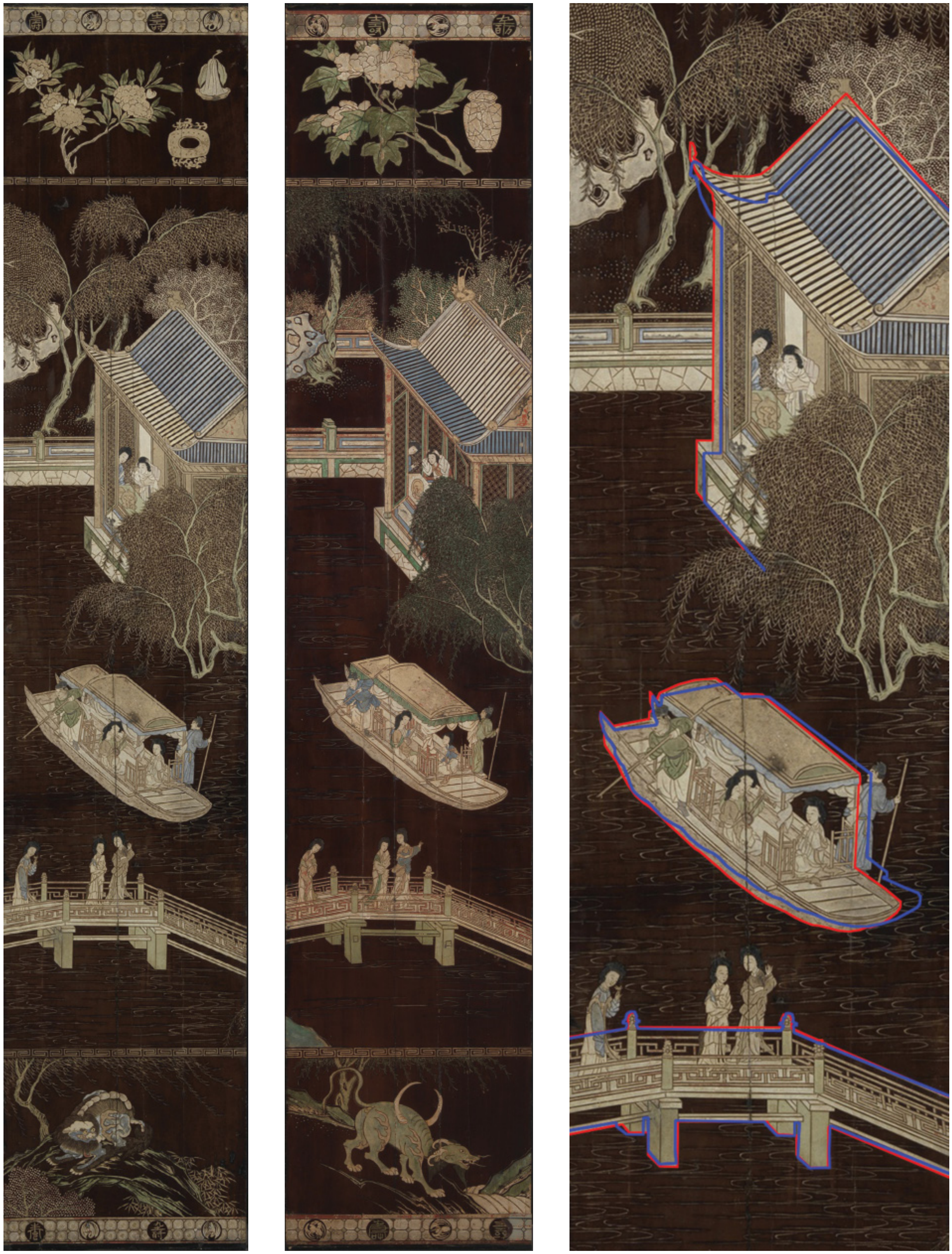


Fig. 8. Leeuwarden Room (BK-16709), corresponding panels A.03 and C.03 (left and center), with a detail (right) including overlaid outlines used to illustrate the relative positioning of individual design elements.

these preliminary results will promote study of the, until recently, rather neglected *kuancai* lacquer technique and further identify and link the specific varieties.

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AUTHOR BIOGRAPHY

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ENDNOTES

1. Screen, China, Kangxi period, ca. 1700, H. 961/16 in., L. 219 in., Museum of Fine Arts Boston (1975-333); Screen, China, Qing dynasty, 18th century, H. 97¼ in., L. 228 in. (http://www.sothebys.com/en/auctions/ecatalogue/2010/asian-art-pf1027/lot.126.html); Screen, China, 17th century, H. 46 in., L. 139 in., Private Collection (Brugier 2015, 136–137).

2. A similar design of a peach stone including an inscribed reference to Xiwangmu (Chao Hunghsi, Zhao Bo, and Xu Huan, pers. comm.) is found on a *kuancai* lacquer screen from a private collection that was on display at the Museum für Lackkunst, Münster, Germany, as part of the exhibition *Gerard Dagly 1660 bis 1715 und die Berliner Hofwerkstatt* (http://www.museum-fuer-lackkunst.de/en/dagly). Other examples include a plaque (http://www.ykhkauction.com/uploads/2015/07/03/npkwi73LATH9b2nV.jpg) and two related stoneware brush washers. For the latter, see Percival David Foundation of Chinese Art (1999, 42, 73) and http://www.christies.com/lotfinder/lot/a-yixing-peach-stone-shaped-brush-washer-dated-5978894-details.aspx?from=salesummary&intObjectID=5978894&sid=1c907191-2a03-4117-8942-bfa68b3b7d25.
3. Silvia Miklin-Kniefacz, who participated in the conservation treatment of Rijksmuseum screen 1995-99, guided an earlier comparative study on Chinese lacquer objects regarding blood additives and possibilities of analysis (Miklin-Kniefacz et al. 2014). A sample of the ground layer from screen BK-1995-99 was analyzed using nanoscale liquid chromatography coupled with tandem mass spectrometry. Nano LC-MS/MS was performed by Dr. Štěpánka Kučková, associate professor at the Institute of Chemical Technology, Prague, Czech Republic (unpublished conservation report, Furniture conservation, Rijksmuseum Amsterdam).

MONICA KATZ

Colonial Spanish American Lacquered Objects in the Collection at the Hispanic Society of America

ABSTRACT—*Barniz de Pasto* and Mexican lacquer were two techniques used to decorate colonial Spanish American objects. Using indigenous materials for a European aesthetic, the colonial objects range in shape from gourds to European forms such as caskets and small boxes. They are often misidentified as painted, japanned, or Asian lacquers. Samples from the Hispanic Society of America's objects were analyzed to identify the lacquer and its properties and confirm the contemporary records that describe the manufacture of these objects. This article focuses on the Society's collection and collates current information, describing the process whereby these objects were decorated.

1. INTRODUCTION

The Hispanic Society of America (HSA) was founded in 1904 by Archer Milton Huntington, and from its inception it reflected his grand passion—as the HSA mission statement put it, to be a "library, museum and educational institution, containing objects of artistic, historic, and literary interest" for the purposes of the "advancement of the study of the Spanish and Portuguese languages, literature, and history, and advancement of the study of the countries wherein Spanish and Portuguese are or have been spoken languages." Huntington was a collector of his time; however, his interests extended far beyond the more typical Old Masters so that alongside paintings by El Greco, Velázquez, and Goya, the museum has an enviable collection of decorative arts, textiles, ceramics, sculpture, rare books, and manuscripts.

The HSA has a small but very fine collection of colonial Spanish American lacquered objects, decorated using two particular techniques: *barniz de Pasto* and Mexican lacquer. Both techniques evolved in response to the need to make wooden objects waterproof long before either type of lacquer became a prized decorative process. The exquisite colonial objects, made using indigenous techniques for a European aesthetic that mimicked Asian lacquer, demonstrate the extraordinary craftsmanship of these largely anonymous artisans whose techniques are still in use today in Colombia and Mexico.

The HSA's objects from both traditions date from the second quarter of the 17th century to 1800, and most have been acquired in the past 30 years. The increased scholarly interest in Mexican lacquer can be attributed, in part, to the Museo Franz Mayer (Mexico City), whose own comprehensive collection and museum-sponsored publications on the topic have introduced Mexican lacquer to a wider audience. Nonetheless, there is clearly room for more study on this topic, as several of the HSA's *barniz de Pasto* boxes were sold as Mexican lacquer, although the decoration is clearly South American.

In part to address the issue of material identification but mostly to understand how these lacquers worked and how to best care for them, the HSA began a study based on non-invasive methods and a limited campaign to analyze samples removed from the objects. A second but equally important focus of the research has been to identify pigments to confirm contemporary accounts. Working with Richard Newman at the Museum of Fine Arts (MFA) Boston, we have finally been able to begin systematic and comprehensive analysis: hitherto the technical materials analysis was piecemeal and far from complete. The purpose of this article is to introduce the objects and materials to fellow conservators.

2. BRIEF HISTORY OF LACQUER IN MEXICO DURING THE PRE-COLONIAL PERIOD

In Mexico, gourds were waterproofed using a paste made from the fat of *llaveia axin* or *coccus axin*, a small scale insect whose cultivation on a variety of local trees and shrubs had been widespread since pre-Hispanic times. The insects would feed off acacias, piñón pines, and hog plums, and in the spring the female insects would be harvested and boiled. Their fat, which would float to the surface, was the crucial ingredient used in the lacquer process. The fat was mixed with other ingredients to make a paste, notably one of two types of drying oil: either chia oil, made from the crushed and roasted seeds of a local sage plant, or the seeds of *chicalote,* a Mexican poppy. The resulting paste was thickened with "fillers," including *pozzalana* (volcanic ash) (Acuña 2012) or mineral clays described as "dolomite" and colored using a variety of locally available pigments (Codding 2015).

Several manuscripts from the early 16th century mention what are likely to be lacquered objects. The *Matrícula de Tributos*, from the second quarter of the 16th century for example, recounts how the towns subjugated by an alliance between the city-states of Tenochtitlán, Texcoco, and Tacuba had to provide 6,400 *jícaras* (gourds) as tributes within 80 days. Fray Jerónimo de Alcalá's *Relación de Michoacán* (ca. 1541), which was recounted to him by the town elders, shows a pictograph of a priest with a lacquered *calabaza* or large gourd, underlining the ritual importance and value of these decorated objects. In 1983, the discovery a Mixtec burial site of a young girl of some status in La Garrafa (Siltepec, Chiapas) with three lacquered objects (two *jícaras* and an *atecomate* or tumbler) confirms that the tradition predated the Spanish arrival. The burial site has been provisionally dated to the late post classical period (1200–1500). Decoration on these lacquered objects was characterized by a limited palette and stylized human and animal figures, as well as geometric designs (Acuña 2012).

More widely known is Fray Bernardino de Sahagún's *Historia general de las cosas de la Nueva España* (ca. 1547). He described the gourd seller at great length as a person "who removes the [gourd's] bumps, who burnishes, varnishes, paints them. He sells gourds with raised [designs], with stripes, with lines, scraped, rubbed with *axin*." Sahagún then goes on to list where the gourds were from: "He sells Guatemalan gourd vessels . . . He sells gourd bowls from Mexico, from Acolhuacan . . . from the Totonaca . . . Michoacán regions" (Sahagún 1961). Indeed, the cultivation of the *coccus axin* extended as far as Guatemala (Williams and MacVean 1995), where the insect was called *niij* and where the fat was rubbed directly onto the wooden substrate as waterproofing before being decorated. In Mexico, the insect is commonly known as *aje*.

Pigments were believed to be locally sourced: mangrove bark for blue; red from brazil wood; mineral clays or cochineal, saffron root, and mineral clays for yellow; and charred corn cob husks or guava tree branches for black (Pérez 1990).

As much as the lacquered objects were clearly valued by the indigenous populations, they became equally prized by the Spanish colonists.

3. MEXICAN LACQUER AT THE HSA PRODUCED DURING THE VIRREINATO

By the 17th century in Mexico, production and design of lacquered objects had shifted in response to Spanish demand and taste. The new aesthetic gave rise to figurative designs combined with pre-Hispanic geometric patterns, and a whole range of new forms were introduced (Pérez et al. 1997): from Spain came the *batea* (tray) and the *vargueño* (portable desk) and various chests, coffers, and other furniture influenced by both European and Asian designs. The very terms used today in Mexico to describe the finish, *el maque* and *laca*, are derived from the Japanese term for lacquer sprinkled with gold and silver, *maki-e*, and from the Arabic, *lakk*.

The HSA collection includes objects from three important areas of production: the towns of Peribán and Pátzcuaro (both in the state of Michoacán) and the town of Olinalá (in the neighboring state of Guerrero). Although they each used a combination of the same basic ingredients, each area of production had different techniques, and although no documentary evidence has been found to support the existence of multiple workshops, the variety of decoration within these techniques points in this direction. For example, an orange lacquer *batea* from Pátzcuaro in the HSA's collection (LS2135) comes from what is known as the *los galgos* workshop: nothing is known about the location or even the dates of the workshop, but *galgos* (greyhounds) are always incorporated into the design. Another example can be found at the Franz Mayer, this time with a cream-colored background. Even the descriptors, *maque* in the state of Michoacán and *laca* in the state of Guerrero (Acuña 2012), point to differences in design: gold leaf and gold paint were used far more frequently in lacquers from Michoacán than those from Olinalá, especially in the earlier periods.

Considered to be the earliest of the colonial techniques and closest to the pre-Hispanic tradition, Peribán lacquer objects date from the first half of the 17th century. The technique uses a limited palette of red, yellow, orange, blue, green, black, and white on a typically black ground, as seen in the examples held by HSA. The paste made of *aje*/chia oil/filler/black pigment is applied to a wooden substrate that may have a preparatory layer of gesso or gypsum. The design is created by removing the black paste ground and inlaying different colored lacquers in the space revealed. It is possible to see score marks under magnification and in areas of loss.

Of the HSA's Peribán objects, two are particularly notable. This *batea* (LS1808; fig. 1) shares a similar limited palette to the pre-Hispanic objects, but the similarity ends there. Likely inspired by print sources but also by the available Asian lacquer

Fig. 1. Batea, Peribán, Mexico, 1600–1650. Wood with Mexican lacquer. 7.9 × 56.5 cm diameter. Hispanic Society of America, New York. LS1808.

Fig. 2. Batea (reverse), Peribán, Mexico, 1600–1650. Wood with Mexican lacquer. 7.9 × 56.5 cm diameter. Hispanic Society of America, New York. LS1808.

objects, the *batea* has a central cartouche with a depiction of a seated European goddess, possibly Diana or Cybele, with two lions against the background of a building with columns. The surrounding areas are crowded with a variety of European figures and animals and plants, both real and fantastic. There are horses and unicorns, horses drawing hay carts, pigs and armadillos, sheep and lions, ducks swimming around the cartouche, birds and butterflies, Spanish nobles on horseback, men in what could be Chinese robes, winged reptiles, and two ornate and tiered fountains that have "shadow monkeys" on their upper tiers spewing water. Typical of these *batea*s, the back (fig. 2) is also decorated, although more simply. The four roundels around the rim are filled with European-style figures, but the central lace-like circular design is reminiscent of pre-colonial work.

As extraordinary as the wealth and concentration of decoration is, more extraordinary still is the fact that, from the cross-hatching that gives the figures depth to the intricate lace-like pattern in the decorative border, each detail is made by excising the ground lacquer layer and inlaying colored lacquer that is burnished as it cures (Codding 2015).

Although the decoration on the *batea* is quite sophisticated, the much cruder representations on the *vargueño* (LS2071; fig. 3) share many of the same elements: black lacquer ground, a limited palette, and cartouches with figures (two on the exterior of the lid, two at either end of the *vargueño*, and one on the central interior drawer). The form itself and the hardware are Spanish. The interior of the lid has a polychrome circular, lace-like design that is reminiscent of the design on the back of the *batea*. The execution of the design as a whole, however, shares far more with the linear and two-dimensional designs of the pre-Hispanic gourds found at the burial site of La Garrafa in the state of Chiapas. Although the exterior and the drawer fronts share the *horror vacui* of the *batea*, the shading is less subtle and refined, and the palette—black, blue, orange, white, ochre—is even more limited.

The objects that come from Pátzcuaro are from a later time and were manufactured using a quite different technique. Although the ground is still made from lacquer, it now varies widely in color from black to orange, from pale blue to cream. However, the decoration here, rather than being inlaid into excised areas, is painted directly onto the ground lacquer layer that has a preparatory gypsum layer underneath. The palettes are much broader and incorporate gold paint and metal leaf, and the technique lends itself to more sophisticated depictions. These later objects tend to have a far more European feel with clearer influences from the lacquered objects of Asia and the japanned objects of Europe.

Made by the only artisan whose workshop was named in the period, the circa 1760 signed writing desk and table stand by José Manuel de la Cerda (fig. 4) is an excellent example of the finest Pátzcuaro lacquer and painting techniques. The largest and most significant of the HSA's lacquered objects, this writing desk and table have images of golden weeping willows, flowering plums, pagoda-like buildings, and cranes, whereas the figures are soldiers and turbaned men doing battle. This work seems even closer to the chinoiserie-inspired japanned furniture that was produced in Europe and North America during this period (Carr 2015).

Fig. 3. Vargueño, Peribán, Mexico, ca. 1650. Wood with Mexican lacquer, iron hardware. 54 × 96.3 × 44.4 cm. Hispanic Society of America, New York. LS2071.

Fig. 4. Jose Manuel de la Cerda. Writing cabinet on table stand. Pátzcuaro, Mexico, ca. 1760. Wood with Mexican lacquer, silver drawer pulls. 154.9 × 102.1 × 61 cm. Hispanic Society of America, New York. LS1642.

The de la Cerda cabinet has been the subject of an exhaustive study by the MFA's furniture conservators, who reached several interesting conclusions (Unckel 2014). The MFA undertook a detailed examination of both the cabinet and table stand's construction, including both x-ray and infrared photography. It is unclear whether the table and stand were originally constructed to be a pair; however, the decoration and pigments are consistent on both. The construction of both the table stand and cabinet were altered substantially before they were decorated. The table stand had the orientation of the two rear legs altered so that it could stand flat against a wall; the cabinet itself had its lopers—slides originally used to support a fall-front lid—nailed in place since the orientation of the lid was changed from drop front to slant up. The wood used for the construction, although mostly Spanish pine (*Pinus* spp.) and linden (*Tilia* spp.), is of different thicknesses, and some boards clearly have been reused (e.g., the drawer blade below the large drawer). All of this highlights that what is important and what was prized about this object is not the construction of the furniture itself but the decoration.

In 2004, MFA conservation scientists Richard Newman and Michele Derrick analyzed the binder and pigments with XRF and SEM. Interpretation of the analysis was complicated by the fact that there are still no "standards" for *aje* fat. Chia oil has such a similar molecular structure to linseed oil that it has been difficult to differentiate between the two (Unkel 2014). Acuña's recent analysis of *aje* fat concludes that it is a hydrocarbon with a high molecular weight and a specific, if slightly rancid, odor and is dark orange in color. It has similar properties to cocoa butter (MacVean, pers. comm.). Acuña notes that the chia oil acts as a catalyst for the polymerization process: she reported the formation of a network of filaments visible under magnification (Acuña 2012).

Both the table stand and cabinet have a preparation layer of gypsum, presumably to create an even surface for the application of the lacquer. The black ground is pigmented with bone black, not carbon black as previously thought, and contains an oil binder. Cross section samples show that both the preparation and ground layer were applied unevenly, supporting the theory that the lacquer was applied as a paste and not painted.

The other pigments on the painted exterior, as indicated by Derrick's XRF results, also show some important divergence from the contemporary sources: the blue is indigo—a locally available dye and one that was widely used—and not mangrove bark; red is vermillion, a mineral clay, rather than the organic dyes cochineal or brazil wood; browns are iron-based pigments; white is lead white; and the green is a copper green. It is important to note that by the 18th century, Mexico was importing pigments. Thus, although we might expect there to be a continuation of local practices, it is not totally outside the realm of possibility that for such a highly prized object (one of only two extant that de la Cerda signed) he would use only the finest pigments, such as those imported from the Old World (Fournier et al. 2008).

In Olinalá, in the state of Guerrero, the lacquer technique differs both in its ingredients and decorative technique. Here, the artisans dispensed with *aje* fat and used alternating layers of chia oil and finely ground pigments and clays to create a lacquer surface. The initial ground layer was colorless, and colored minerals were added to create the distinctive and often orange or green lacquered surfaces. Once the first layer was dry, a second contrastingly colored lacquer layer was applied. The design was scored into the lacquer with a sharp point and then the second layer of lacquer was removed around the design, revealing a silhouette in slight relief, a technique known as *rayado* (Lechuga 1997).

Newman's FTIR analysis of the circa 1800 Olinalá coffer (LS2249; fig. 5) confirms both the absence of *aje* in the lacquer and the presence of ground minerals: red lead or minium in the orange layer and Maya blue (a combination of indigo and palygorskite, a natural clay) in the green. In 2007, sample analysis commissioned by the Museo de América in Madrid on a *calabaza lacada* in their collection also confirmed the presence of red lead in the orange and indigo in the blue and further confirmed that the lacquer itself was a mixture of oil (linseed, although given the similarity of the spectra, it could have been chia oil) and gypsum and calcium carbonate, the elements also found in the HSA coffer.

Joaquín Alejo de Meave, writing in 1791, went to great lengths to describe the color recipes used in Olinalá lacquerware and the techniques used. His account is mired in the local nomenclature for local clays used—*texicaltetl* and *toctetl* found in quarries and underground; *tlalxococ*, which is yellow; and *texotlali*, a blue clay. To these were added more colorants, vermillion and red lead for red, indigo for blue, cochineal and indigo for purple, and carbon black from charred maize cobs (Meave 1791)—all consistent with the analytical findings conducted by the MFA.

Fig. 5. Coffer, Olinalá, Mexico, ca. 1800. Wood with Mexican lacquer, metal hardware. 19.5 × 23.5 × 13.5 cm. Hispanic Society of America, New York. LS2249.

4. INTRODUCTION TO LACQUER IN COLOMBIA AND ECUADOR

In Colombia and Ecuador, a second, more mysterious but equally sophisticated lacquer technique used a completely different ingredient to produce its lustrous finishes. Called *barniz de Pasto* by the Spanish, the term is still used for objects made since the arrival of the Spanish to the present day (Codding 2015). Commonly known as *mopa mopa*, *barniz de Pasto* is made from a translucent pale green resin obtained from a species of the genus *Elaeagia* that produces significant quantities of resin: *Elaeagia pastoensis Mora*, a plant native to tropical rainforests in the upper Andes (Newman et al., 2015).

Its pre-colonial existence has been tentatively confirmed by the discovery of beads made from the resin, which were found in the Piartal-Tuza tombs in Vereda Miraflores in the municipality of Pupiales-Narino in southern Colombia (Botina 1990; Friedemann 1990), but in conditions that make any further contextual analysis difficult. That said, it has long been the assumption that environmental and climatic conditions in the area precluded the survival of pre-Hispanic artifacts (Botina 1990). Environmental factors may also help to explain why a disproportionately large number of colonial objects survive in collections outside of Latin America compared to collections within Latin America.

5. QEROS AND THE REST

Until 2015, it was widely accepted that there were two lacquer traditions using *mopa mopa* that evolved more or less independently. The first tradition originated in Ecuador, in the Peruvian Andean highlands, and in Bolivia, and this tradition is stylistically associated with *qeros*, the ritual cups made in pairs for drinking *chicha* (maize beer). The second, *barniz de Pasto* tradition stretches from Pasto in Colombia to Quito in Ecuador and, during the colonial period, produced largely European-form objects decorated with the resin in a variety of techniques (Codding 2015).

Separated by a distance of more than 2,000 miles, the two traditions technically have little in common. *Qeros* are made of wood decorated with incised linear designs and carved low-relief geometric and later figural designs filled with the opaque-colored resin. It is rare for the resin to completely cover the substrate, unlike the *barniz de Pasto* pieces, in which the decoration is often created by the layering of resin sheets. To the naked experienced eye, the aged resins on the two types of objects also look quite different: the resin applied to the *qeros* is very brittle and shows a distinctive craquelure pattern, whereas the *barniz de Pasto* pieces seem to retain significantly more elasticity. Although made well into the colonial period and hence notoriously difficult to date, samples from the decoration of the Inka *qeros* both excavated (pre-Hispanic?) and unexcavated (post Spanish arrival?) tested as *mopa mopa* (Newman et al. 2015; Pearlstein et al. 1999).

In research published in 2015, Newman found a way to differentiate between the species *E. pastoensis Mora* and another species, *Elaeagia utilis*, which also produces significant quantities of resin. He compared samples from vouchered herbarium specimens with samples of the polychromy (pigmented resin) from artifacts; all of the *qero* samples he analyzed are *E. utilis*, whereas the *barniz de Pasto* samples provided by HSA and others are decorated with *E. pastoensis*. Samples from beads reported as pre-Hispanic were analyzed as well, and they were also made from *E. pastoensis.* Possibly confirming the use of *mopa mopa* (*E. pastoensis*) in the pre-Hispanic period, these beads were allegedly excavated in Pasto, although we have no way of knowing their age or their context. Although the discovery that *qeros* are made with *E. utilis* explains some of the stylistic and surface differences between objects from the two traditions, it does not help us arrive at a better understanding of how the traditions evolved—neither does it prove or disprove any connection between the traditions.

6. LACQUER IN THE VICEREGAL PERIOD IN COLOMBIA

The historical chronicles and accounts help to establish a theoretical timeline (Botina 1990; Codding 2006). The earliest reference to the use of *mopa mopa* is found in Jerónimo de Escobar's 1582 account that describes the colored staffs made by the people of Timaná—a town that is 30 miles from the tombs of Vereda Miraflores and the excavated resin beads (Codding 2015). Later chroniclers described the work from Pasto itself: a 1676 account by Piedrahita, a Colombian bishop; accounts by the naturalist explorers Jorge Juan and Antonio de Ulloa in 1748; and most famously, the 1801 account by Alexander von Humboldt. Several described the Pasto wares as comparable to Asian ceramics and lacquers. Humboldt described a very well established cottage industry: 80 *barnizadores*, who used 600 to 800 lb. of the resin per year and whose output was worth the equivalent of $10,000 to $15,000 in 1801 dollars. Humboldt also recounted a still unverified "origin" story for *barniz de Pasto*: a Catalina Petronila de Mora had learned the art from her Indian laborers and then perfected it in Pasto (Codding 2015).

The sources, however, make no mention of individual workshops or the variety of techniques used, and make very little mention of the geographical extent of the tradition that can be readily confirmed. That there were early workshops in Quito is assumed by the existence of a *vargueño* inscribed "facto in Quito en 1709" in the Museo Franciscano Fray Pedro Gocial. Here, as in Mexico, the Spanish had commissioned objects of European form to be decorated using an indigenous technique to imitate Asian lacquers.

By the colonial period, indigenous people were collecting the resin into cakes and transporting it over a 4-day hike to lacquer artisans in the city of Pasto, who purified and processed it to decorate wooden objects. Since the resin is produced by a plant as a protective coating for its young leaf shoots, the resin cakes contained both plant matter and bark, which was removed by repeatedly boiling in water and then chewing. The resin regained considerable elasticity in this process. It could be stretched, traditionally between two artisans who would pull it into a very thin sheet (the consistency of kitchen plastic wrap) using their teeth and hands. The decorative elements were cut out of the thinnest central part of the sheet and applied, with heat, directly to the substrate. The sheet in its natural state was translucent greenish-yellow; it was colored by mixing in pigments, either by kneading, grinding, or chewing (Codding 2015).

Artisans treated the resin sheets in two different ways to make objects that were known as matte or *brillante*. For matte *barniz* objects, the artisans saturated the resin with pigments, drew it into thin sheets, and made the design by inlaying different colors and shapes into the excised areas. For *barniz brillante*, the artists used the colored resin as tinted glazes layered over silver leaf (Portell 1992) or to build up color or design elements. The HSA has examples of both the matte and the *brillante* in its collection, including a *barniz brillante* writing box that can be dated with some accuracy to 1684.

Lavishly decorated both inside and out, the portable writing box (LS2000; fig. 6) was commissioned by the bishop of Popayán, Cristóbal Bernardo de Quirós (who died in 1684), as a gift to his brother Gabriel upon being named Marqués de Monreal by Charles II in December 1683. The construction of the writing box is particularly interesting, as its joinery and shape with curved lids mimic Asian construction, as does the exterior decoration. Instead of the classic Asian motif of a grapevine with squirrels, the cream-colored ground is decorated with a trellis of passion fruit vines, interspersed with birds and monkeys. When the original precious metal hardware was replaced with modern brass, the box surface was repaired with resin, showing clearly its elasticity.

Fig. 6. Portable writing desk, Pasto, Colombia, ca. 1684. Wood with *barniz de Pasto*, yellow metal hardware. 20 × 31 × 36 cm. Hispanic Society of America, New York. LS2000.

To make this design, and working quickly while the sheets were still elastic, resin sheets were applied to the substrate and pricked to prevent the formation of air bubbles. Clear and colored resin shapes were applied to build up the design in relief, in amazingly intricate detail. The vines, of which an example is shown in figure 7, are made up of alternating dark and light yellow stripes over metal leaf, and the passion fruit flower petals are orange over silver leaf, with details rendered in silver (under clear *barniz*) and shading and other detailing in black. Each change of color required the inlay of different colors and shapes from tiny pieces of resin, with the whole covered again with a single sheet. Some of these details are many layers thick. It is presumed that the extent of silver oxidation visible particularly on the lid is a result of the sheet being pricked: the exterior was as originally dazzling as the interior, whose decoration truly reveals the box's origins. Surrounding the Quirós' black and gold coat of arms, the highly sophisticated design is crammed with local details—parrots and a basket of tropical fruits, and bunches of a fruit against an equally busy background of vines, leaves, and tropical berries, including *agraz*, a local indigenous fruit.

Humboldt was one of the first commentators to identify the colorants used in *barniz de Pasto* work: dilute indigo for blue; pure indigo for black; annatto for red; the powdered *Escobedia scabrifolia*, a saffron-like root, over silver leaf for gold; and lead oxide for white (Codding 2015). Newman analyzed the

Fig. 7. Portable writing desk (detail), Pasto, Colombia, ca. 1684. Wood with *barniz de Pasto*, yellow metal hardware. 20 × 31 × 36 cm. Hispanic Society of America, New York. LS2000.

Fig. 8. Coffer, Pasto, Colombia, ca. 1650. Wood with *barniz de Pasto*, silver hardware. 19.2 × 27.2 × 13.6 cm. Hispanic Society of America, New York. LS2067.

pigments and found both lead white and indigo, confirming that the binder is indeed *E. pastoensis*.

Two of the other *barniz brillante* objects in the HSA collection are believed to pre-date the bishop's box: a small coffer (LS2067, ca. 1650; fig. 8 and fig. 9) and a lacquered gourd (LS2400, ca. 1650–1675). Both objects have a dark ground and are decorated with a wide variety of intricately depicted creatures and floral and foliate designs in compartments that have geometric borders. In the case of the coffer, the border is a gold band with a stylized flower made from five small orange circles alternating with a red scroll. They both have characteristic dark red translucent *mopa mopa* interiors. Unlike LS2000 (the bishop's writing box), decoration is flat and the technique involves fewer layers, perhaps explaining the greater incidence of oxidation in the silver leaf. However, this does not mean that the quality of the decoration is any poorer, with each object rendered in extraordinary detail. Working directly on the object, each line detail required it to be inlaid into a cleared area, and depth was created by additional *barniz* details. The llama on the reverse of the small coffer has a design of cream spirals on top of the red-tinted resin over silver—each filament individually laid in and the whole covered in a single protective sheet. The long-tailed birds have the tiniest of contrasting colored squares embedded in their tail feathers to give depth and create the sense of movement.

Absent any documentary evidence, these objects are dated partially by the iconography (a less reliable tool when dealing with design in the Americas, where motifs and styles remained popular long after they had died out in Europe) and the quality of the work. The decoration, including snail-men, mermen, birds, fantastic animals (e.g., unicorns), and the display of horror vacui, recalls the Peribán *bateas* of the same period, and possibly derived some inspiration from 15th- and 16th-century European sources, such as illuminated manuscripts, prints, and drawings (Codding 2015). Clear also is the reference to Asian lacquer: the black ground with its sparkling and lustrous decoration. The

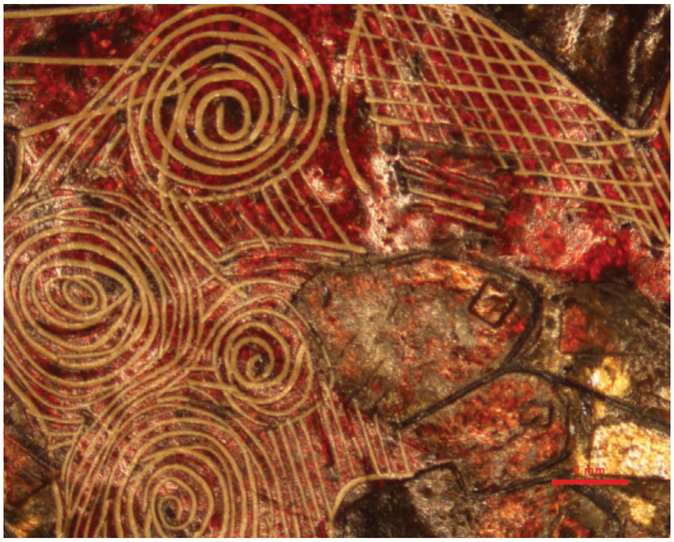

Fig. 9. Coffer (detail), Pasto, Colombia, ca. 1650. Wood with *barniz de Pasto*, silver hardware. 19.2 × 27.2 × 13.6 cm. Hispanic Society of America, New York. LS2067.

Fig. 10. Coffer, Pasto, Colombia, ca. 1650. Wood with *barniz de Pasto*. 15 × 18 × 8.6 cm. Hispanic Society of America, New York. LS2361.

quality of the original hardware reinforces the inherent value the object had when it was made.

The lacquered gourd is decorated with a similar if less fine or complex technique. Although the outlines are still inlaid and the thinnest of *barniz* strips are used for detailing, there are fewer color changes in each design element and no inset colored squares for emphasis. For example, the border pattern is simply red with gold crescents. It is the only known example of a colonial lacquered gourd, which is particularly interesting since this gourd appears to have been manipulated while it grew to achieve such a regular shape. Were gourds systematically cultivated for this purpose?

Far fewer objects from the matte *barniz* tradition seem to have survived: the HSA has one, a small wooden coffer (LS2361; fig. 10) that dates from circa 1650. This is decorated using resin sheets saturated with pigment. The box is covered with a resin sheet of the black ground color, the designs are incised directly into the ground layer, and contrasting colored *barniz* threads are inlaid. As in the *brillante* objects, the designs are likely inspired by European print sources mixed with characteristically South American elements. This box has a hunting motif with a Spanish man on horseback, a noblewoman, a cherub, stags and deer, hare, lion, birds, and stylized bunches of *agraz* berries similar to those that appear on the *brillante* bishop's box (LS2000). The costumes are consistent with a circa 1650 date (Codding, pers. comm.). Although Newman's analysis confirmed that this box was also made from *E. pastoensis* with organic colorants, only further testing will determine what they are.

Detailed analysis of these objects has only just begun, and there are many questions about the objects that still need to be answered. It is not clear if there is any significance to two such visually different traditions coexisting. Could the use of matte *barniz* be a remnant of Inka influence? What is the implication of Newman's discovery of the resin's plant sources on the history of *mopa mopa* objects? What, if at all, is the connection between *qeros* and the colonial tradition?

7. CONCLUSION

The study of Latin American lacquers and the objects decorated with them is still in its infancy. Often historically misidentified as painted or japanned, or even as the Asian lacquer it tried to imitate, these objects are now being appreciated in both historical and artistic contexts for the high level of skill of the artisans who created them and the global nature of their source of inspiration. The materials research into the lacquer traditions has just begun, but it is hoped that by introducing them to a group of practicing conservators, more light will be shed on the manufacture and history of these exuberantly beautiful objects.

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APPENDIX A. PARTIAL GLOSSARY OF TERMS

Agraz (Colombian): Indigenous fruit depicted on *barniz de Pasto* objects; often mistaken for stylized bunches of grapes

Aje (Mexican): Common term for fat used in Mexican lacquer

Annatto: Orange/red food colorant from the achiote tree (*Bixa orellana*; Latin) used as a red colorant in *barniz de Pasto*

Atecomate (Mexican): Translated as "tumbler, vessel for drinking water"

Axin (Latin): Term used by Sahagún to describe fat used on wooden objects in Mexico

Barniz (Spanish): Translated as "varnish"; term used interchangeably for resin used both on *qeros* and on colonial objects from Colombia and Ecuador

Barniz brillante (Spanish): Used to describe the *barniz de Pasto* decorative technique that uses resin as a glaze over metal leaf

Barniz de Pasto (Spanish): Translated as "varnish from Pasto"; term used for objects decorated with resin from *Elaeagia Pastoensis Mora*

Batea (Spanish): Wooden tray; form introduced by Spanish artists and adopted by the Mexican artisans for decoration with Mexican lacquer

Calabaza (Spanish): Large gourd

Chicha: Maize beer, drunk out of *qeros*

Chia: Common name for *Salvia hispanica* (Latin); drying oil used as an ingredient in Mexican lacquer

Chicalote (Spanish): (Latin*: Argemone munita*) Also known as flat-bud prickly poppy; seeds used to make oil added to Mexican lacquer

Coccus axin (Latin): (Family: Margarodidae) Latin name for the insect cultivated since pre-Hispanic times in Mexico and Guatemala; its fat is used to waterproof wooden objects; used for medicinal purposes; as an ingredient in Mexican lacquer

Dolomite: $CaMg(CO_3)_2$; term used in historical accounts to describe "filler" added to Mexican lacquer; MFA analysis does not substantiate this claim to date

Elaeagia pastoensis Mora: Latin name for plant that produces resin used to decorate *barniz de Pasto* objects

Elaeagia utilis: Latin name for plant that produces resin used to decorate *qeros*

Escobedia scabrifolia: Latin term for root known as "saffron" and used to color *barniz de Pasto* yellow

Galgos (Spanish): Greyhounds; term used to describe a workshop producing colonial Mexican lacquer decorated objects, all featuring greyhounds in the decoration

Jícara (Mexican): Translated as "gourd"

Laca (Mexican): Term used in Mexico to describe Mexican lacquer; derived from the Arabic word *lakk*

Maque (Mexican): Term used in Mexico to describe Mexican lacquer; derived from Japanese *maki-e* (lacquer decorated with gold and silver leaf)

Matte *barniz*: Used to describe the *barniz de Pasto* decorative technique that uses pigment-saturated resin

Mopa mopa: Term commonly used to describe resin used on both *qeros* and *barniz de Pasto* objects

Niij (Guatemalan): Common term for *coccus axin* in Guatemala; cultivated since pre-Hispanic times and used to waterproof wooden objects

Pátzcuaro: Town in Michoacán, Mexico; colonial center of Mexican lacquer production

Peribán: Town in Michoacán, Mexico; colonial center of Mexican lacquer production

Qeros: Ritual cups, made in pairs, for drinking maize beer

Olinalá: Town in Guerrero, Mexico; colonial center of Mexican lacquer production

Vargueño (Spanish): Portable desk; form introduced by Spanish and adopted by the indigenous artisans for decoration

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CHARLES J. MOORE

Ghostly Evidence: Interventions in a 20th-Century Installation of 18th Century Asian Lacquer Panels

ABSTRACT—From 2007 to 2013, a campaign of research, documentation, and conservation treatment was undertaken for a group of 18th-century Chinese lacquer panels and an early 20th-century panel in the Breakfast Room of The Elms in Newport, Rhode Island. The work revealed a variety of techniques, repairs, and modifications using both Asian and Western materials and methods. Cross section microscopy and scientific analysis provided solid details about craft technique and materials, as did evidence provided by a collection of vintage photographs and the discovery of visual details previously unseen. All of this provided an interesting and surprising chronology of construction and intervention by a cast of characters—some known, some intuited, and others of mysterious origin.

1. INTRODUCTION

The Elms (1901), a Gilded Age mansion in Newport, Rhode Island, was designed by Horace Trumbauer for Edward Berwind with interiors by the then-popular Parisian designer Jules Allard (fig. 1). The museum is one of 10 open to the public and administered by the Preservation Society of Newport County.

Fig. 1. The Elms (1901), West façade

Fig. 2. Lacquer panel and overdoors in the Breakfast Room

In The Elms' Breakfast Room, the following description is found in the curatorial record (fig. 2):

> A SET OF THREE CHINESE BLACK AND GOLD LACQUER WALL PANELS (Chinese, 18th century); (K'ang Hsi Period, 1662–1722); together with three matching overdoors and a wall panel in black and gold lacquer from the workshops of Allard et ses Fils of Paris (French, circa 1900).

In 2005, long-range planning initiatives identified the conservation of the panels to be the most important interior project at The Elms. With a variety of grants, work was finally completed in summer 2013. The primary practitioners were Project Conservator Maria João Petisca, Consulting Conservator Melissa Car, Technician Aynsley Schopfer, and the author serving as project manager and chief conservator.

The purpose of this presentation is to look at the evidence discovered during the assessment and treatment of the panels as it reflects the presence and practices of people who were at work on them over time. Sometimes it is obvious, sometimes less so. Although there were a variety of characteristics to explore, the work presented here will be limited to the panels' structure and the lacquers on them.

2. THE PANELS

The lacquer panels at The Elms lived a long and perilous life; it is a wonder that they exist at all. For the purpose of understanding campaigns of intervention, a timeline is in order. The panels are without written provenance. If the history as presented is somewhat vague, it is because it is only though the Preservation Society's oral tradition (suspect at best), the opinion of experts, and conservation forensics that help provide background. As we understood it:

- The antique lacquer panels were probably made in Canton in the early to middle 18th century and exported to France, likely to have been an order of Parisian marchands merciers. They, along with the overdoors, could have wound up in an upscale Parisian townhouse. There are examples of these, such as those in the Musée des Arts Décoratifs from the Hôtel du Châtelet. (for an image, see http://www.ornamentalist.net/2016/07/a-visit-to-musee-des-arts-decoratifs.html).
- They had a working lifetime as decorative objects through the 18th and 19th centuries, perhaps in an architectural context, with a history of degradation, repair, and eventual decline.
- They were salvaged as architectural fragments—maybe as a result of the demolition of townhouses due to the boulevarding of Paris in the 19th century—and found their way into the architectural materials archive of Jules Allard, where they underwent another period of neglect.
- When a suitable commission came along (and the new wealth of America supplied prime commissions for Allard), the panels were restored, a fourth panel was created, and all were prepared for installation at The Elms (1901), where they underwent subsequent deterioration and treatment of various kinds, culminating in the conservation treatment ending in 2013.

3. STRUCTURE

Each of the three large antique panels began life as three narrower panels, edge glued. This tripartite nature suggested they were made from screen panels, which were popular decorative imports. Upon removal from the walls, the reverse of all panels was found to be covered with a thick paper backing, glued and nailed at the edges (fig. 3).

When the paper was removed from the antique panels, a wood cradle was revealed, supporting a full-thickness panel that had no decoration on the back side, just uncolored reddish-brown colored lacquer together with evidence of the three, narrow panels (fig. 4).

The cradles were nicely made of oak with witness (layout) marks typical of French workshops. They were designed like cradles for panel paintings: to provide support but allow them to expand and contract. "Buttons" were fixed to the panel and half-lapped onto the frame. It was a great idea (fig. 5).

Fig. 3. The rear of the panel is covered with thick paper.

Fig. 4. Underneath the paper is a cradle supporting three lacquer panels glued together. The lacquer on the back is uncolored, and there is no decoration.

However, x-radiography on the East panel revealed mitered breadboard construction at each end that confounded the theory of the cradle: each narrow panel was constrained by its own end piece, with inevitable cracking within its structure. Also shown were the individual boards that made up each narrow panel and the long bamboo splints that used to dowel the edge joints. One also sees the modern dowels used by Allard's workshop to stabilize and reinforce the end boards (fig. 6).

The presence of two breadboard ends suggested that, if the panels had ever been screens, they were screens without legs, as evidence of a mortise and tenon for the bottom rail would have been seen in the x-rays.

Regarding the unfinished backs, why were they left in such a raw condition? Perhaps it is a matter of appreciating the creativity of the French marchands merciers and their genius for adding value to antique Asian decorative arts, such as the gilded bronze mounts on ceramics. One could conclude that the panels they ordered were made without decoration on the back so that they could be used in a flexible manner, like on a wall, as we see at The Elms, or some other way. It would certainly be less expensive to buy panels with only one side decorated and would eliminate the labor required to split the two decorated sides from one another, which was a known practice.

In fact, fragmentary evidence was found for just such a consideration, as on the back of the East panel, at one of the joints between narrow panels, fragments of red silk threads were found (fig. 7). In our limited x-ray work, we did not see evidence supporting hinges; however, it was clear that the edges had been damaged/repaired and perhaps that evidence was no longer visible, or perhaps hinges were made of fabric. Maybe the panels did indeed start out life as three-panel screens with their backs covered in red silk. If so, it would confirm the cleverness of the French merchants.

The antique panels had a history of shrinkage cracks, both restored and active. The modern Allard panel, which was custom made for the installation, and the overdoor panels, which have transferred decoration, do not have any shrinkage cracks. This is because the substrates of the Allard panel and the overdoors described previously are made of plywood rather than

Fig. 5. Slip joint with French witness marks on the cradle

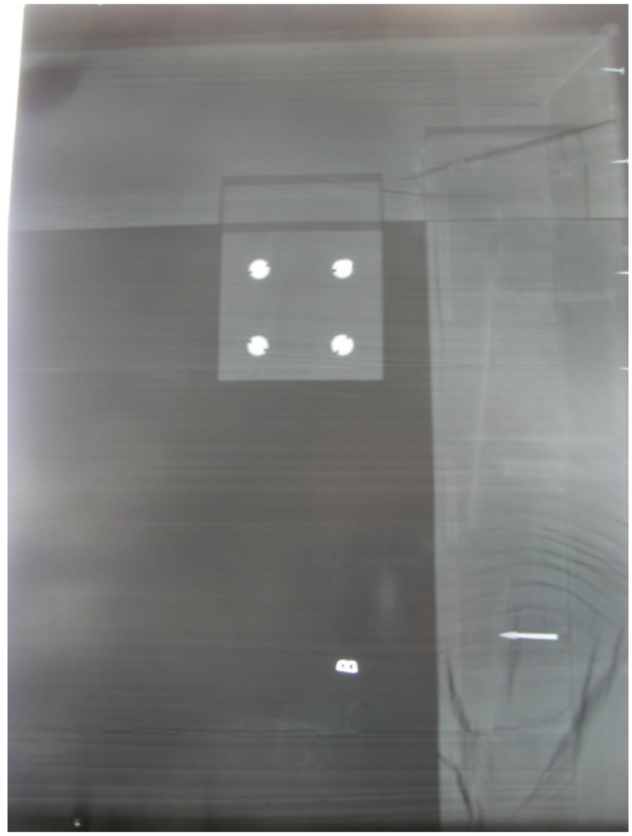

Fig. 6. X-radiography shows a mitered breadboard end, as well as bamboo splints and doweling.

Fig. 7. Some red silk fibers are pinched between the panels.

Fig. 8. Wood laminations are visible on the edge of the West panel.

Fig. 9. A comparatively crude frame, white paint, and the four narrow plywood panels that make up the whole

solid wood (fig. 8). This is somewhat remarkable considering that the large panels are 83 × 120 in. However, there are many instances of plywood being used in Allard's work at houses owned by the Preservation Society, such as the Ladies Reception Room at The Breakers. He was a clearly a savvy woodworker (note the technology of the cradle for the large wooden panels) and appreciated the stability of a laminated sheet. When the back of the panel was revealed, one could see that it was made of four narrow sections edge glued together (fig. 9). The width of the sections was probably determined by the re-saw capacity of the hand or bandsaw available.

The Allard panel also had a cradle, but it was not of the same quality as those on the antique panels. It was painted white along with the panel back, which was a lot of trouble to go to considering that the plywood would not be expected to move very much. The laminated panels vary noticeably in thickness. One can see this on the back, especially where the buttons had to be scribed to fit, but the lacquered face is precisely flush.

We believe that someone was hired to prepare the group of panels for the installation and instructed to make the modern plywood panel a replica of the antique panels by adding a cradle and to cover all with paper. We did expect this to have happened somewhat in advance of the building of the house. We were surprised, then, to find a notation on the back of the paper on the Allard panel—"Edward Valleby (sp?) Newport, Rhode Island April 28, 1895"—fully 6 years before the house was completed (fig. 10). It is possible that the panels were prepared for The Elms well in advance, but it does complicate somewhat our understanding of their later history.

We see in this review that the panels might, in fact, have been used as screens. We also see that a lot of effort was expended in France, using sophisticated woodworking concepts and techniques, to redefine the panels (by making them large surfaces unimpeded by joints or moldings) and to contribute to their preservation by applying the cradles and to use laminated wood substrates for the new panel and overdoors.

4. LACQUER

Upon first examining all of the panels, both antique Asian lacquer and campaigns of European lacquer work were identified. We automatically presumed that the Allard panel was made using European methods as well. How could it not be?

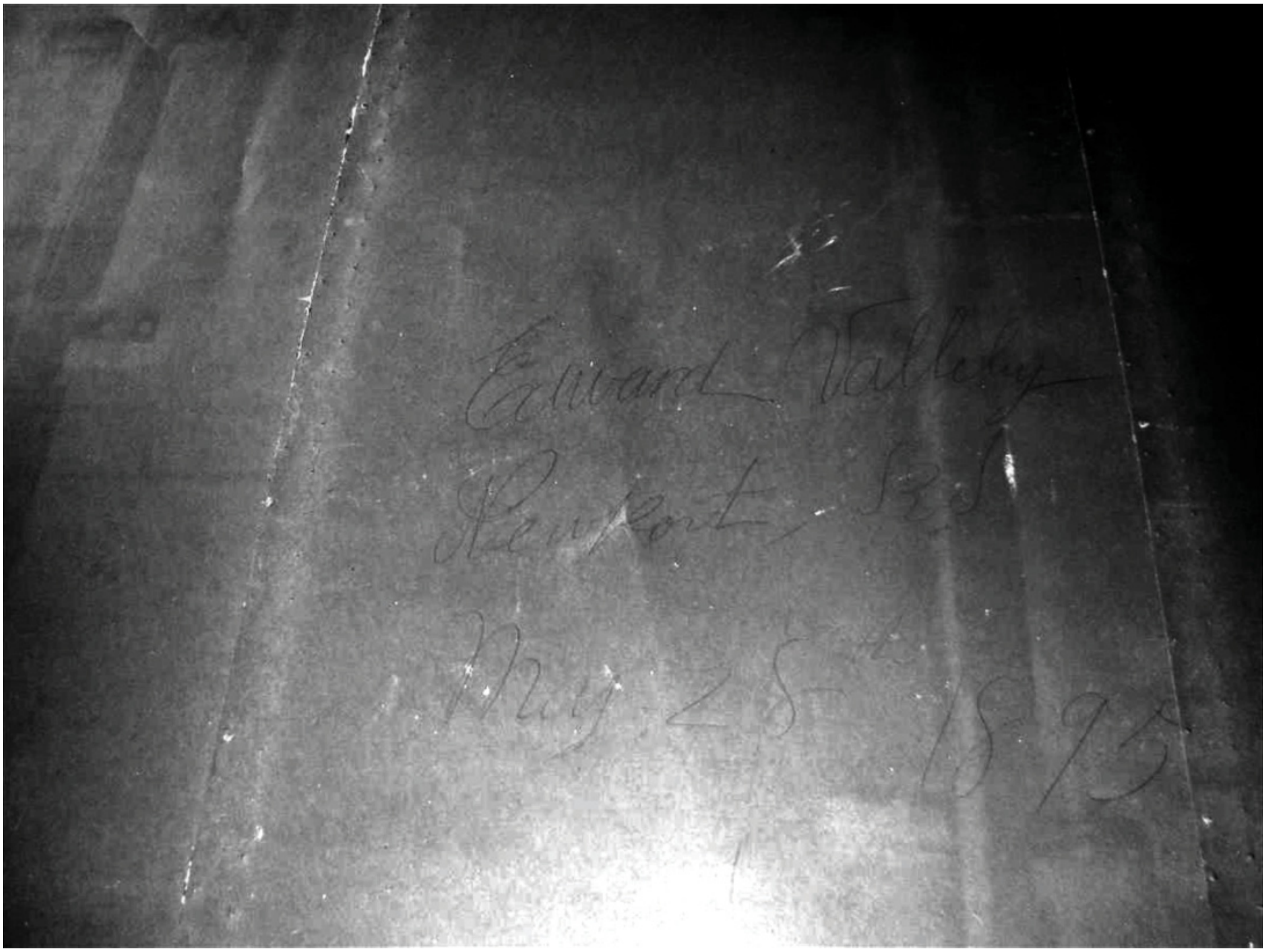

Fig. 10. Image desaturated and enhanced for clarity in Adobe Photoshop

The results of cross section microscopy revealed the character of the original lacquer and other past campaigns of surface treatment. There were similarities among the antique lacquer samples. The lacquer on the large panels and the overdoors had very similar stratigraphies and seem to be typical of 18th-century Chinese export. There is an amorphous nature to the finish lacquer layers in UV, suggesting dyed lacquer rather than pigmented. There is frequently a fibrous layer in the ground (fig. 11).

Smooth and particularly fine repairs (hereafter called the *Fine Repairs*) to the antique panels were thought to be work done in France in advance of the installation in Newport (fig. 12). Samples from these had some of the visible characteristics of Asian lacquer identified in the antique samples, but there were differences (fig. 13). The ground is very similar, but one sees fibers in it in UV light. The finish layers are rather opaque looking in UV (compared to that amorphous appearance of the antique material). There is a dark line between layers and a red pigment of some kind in the final layer.

Figure 14 shows a sample of the Fine Repair work (Asian lacquer) on top of European lacquer, a situation that is more frequently seen in reverse. Note also the evidence of shellac used as a coating and toner both in the cross section and on the surface of the panel after cleaning.

The Allard panel had a surface that was in very good condition, which we assumed initially to be made using European methods. When samples were finally taken from the panel, the stratigraphy was in no way related to European methods. Although the finish layers on the Allard panel were different in appearance than that on the antique panels, the technology was quite similar (fig. 15).

Ground layers were alike, but certain idiosyncrasies were notable: one could see fragments of lacquer, even with gold powder or black lacquer in it—maybe sweepings of some kind incorporated into the ground layers. It was very strange. The finish layers are somewhat opaque looking in UV, and there is a coarse woven mat used in the early finish layers. There is also a

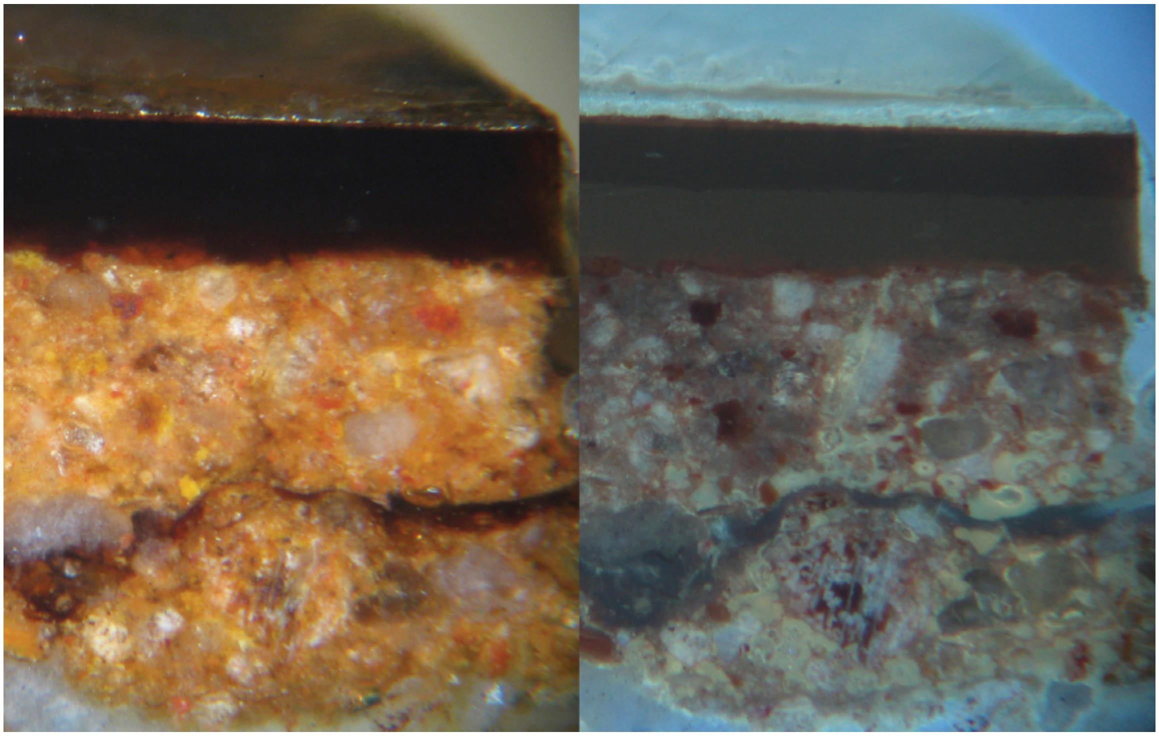

Fig. 11. This cross section image from an antique panel is typical of 18th-century Chinese export lacquer

Fig. 12. Example of very high quality repairs that were made to the panels

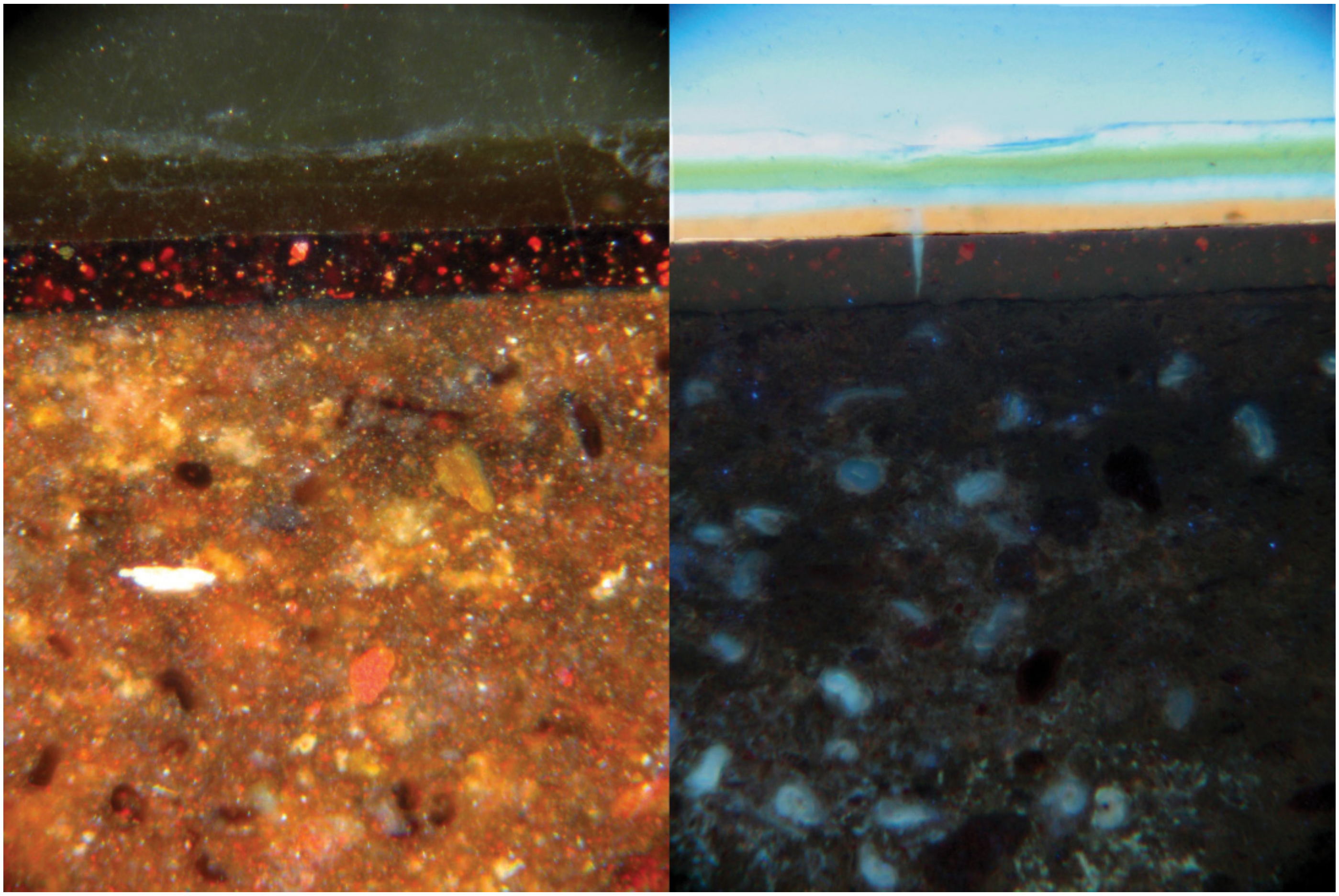

Fig. 13. Cross section of the Fine Repair material. Note embedded fibers, pigmented lacquer, and use of shellac.

robust, unwoven fiber mat used between two of the ground layers (fig. 16).

This makes three instances for the use of Asian lacquer: the antique panels and fragments on the overdoors, a campaign of repairs to antique panels (Fine Repairs), and the Allard panel. Getty Conservation Institute analysis eventually provided the following information about the lacquer: the antique lacquer panels were made using Vietnamese lacquer (containing laccol). The ground layers are of high quality, containing a lacquer binder rather than a cheaper, protein binder. The lacquer used on the Allard panel and the Fine Repairs noted on the antique panels is the Chinese/Japanese/Korean variety (containing urushiol).

The microscopy and analytical results confirm the place of the antique lacquer panels in the universe of 18th-century Chinese export. The work on the Allard panel and that of the Fine Repairs has more mysterious origins.

For instance, where would an Asian lacquer panel have been made in Paris circa 1900? There was certainly a Vietnamese community in Paris during that period who would have been conversant with lacquer. There was also the presence of Japanese artisans associated with the 1900 Universal Exposition—for instance, Seizo Sugawara, who taught Asian lacquer craft to Eileen Gray and Jean Dunand. In fact, to go full circle, Dunand was known to have used Indochinese lacquer and practitioners, so there is that documented connection, although it is later in the 20th century.

In addition, a question we kept asking was why weren't the characteristics of the Asian lacquer used on the Allard panel the same as that used for the Fine Repairs? One would think that they would be the same if Allard were in charge of both campaigns.

To wrap up so far, evidence suggests that Allard archived the panels until he found a client. He did all work of restoration and fabrication using Asian and European lacquers mentioned earlier to furnish four walls and three overdoors at The Elms. Then all of the panels were sent to Mr. Valleby (sp?) for prep: cradle for the large panel, paper on everything, including the antique panels. Then installation. We believed that all of the real restoration work up to that point was done, leaving only

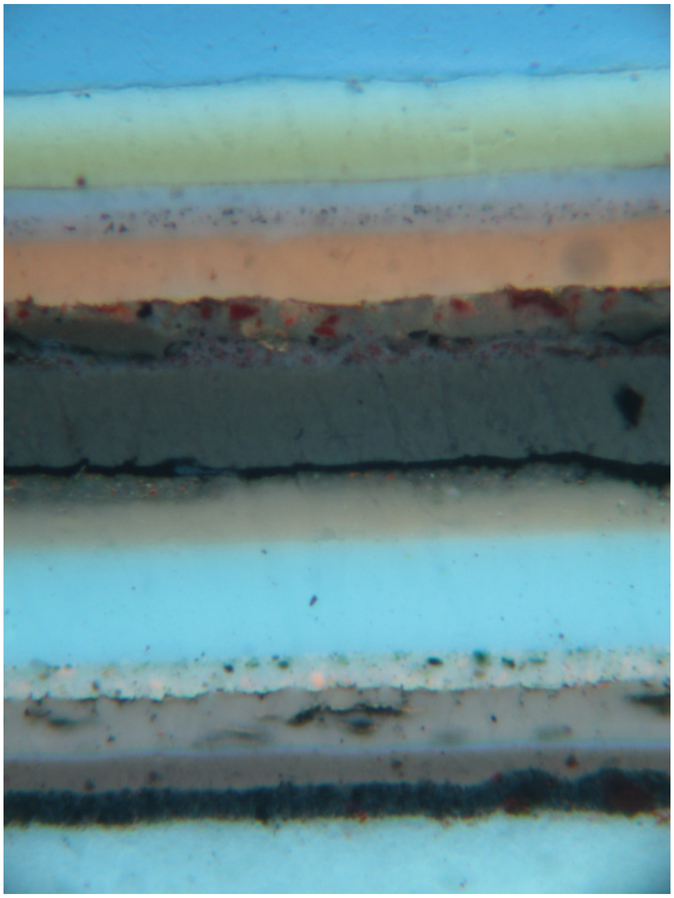

Fig. 14. The Asian lacquer has been applied on top of an earlier repair using European methods.

the bronze paint and crude inpainting that occurred after installation.

5. FURTHER QUESTIONS

However, questions remained. During the wrap up of the large panel treatment, we started to review findings and have a fresh look at certain things. For instance, when the panels were turned over to treat the shrinkage cracks from the back, in certain areas there was notable squeeze-out of a hard, black material (fig. 17). It looked like it had been applied from the face to fill the crack. Eventually we came to the realization that the panels must have been lying on their backs during filling, as gravity caused the filler to hang down, somewhat like stalactites. No attempt was made to clean off or level the filler on the back. We discovered that in every case, the presence of this material was in an area where there was one of those beautiful Asian lacquer repairs. In fact, per GCI analysis, the filler contained a relatively high proportion of urushi. A more careful review of the evidence for historic shrinkage cracks suggested that there were actually three major campaigns of repair for these: historical European lacquer (pre-Allard), what we came to know as a campaign of Allard European lacquer, and the Asian lacquer (Nice Repairs), which we thought was of the Allard era as well. We understand now that the last of the historic crack repairs was clearly in response to a pretty massive splitting event *after* installation in the house, probably because of central heating.

We had been lulled into believing that these lacquer repairs had been made in Paris. The Great Oral Tradition had it that the panels had never been removed from the walls of the Breakfast Room. In fact, it was said that when the contents of The Elms were auctioned off in the 1960s that Doris Duke bought the paneling, but her carpenters were unable to remove them from the wall. As we worked, we found differently. The panels could indeed be removed from the wall, and there was even evidence that someone had tried previously and damaged the moldings that hold them in place.

Then, although the author had "carefully" reviewed the documentation previously, Maria João Petisca noticed in the two sets of vintage photographs (1901, 1927) that the order of the panels on the walls had been changed in the later series (figs. 18, 19). Thus, the panels had indeed been down. The untidy presence of the filler on the back was because the paper barrier was in place, preventing access. Therefore, we can say the lacquer repairs were done sometime between 1901 and 1921. The analytical characteristics (presence of urushi) combined with the visual characteristics of the lacquer (a thin, black line between lacquer finish layers) suggested a Japanese artisan (fig. 20).

Who was this Japanese artisan who came to Newport to do this work?

6. THE GHOSTLY PRESENCE

Two rather frustrating Preservation Society references were found in this regard. One was from an undated, handwritten history from one of Berwind's old employees. He states, "The Breakfast room in the house was done by imported Japanese help. Lots of gold leaf was used and really beautiful work." Another intriguing reference is in the Elms Historic Structure Report., which states "It was discovered that the lacquer of the panels was granulating off perhaps as a result of dusting. As a result, the Berwinds hired a Japanese couple to retouch the panels, they would not reveal the process of restoration." Unfortunately, the source of this reference, although attributed to the Preservation Society's archives, could not be found. Both accounts ring true, however.

The author has two thoughts about how the artisan may have come to Newport. One is that Yamanaka and Company, the famous purveyor of Asian antiquities, had a presence in New York and Boston (fig. 21). The company also had a seasonal office in Newport and would certainly have been able to provide or connect with a lacquer artisan capable of traditional work for an Asian project for one of the wealthiest men in the country.

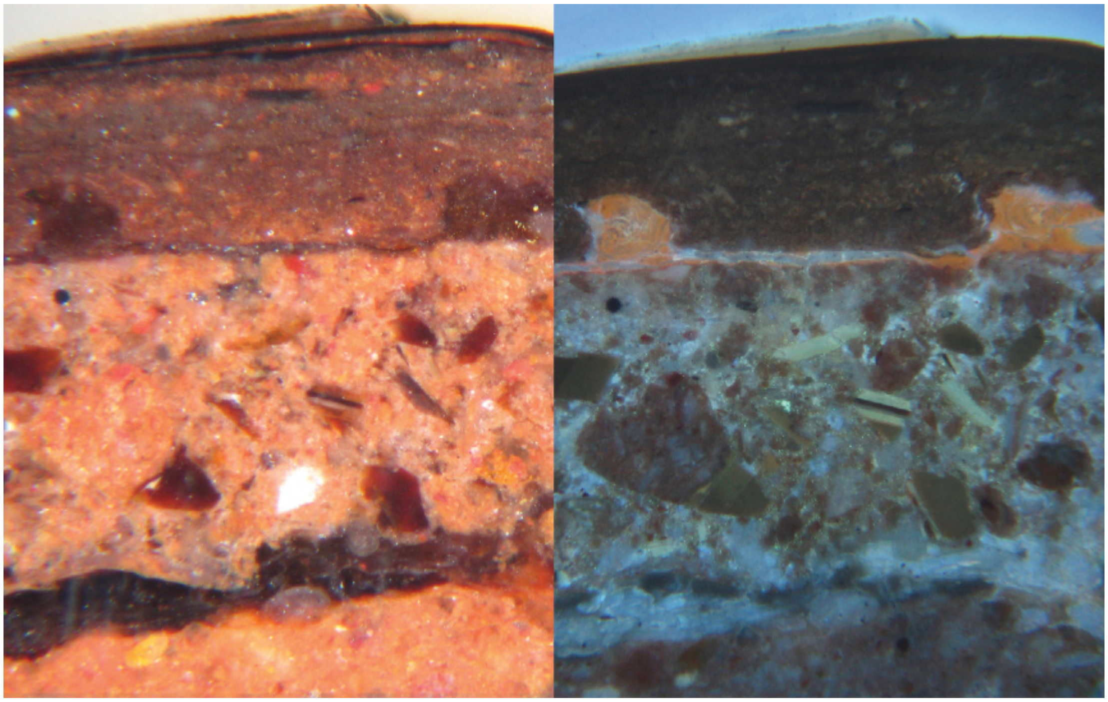

Fig. 15. The lacquer on the West panel has a pigmented finish layer and embedded fibers. Fragments of lacquer, complete with stratigraphy, are found as filler in the ground layer.

Fig. 16. A non-woven mat and a coarsely woven textile are embedded in the layers of the lacquer used on the West panel.

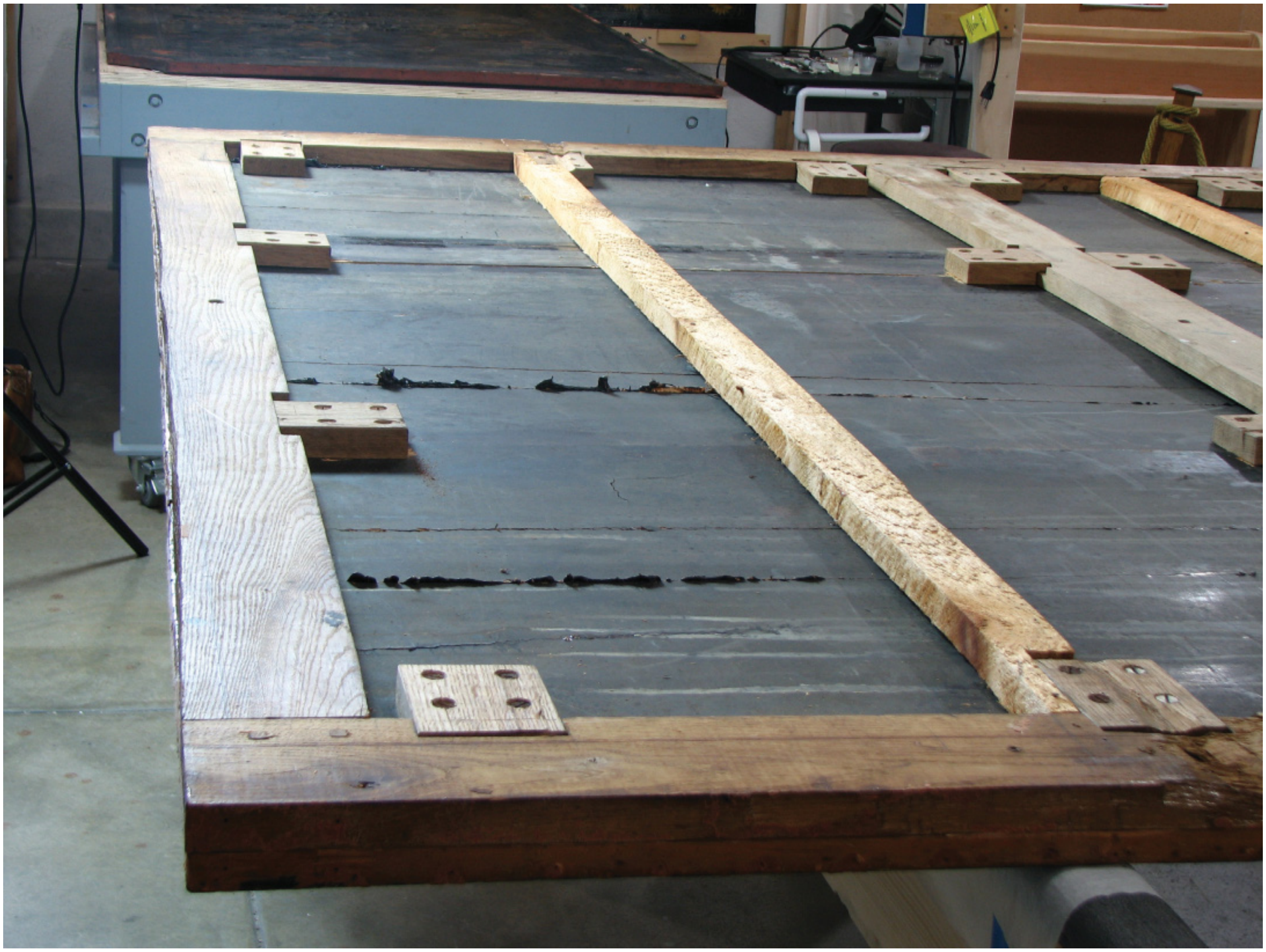

Fig. 17. Black, urushi-containing filler extruding from rear of panel

Another thought, more interesting and possibly fraught with Gilded Age societal intrigue, relates to Isabella Stewart Gardner. Rokkaku Shisui was a famous Japanese lacquer master and designer who was brought to the Boston Museum of Fine Arts (MFA) by Asian Arts curator Okakura Tenshin (fig. 22). He worked on Japanese lacquer cataloging and conservation until 1908—in the meantime traveling to the Metropolitan Museum of Art and museums in England. Isabella Stewart Gardner was quite friendly with Okakura and knew Rokkaku as well. In fact, he stayed frequently at Mrs. Gardner's guest house and is recorded to have appeared in photographs there from that period.

Unquestionably, there was social exchange between Boston and Newport: for instance, John LaFarge was a major personality who moved in both communities. Perhaps Rokkaku-san would have known of a practitioner through the Tokyo Fine Arts School willing to take on a well-paying lacquer commission. There is another fascinating tidbit: Anne Nishimura Morse, senior curator of Japanese Art, MFA Boston, published a few paragraphs about Rokkaku for an exhibition, and in it is mentioned that "he was experimenting with a 'pitchy substance' for potential use repairing panel paintings."

Pitchy substance? Panel paintings? Sounds familiar.

We may never know exactly who this person was, but some things we do know: he was a genuinely good lacquer artisan, and we are sure that he had a sense of humor. How do we know? We as conservators are frequently privy to the hand of those who preceded us—the ghostly practitioners—because we see the evidence, such as we have seen so far. Sometimes it is subtle and hard won, found by examining the materials, identifying techniques, and gleaning information as is presented visually in UV or IR light, using cross section examination, or by

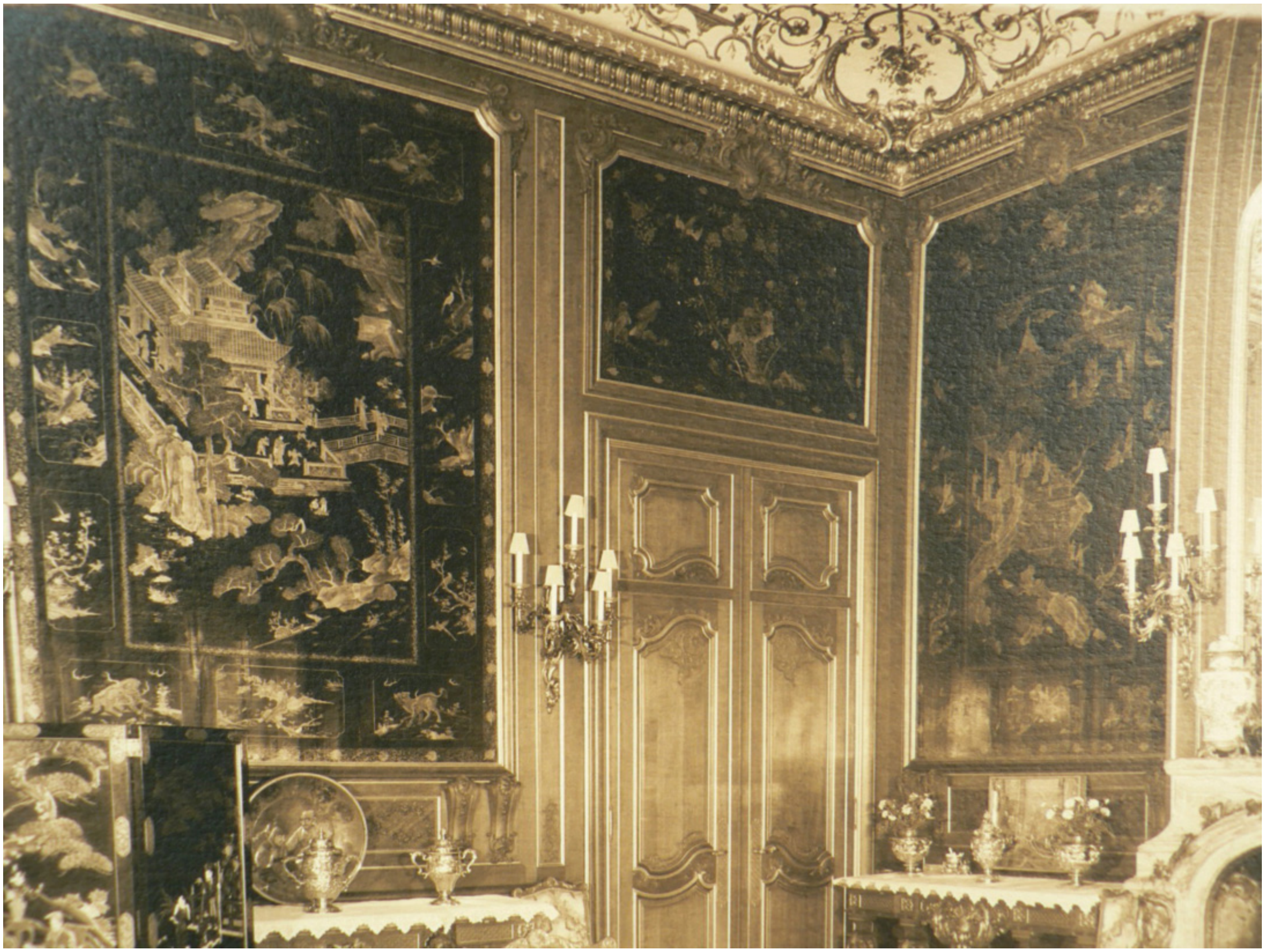

Fig. 18. Vintage photo of the Breakfast Room in 1901

scientific analysis. Sometimes there are more obvious witness marks like on those cradles or signatures, as on a crawl space stud the list of Irish plumbers from New York City who worked at Marble House or like those by craft practitioners at the Isaac Bell House (fig. 23).

The author confesses to a moment of weakness, when he had the opportunity and context to "sign" his work. As a young conservator, he was working on some overdoor woodwork in the Gothic Room at Marble House. One of the grotesques in the trumeau over the door was missing its head and neck. Using a similar grotesque in the room, he made a mold and cast a copy of the missing part . . . only adding a mustache like his own (fig. 24). The world of Gothic wood and stone carving was and is rife with personal commentary—that is his defense and he is sticking with it.

Our lacquer practitioner seems to have had a similar inspiration. Maria Joâo Petisca was working on the South panel and spoke up (in her unique declarative manner): "There is a man in the moon." Not knowing what to make of such a statement, we went over to have a look. Sure enough, his image shows faintly in the shining moon, and he looks like the genial sort (fig. 25). The author sincerely appreciates this bold, irreverent move on the part of the artisan. Did he just want to say "I was here"? Is it a personal commentary on the quality of his work versus the original? We do not know his motives, but we do know that his work was fine and he left his mark in more ways than one.

Hello ghostly presence, nice to see you! Maybe we will get to know you better someday.

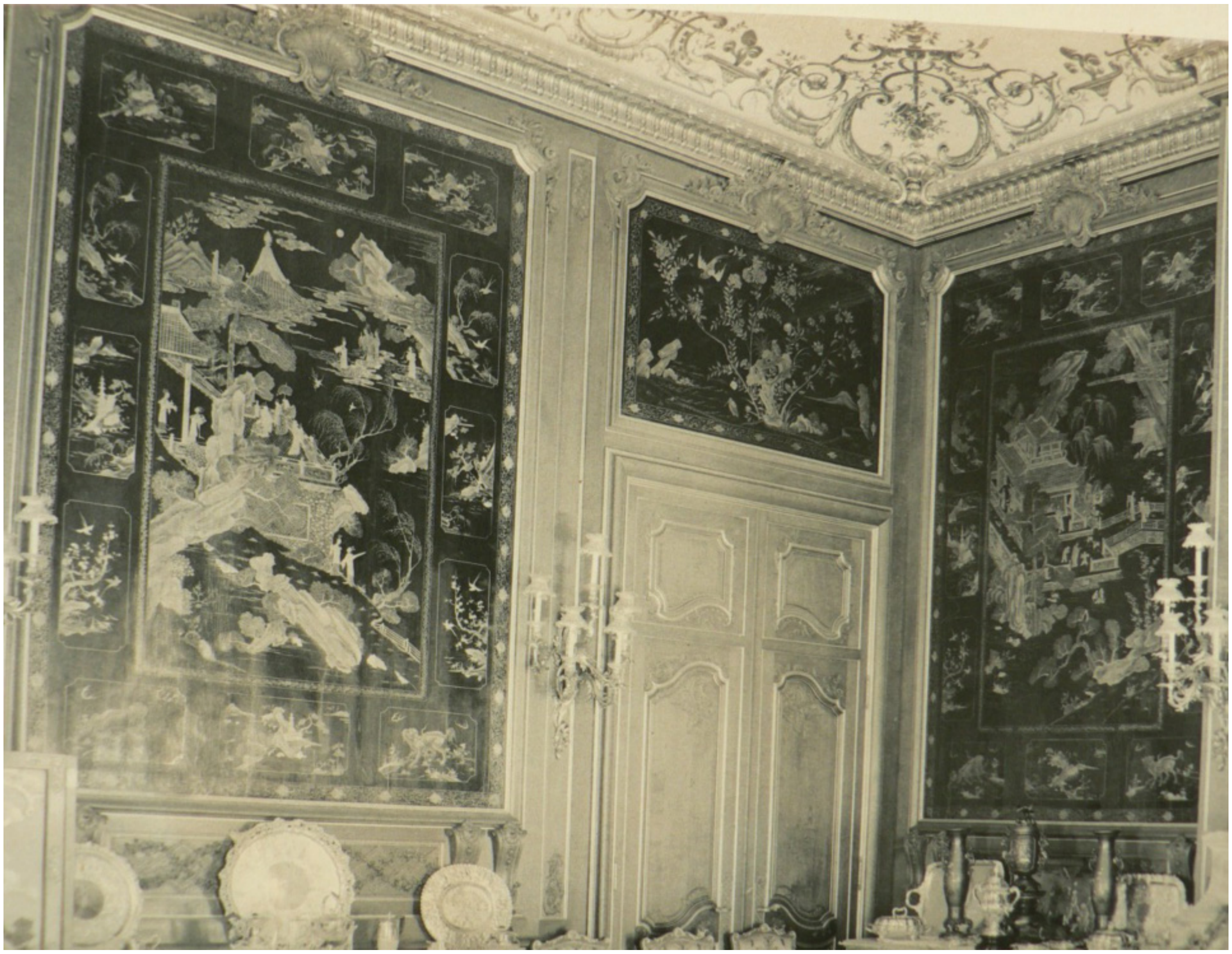

Fig. 19. The Breakfast Room in 1927. Note how the panels have been switched.

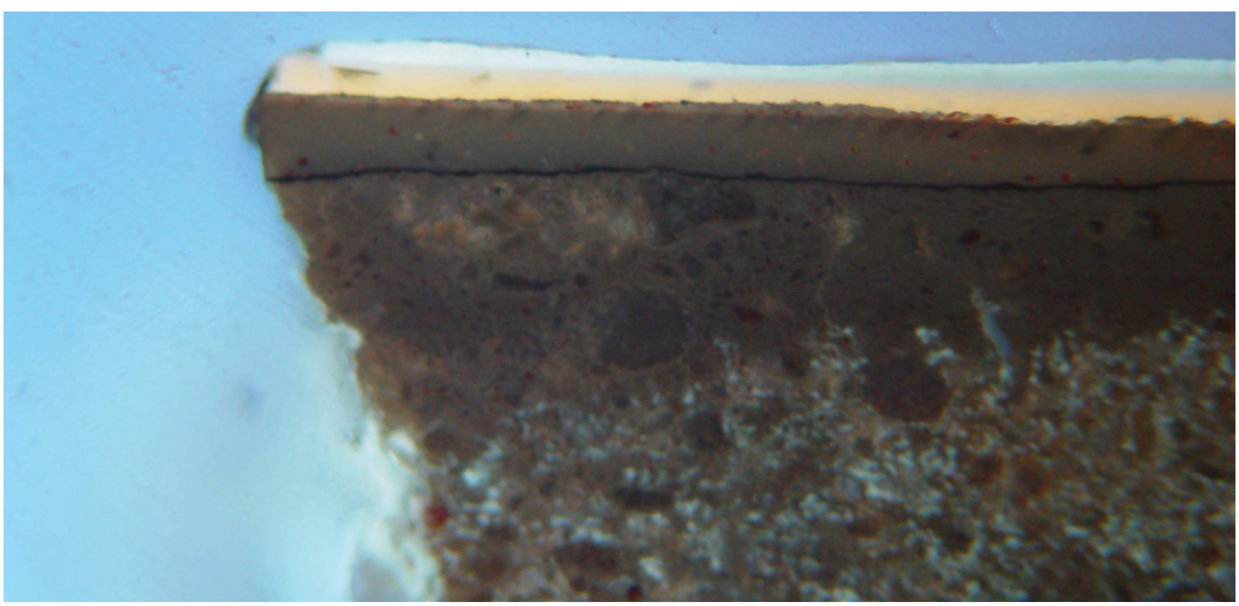

Fig. 20. The presence of urushiol and the black line in the cross section suggest a Japanese practitioner.

紐育支店

Fig. 21. Yamanaka and Company in New York

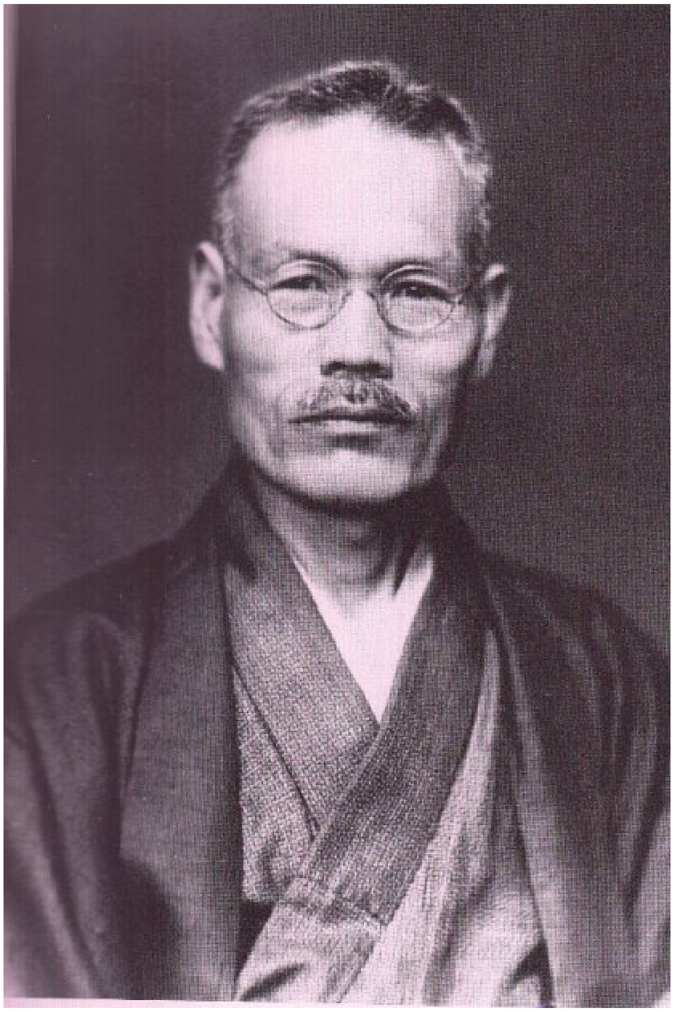

Fig. 22. Rokkaku Shisui, lacquer master and professor at Tokyo Fine Arts School

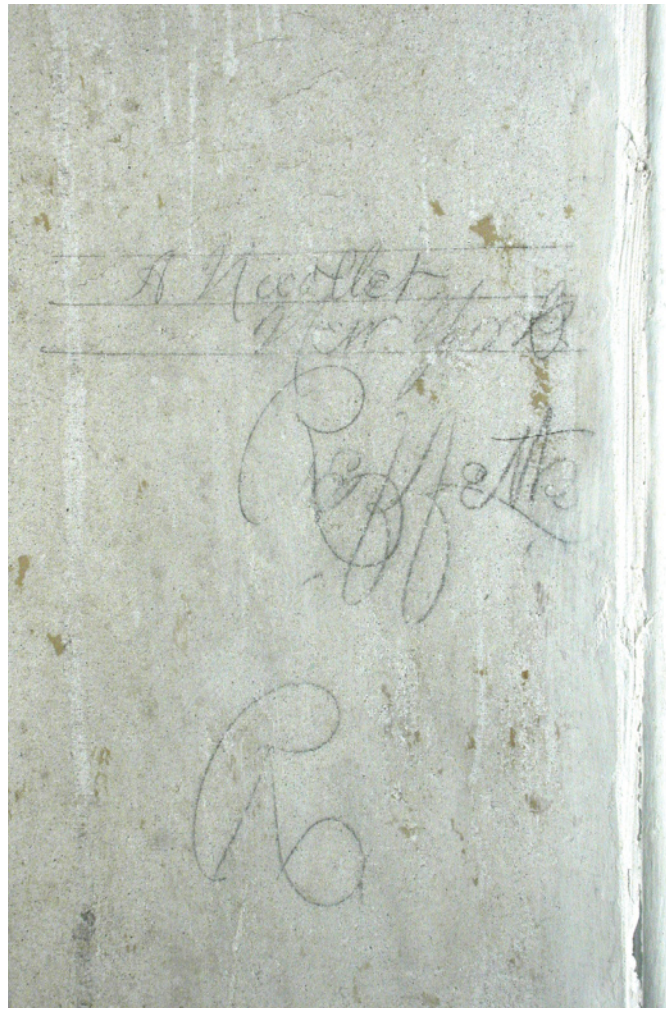

Fig. 23. Workmen signed the wall at the Isaac Bell House, likely the upholsterers who installed the textile-covered walls.

Fig. 24. Grotesque with suspicious mustache at Marble House—a modern, cast replacement

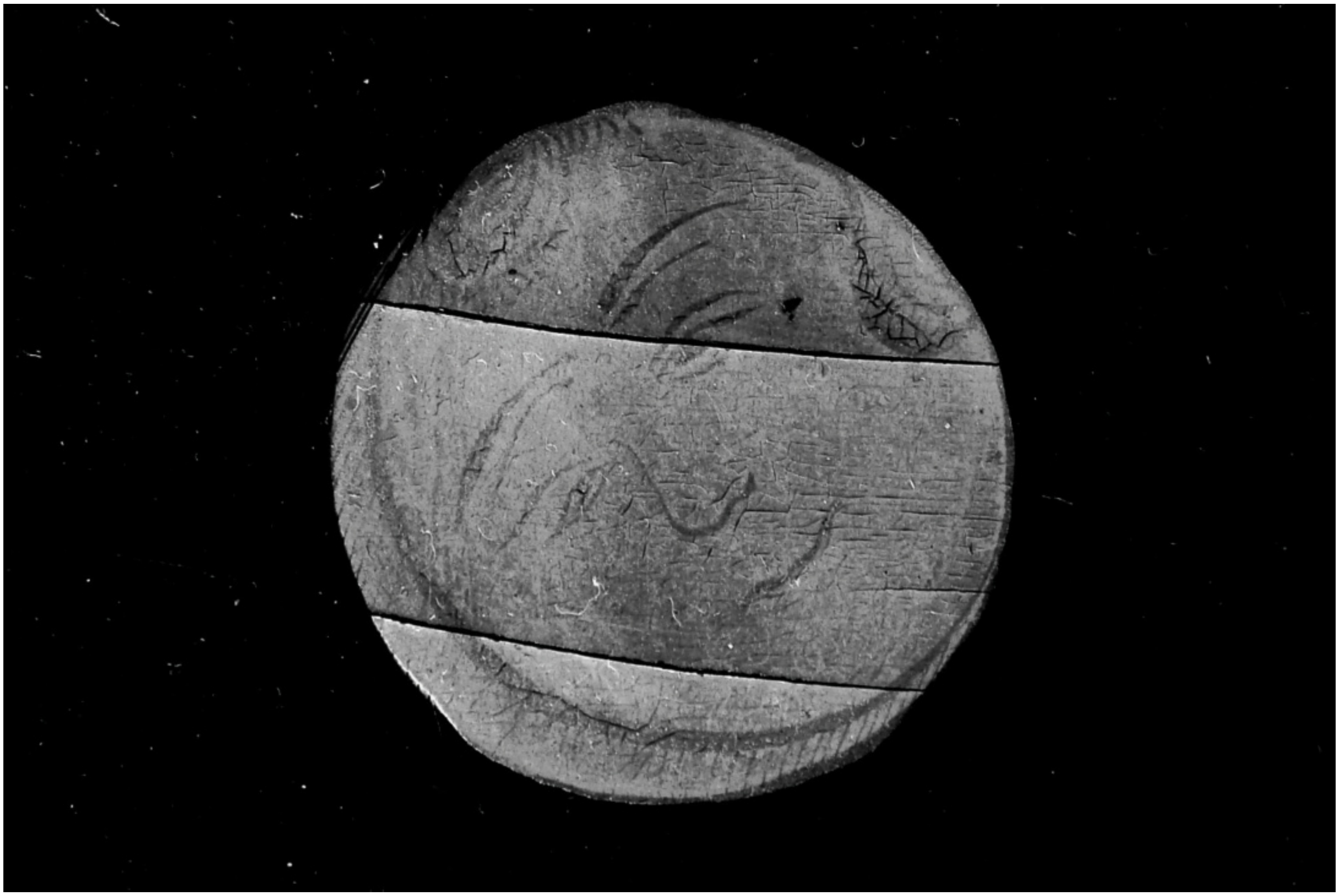

Fig. 25. The Man in the Moon, desaturated and enhanced for clarity in Adobe Photoshop

AUTHOR BIOGRAPHY

CHARLES JEFFERS MOORE (JEFF) enjoyed a 10-year career as a cabinet maker, which culminated in being chief carpenter of the Washington National Cathedral in Washington, DC. He was then fortunate to obtain a position at the Preservation Society of Newport County, during which time he completed his BS in Historic Preservation at Roger Williams University and was accepted as a Fellow in the Furniture Conservation Training Program at the Smithsonian's Conservation Analytical Laboratory. He has served as program chair and chair of the Wooden Artifacts Group. He retired in June 2015 after 31 years at the Preservation Society but continues to do limited work in private practice. In 2016, Jeff served as Conservator in Residence in the CRAFT Program at the Forbidden City, Beijing.

ALLISON JACKSON, ADELINE LUTTS, AND CAROLA SCHUELLER

The ABC's of a Monumental Frame: Analysis, Bronze Paint, and Chelators

ABSTRACT—This article focuses on the technical examination and conservation treatment of an 18th-century English carved and gilded Carlo Maratta frame of monumental size. The frame is original to the painting *Devout Men Taking the Body of Saint Stephen* by Benjamin West, dated 1776, held in the collection of the Museum of Fine Arts, Boston. Cross section examination confirmed the presence of water- and oil gilding underneath heavily oxidized bronze powder paint. Protocols were developed for large-scale gilding conservation. The conservation treatment included removal of bronze paint with chelator gels and inpainting and toning of the remaining gilding.

1. INTRODUCTION AND HISTORY

The large altarpiece painting by American-born painter Benjamin West, *Devout Men Taking the Body of Saint Stephen*, dated 1776, was commissioned for the centennial of the church of St. Stephen, situated in the central London neighborhood of Walbrook. The frame (object no. FR.4751) is original to the painting; early lithographs celebrating the church's elegant architecture showcase the painting in a frame of the same proportions and style (fig. 1). Drawings and prints show that the painting was first hung at the east end of the church, behind the altar and draped in red cloth. It moved to the north wall in 1850. During the 1940 London Blitz, bombs hit the church, but the frame and painting seem unharmed in a drawing of the aftermath. In the 1980s, the painting was deinstalled and placed into storage. The painting and frame resurfaced again in 2013, when they were sold at an auction to an anonymous American collector. They were loaned to the Museum of Fine Arts, Boston (MFA) and in 2014 were given as a gift in commemoration of the departing director, Malcolm Rogers.

Due to the scale of the object, conservation treatment took place in the MFA's Conservation in Action gallery, allowing visitors to view the entire process over 8 months. It became a

Fig. 1. Views of Benjamin West's *Devout Men Taking the Body of Saint Stephen* over the years

popular spot for school groups and tours. Curatorial text panels introducing the West frame and painting flanked the gallery's window. Conservators frequently updated visuals and text on a rail inside the gallery window to educate the public about the project. Images of microscopy samples, before and after images, and descriptions of the materials used, such as molds for casting and cleaning tools, were included. A pair of carts was custom made to maneuver the frame rails around the room such that they could be worked on from all sides.

2. EXAMINATION OF THE FRAME

2.1 CONSTRUCTION

The frame is a classic Carlo Maratta type, created by applying individually planed and carved elements of molding to a wooden substrate. The dimensions are 214 × 142 in. (5.4 × 3.6 m). Larger pieces of wood were glued to the substrate, whereas smaller moldings were attached with nails. The frame consists of five different elements of carved running ornament: an egg and dart molding, a feather or leaf and dart, a ribbon and stick, an acanthus leaf molding, and a running laurel leaf (fig. 5).

Except for the arched top, which is composed of six sections, each of the frame members is made up of one length of wood, likely pine. The wooden rails were clearly carefully chosen, as they are still incredibly straight despite having been cut out of the tree tangentially—with the tree's growth rings spanning the width of the rails. The corners are mitered and have small mortise and tenon joints, which act as keys holding the rails in plane. The miters are drawn together with long bolts and nuts that are embedded in the rails. The original construction is reinforced with hand-forged L-brackets screwed into the frame's back. Overall, the construction of the frame, carving, and original gilding are all of exquisite quality.

2.2 SURFACES AND GILDING

This complex frame was gilded in the tradition of 18th-century English craftsmen. Gilding techniques have been well described by Stalker and Parker in their *Treatise of Japanning and Varnishing*, published in 1688, and by Dossie in *The Handmaid to the Arts* from 1758 (Gregory 1991). The techniques described had not changed much in the interim, and English gilders were working in the same tradition as described in these manuals (Stalker and Parker 1688). The main innovations of the 18th century are the intricate design of various ornamentation and molding in one frame, the skillful combination of burnished and matte surfaces, and the subtle toning of surfaces (Dossie 1764). However, a later restoration, in which a second coat of gesso was added, obscured the quality of the craftsmanship and beauty of the frame.

An area of first-generation gesso exposed by conservators reveals a more defined surface (fig. 2). Details such as recutting

Fig. 2. Detail of exposed first-generation gesso and oil size next to second-generation gilding.

Fig. 3. Sight edge with original water gilding

to form veins in the leaves were more clear, and carvings such as the ribbon and stick had more depth.

The presenting surface included two generations of gilding under a layer of corroded bronze powder paint. The second-generation surface is entirely oil gilt, except for the cove in which the acanthus leaf ornament sits, which is water gilded. Losses throughout the frame reveal both highly burnished water-gilded surfaces as well as oil-gilded passages. The first generation of water gilding is distinguished by a plum-colored bole (fig. 3). The second generation has a red bole and a bright orange-tinted oil size.

Traditionally, tinting oil size serves several purposes: (a) to make it easy for the craftsman to see where the size was applied to ensure coverage, (b) to disguise faults in the gilding, and (c) to enhance the tone of the gold leaf itself.

In the case of this frame, craftsmen economized where possible: the outside edges of the top rail are not gilded, nor is the area underneath the acanthus leaf ornament; portions of the egg and dart ornament on the arched upper member, which would not have been visible to the public, were left uncarved.

2.3 Examination of Cross Sections

2.3.1 Objective and Methodology

The objective of the technical examination was to determine the decorative scheme and confirm what was seen with the naked eye. Systematic documentation and interpretation of cross section images helped to distinguish between different gilding techniques and gesso layers.

Samples cast in transparent Bio-Plastic resin were sanded down to expose the individual layers in cross section. They were examined using an Olympus BX51 binocular microscope under a bright light filter, in visible light (VIS light), and under UV radiation (UV light) at a magnification of 50x, 100x, and 200x. The first group of samples were taken with a scalpel, and a second set of samples was taken with a jeweler's saw. The latter had the advantage of all layers staying intact, so the sample was of better quality; the disadvantage was that more original material was sacrificed. The cross sections were photographed using Q-Capture imaging equipment and software. For consistency, samples were taken from all four frame members. Different gilding techniques were expected on various parts of the ornamentation, so each type of molding was sampled, as well as the three coves and the outside edge of the frame (fig. 4).

2.3.2 Conclusions

Cross section examination confirmed observations made with the naked eye; the gilded surface decoration of the frame consists of two generations of gilding with a bronze paint coating on top.

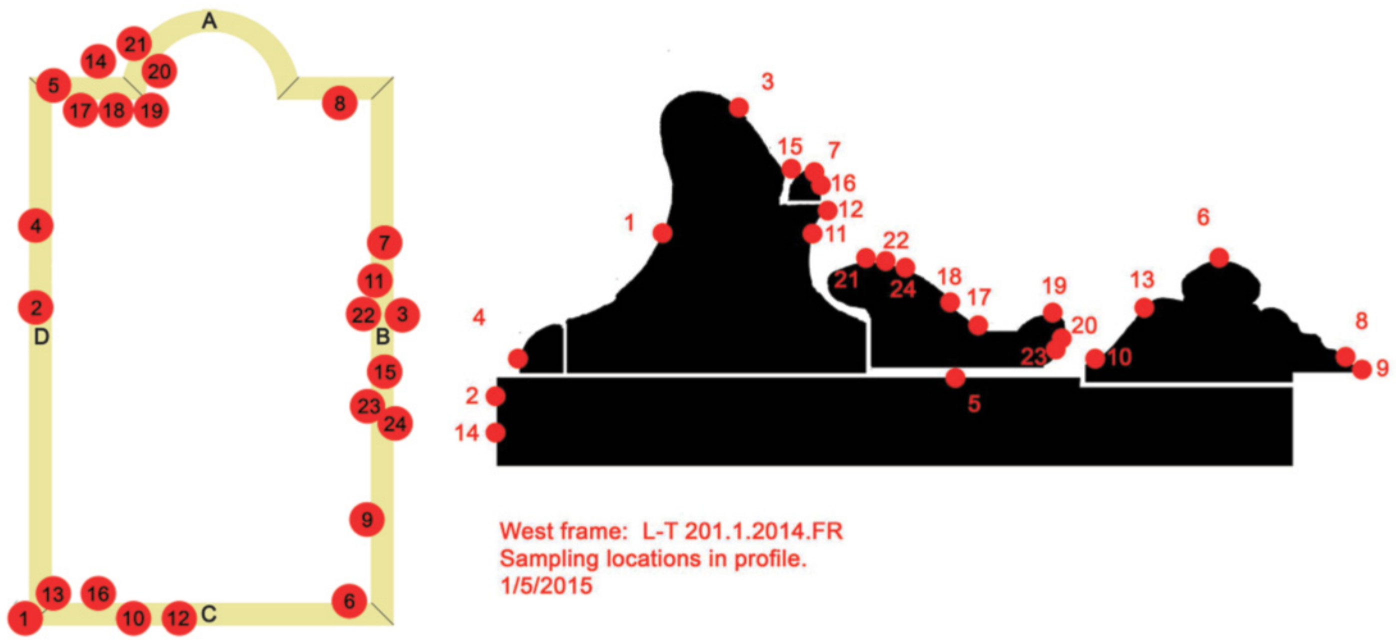

Fig. 4. Overview of sample locations, maps in plan, and elevation.

The original gilding scheme had burnished water-gilt areas alternating with matte oil-gilt areas to maximize the effect of the reflecting of light off the gold leaf. The coves and the ogee at the sight edge were water gilded. All areas with intricate, relief carving were oil gilded. The central acanthus leaf ornament showed an alternating pattern of matte oil gilding and shiny water gilding. The following diagram illustrates the original gilding scheme (fig. 5).

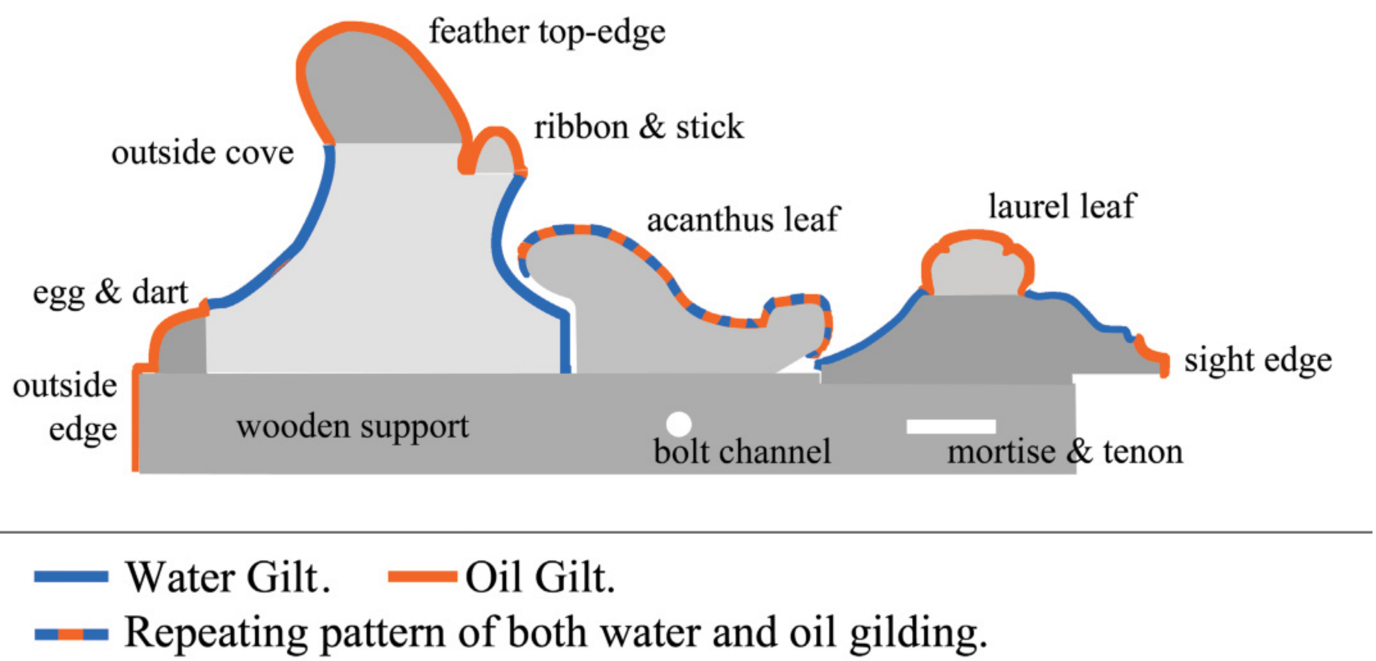

Fig. 5. First-generation gilding with water gilding in blue and oil gilding in orange (MFA FR.4751).

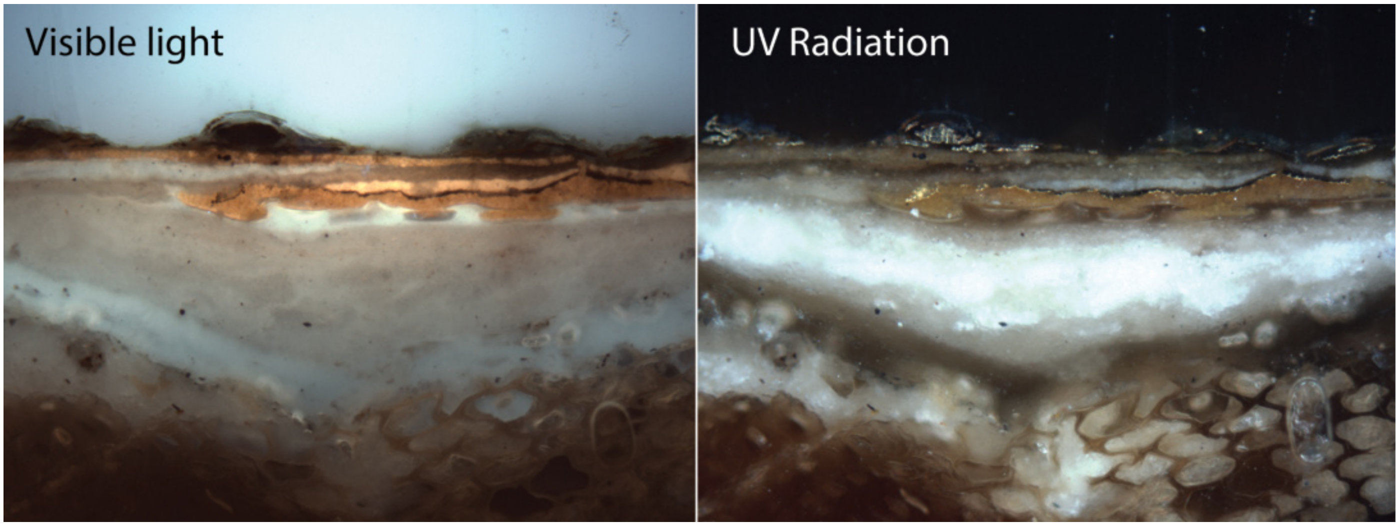

Fig. 6. Transparent sealing on wood in sample 3 in visible light, 200x magnification. Bluish fluorescence of sealing layer in sample 3 under UV radiation, 200x magnification

Cross sections of the first-generation oil gilding showed a transparent sealing layer of glue, most likely animal protein, on the wooden surface, fluorescing in a typical blueish color under UV radiation (fig. 6). On top is an even and thick gesso layer on both water- and oil-gilded areas. Different densities and binder concentrations are visible within the gesso, which indicates the application of multiple layers, as is done in general gilders' practice. Contemporary literature on gilding techniques describes how gesso layers are built up (Gregory 1991). Original oil-gilded areas show a sealing layer on the gesso to provide a base for an oil-bound paint or bole. This layer fluoresces the same in all samples, a bright whitish-blue color, and is likely a varnish or varnish mixture. This is followed by a yellow bole or paint and gold leaf on top. Some samples show the oil size directly underneath the gold leaf, fluorescing bright orange under UV radiation (fig. 7).

Water-gilded areas show a plum- or red-colored bole on the top of the gesso. The bole has large, dark particles indicating a glue-bound earth pigment (fig.8).

Cross sections taken from the different leaves of the acanthus ornament confirm the pattern of oil- and water gilding within the same element, which again shows the skilled and deliberate combination of the two gilding techniques.

The ribbon and stick and laurel leaf ornament show three layers of gilding. The second and third likely represent double gilding, a method to ensure coverage in areas of ornament that has a lot of undercuts and is therefore hard to gild in one pass. The outside edge shows three generations of yellow and ocher paint, and was never gilded. Examinations also show that not all areas were prepared with gesso in the same manner. The egg and dart ornament at the back of the frame, for example, has only a thin preparation gesso layer. The cove hidden by the acanthus ornament seems to have a very thin bole layer on top of the gesso and was made of rougher and larger particles than visually exposed areas. Either the gilder spent less time grinding and straining the particles or purchased a cheaper pigment.

3. CONDITION OF THE FRAME

3.1 SUBSTRATE, JOINERY, AND HARDWARE

Taking into consideration the age of the frame, the wooden substrate was in good condition overall. Two of the structural bolt channels had areas of splitting and loss. All bolts used to secure the miters were missing, but the original nuts that corresponded to the bolts were still embedded in the frame rails. The nuts were hand forged, about 1/4 in. thick, and had approximately 1 1/2 worn threads. The frame had its original hanging hardware, two 9 in. long iron brackets with large rings at the top, attached by screws to the reverse of each of the side rails. Similar in composition and age, large hand-forged L-brackets used to reinforce the miters were also present, but three of the six were lost.

Small dowels could be seen from the back of the frame at each of the miters, corresponding to holes in the lost L-brackets. The dowels were likely used to fill holes left by screws that were once used to fasten the hardware, and in some places protrude through the substrate, resulting in cracks in the front face of the frame. The dowels were an indication that the hardware had been removed and reattached.

3.2 ORNAMENT

The frame's carved wooden ornament was in great condition for its age and mostly complete. There were areas of damage, including dings and abrasions, small losses, and lifting molding.

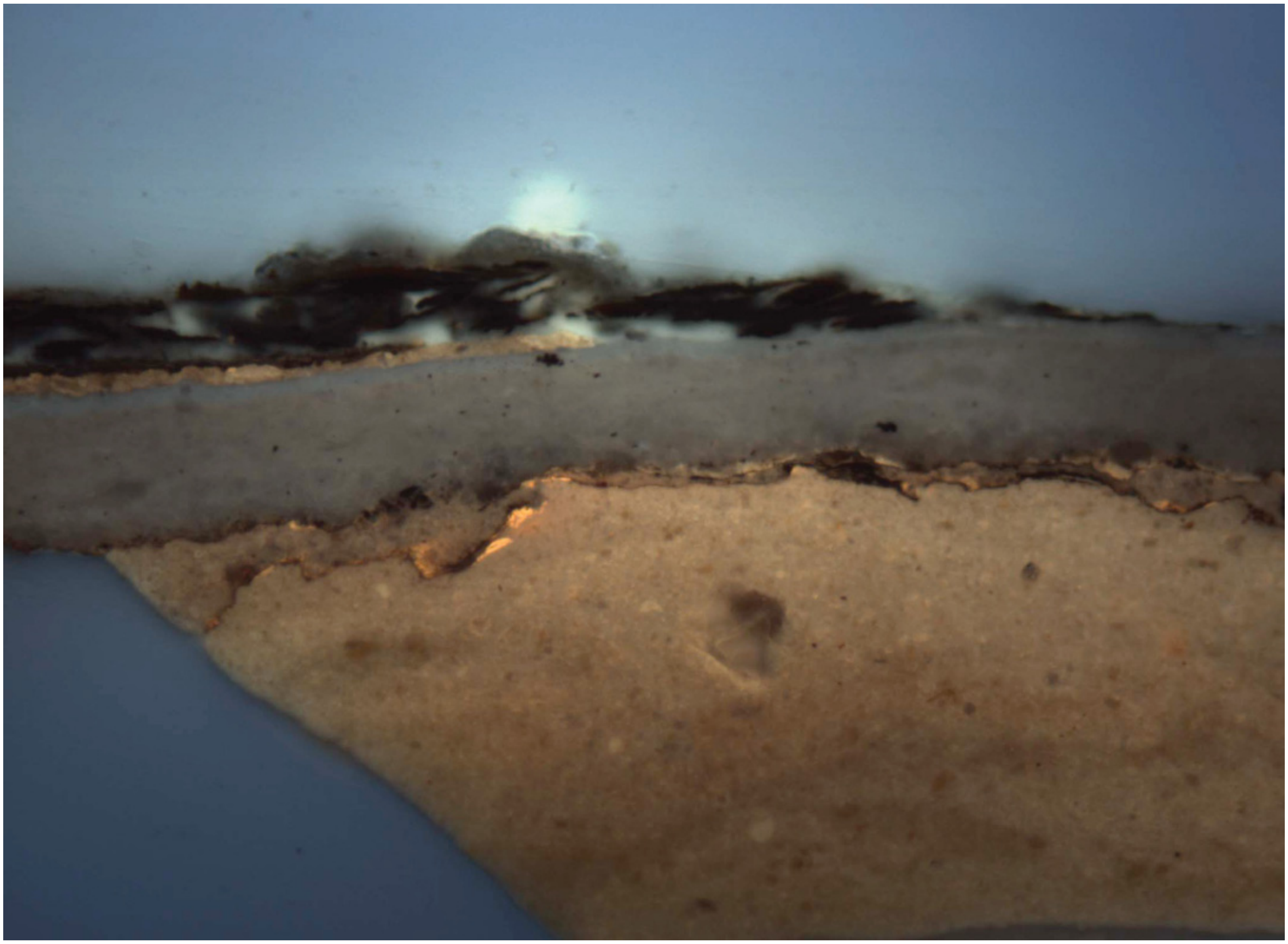

Fig. 7. Fluorescing oil size under first-generation gilding in sample 7 under UV radiation, 200x magnification

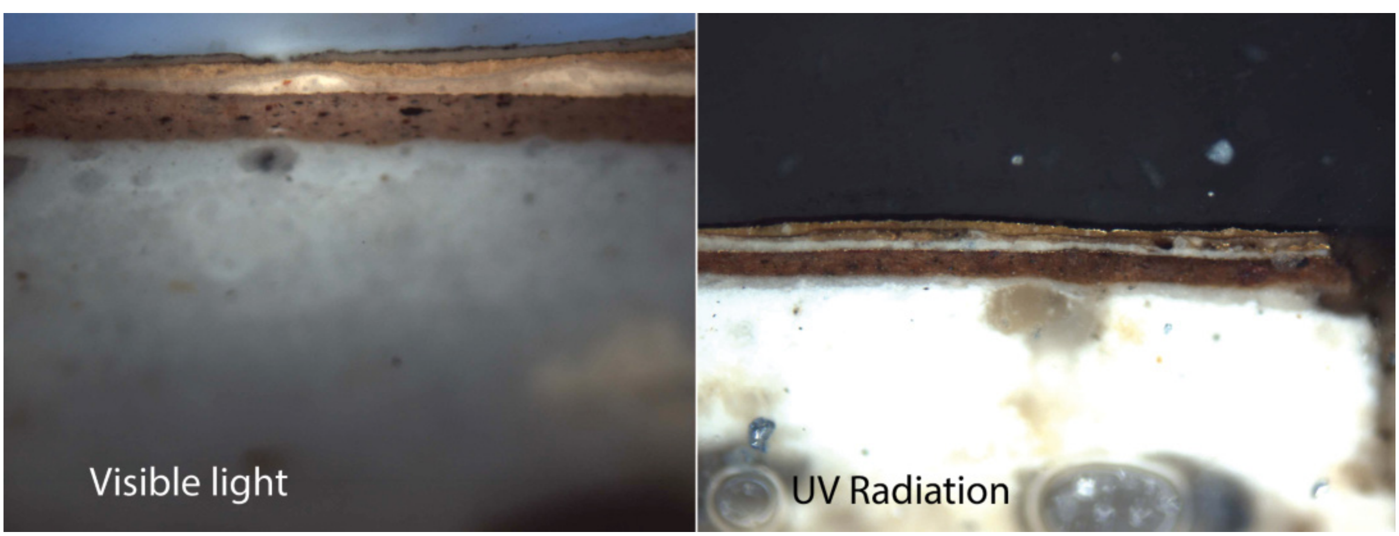

Fig. 8. Sample 1 in visible light 100x, and UV radiation 200x, example of first-generation water gilding at the back cove

Most of the damage had occurred near the miters, along the sight edge cove, and to the top edge ornament—all typical areas of wear.

3.3 PAINTED AND GILDED SURFACES

The surface of the frame was in poor condition, with lifting and cracking gesso, flaking, tarnished overpaint, and a thick layer of dirt and dust. The gilding was abraded, and in many areas there was little or no gold left. Gesso, bole, and crazed oil size were all visible.

Darkly oxidized bronze powder paint coated over 80% of the frame surface in varying thicknesses. In many instances, visible brushstrokes indicated how the paint was applied.

Large flakes of the second gilding campaign of gesso and gold leaf had taken the original gilding with them as they delaminated. The original gold leaf could be seen on the back of individual flakes. It is likely that the second generation of gilding involved binders that were significantly stronger than those of the original gilding. Crazing was evident throughout the ornament where the oil size pooled or was thickly applied; it has since shrunk, pulling gold, finish, and surface dirt with it. Areas of crumbling in the recesses of the ornament consisted of a buildup of dirt and bronze particles.

4. CONSERVATION PLAN AND TREATMENT

Due to the condition, multiple layers of gilding, instability of the surface, and presence of bronze paint, the gilding treatment was challenging. It was not practical to expose the original surface, as the second-generation gesso was firmly adhered to the original gold leaf, and there was no way to separate the two. Not being able to return to the original surface, the second generation would have to remain as the majority of the presenting surface. Gilding even portions of the frame was decided against because the existing surface was too compromised. Regilding would not have been possible because of the disrupted surface and budget. These factors led to the decision to stabilize existing gilding and to improve the visual experience of the remaining surface. Because of the complexities and poor condition of the frame surface, the conservation treatment was not fully designed at the outset but rather was taken one step at a time so the condition could be reassessed and all options could be considered along the way.

4.1 CLEANING AND CONSOLIDATION

The first step of the treatment was to carefully remove the thick layer of surface dirt that had accumulated after 30 years of storage by using a vacuum and soft brushes. Once the majority of surface dirt was removed, the extent of the flaking and loss was more visible and the frame could be consolidated. Lascaux 4176 Medium for Consolidation was chosen after testing multiple consolidants, including rabbit skin glue. After an initial round of consolidation, the frame was cleaned with dry sponges; two types Wishab and Magic Eraser vulcanized rubber sponges were used. The dry sponges chosen were non-invasive, did not leave a residue, and were very easy to control. After several passes of dry-cleaning, everything was consolidated again.

4.2 REMOVAL OF OVERPAINT

4.2.1 From Water Gilding

The thickly applied and corroded bronze paint on top of water gilding was removed with Zip Strip, a common methylene chloride paint stripper. Left on the surface for a few minutes, it worked to remove swaths of bronze paint from the water-gilded portions of the frame on either side of the cove beneath the acanthus leaf ornament. The cleaning revealed an abraded surface of gesso, bole, and what remained of the gilding.

4.2.2 From Oil Gilding

Removing the bronze paint from the oil-gilded surfaces presented a challenge. Solvent testing under a microscope on a detached section of the acanthus leaf ornament was undertaken to determine how to proceed. The oil gilding was soluble in all of the same solvents that solubilized the paint. Gelled solvents had the same problem. A solution was found in chelating chemicals, which targeted the bronze particles instead of the binder. By using an aqueous gel with ethylenediaminetetraacetic acid (EDTA), the corroded metals could be precipitated into the gel and then rinsed away with water. Gels at a pH of 7.5 and 8 worked best on the heavily corroded areas of bronze paint, without damaging the surface below. A water-based, polar gel can do damage to gesso, as the chelators also sequester calcium carbonate. Thus, it was important that the gel was not left on for too long.

Working in foot-long sections on each of the different bands of running ornament, the chelator gel was brushed on; after sitting for 3 to 5 minutes, the gel was removed with cotton moistened with deionized water. After treatment with the chelating gel, the bronze paint structure was broken down; areas with remaining overpaint could be further removed with ethanol-soaked poultices and cotton swabs. The ethanol did not affect the oil-gilded surface.

None of the processes removed all of the bronze paint from the frame surface, but the effect of the paint removal was significant in revealing the second generation of gilding, bringing the bright reflective quality of the gold leaf back to the frame surface. The bronze paint removal also revealed how compromised the gilding was, as much of the gesso was now exposed (fig. 9).

4.3 SURFACE INTEGRATION

After ruling out any form of regilding or in-gilding, inpainting was chosen as the best method to integrate the discrepancies created by the many losses on the treated frame surface. Golden fluid acrylic emulsion paints were chosen mainly because of previous experience with the medium, its ability to imitate gold, and for its reversibility and long-term stability. A final coating of dilute rabbit skin glue, a traditional toning material for gilded surfaces, was applied to create a protective layer, visually tie the whole piece together, and to counteract the synthetic sheen of the acrylic paints (fig. 10.).

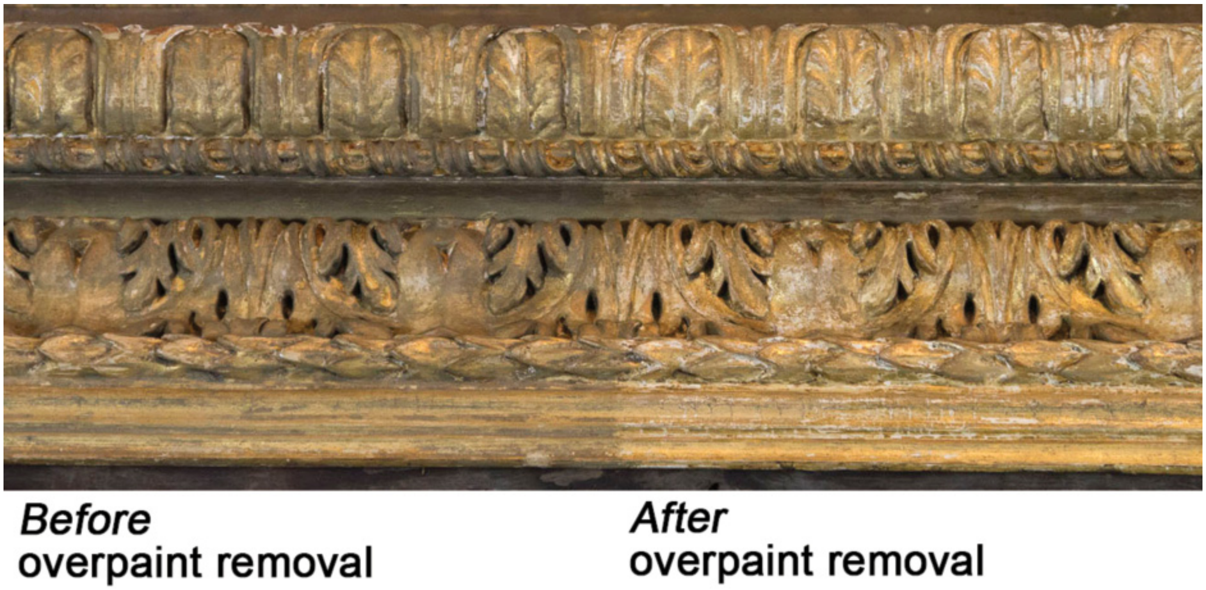

Fig. 9. Section showing the gilding before and after removal of corroded bronze powder paint

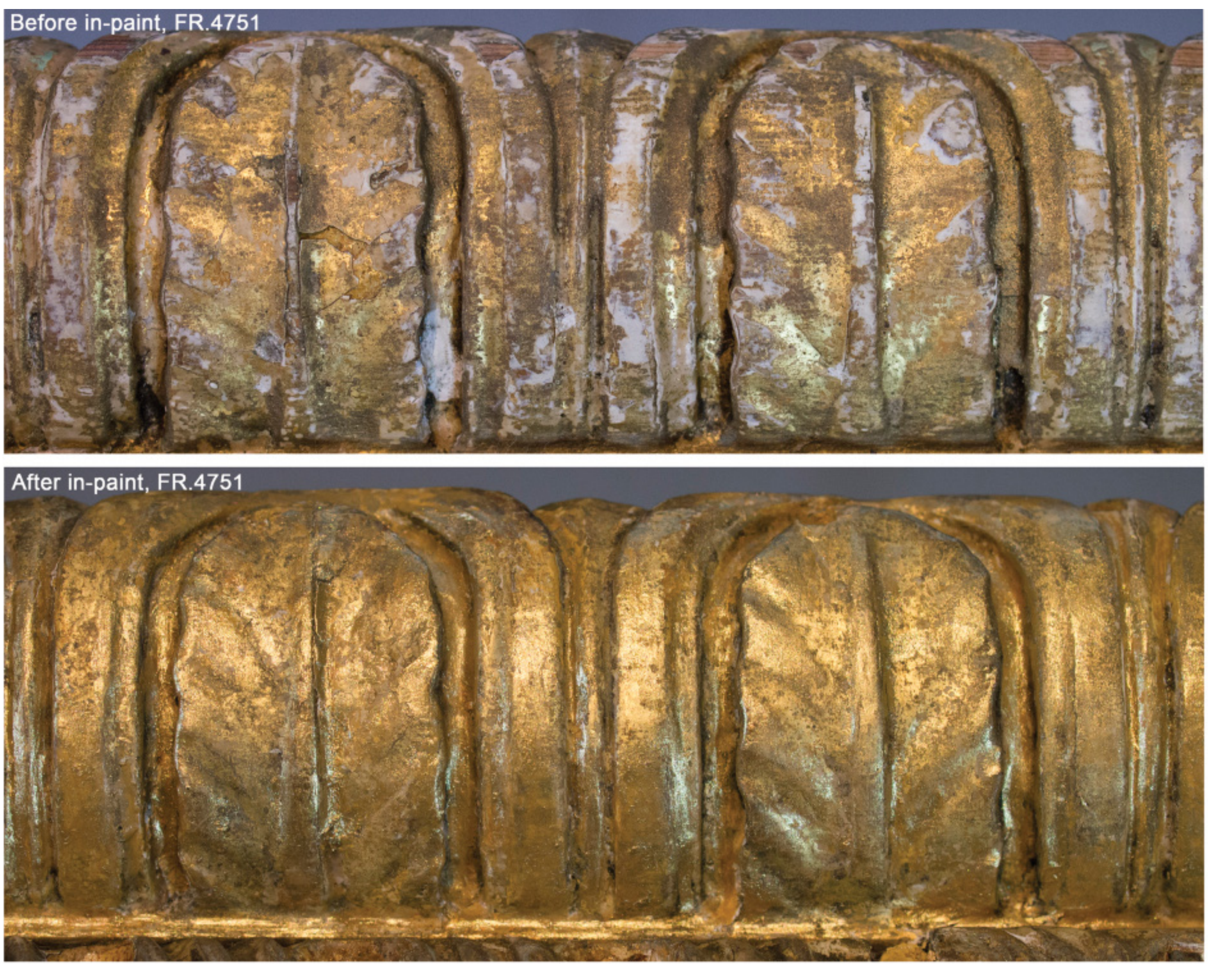

Fig. 10. Section showing the frame before and after in-painting.

4.4 DOCUMENTATION

Detailed documentation and photography were essential because of the scale of the project. Maps and diagrams were not only created to educate the public, but to keep track of the information collected, and to inform future conservators.

5. CONCLUSION

As frame conservation gains ground in the larger professional conservation field, projects like this one become possible. It is important to dedicate time and resources to frames as significant objects, as with the paintings within, enhancing the integrity of both components. Although the frame could not be returned to its full original splendor and glory, the results were successful. The opportunity to do a full-scale examination and treatment of a frame of this scale is rare. The information gained by analysis of the gilded surface closely supported the conservation plan and will inform future gilding conservation projects.

SOURCES OF MATERIALS

Bio-Plastic Resin (http://www.wardsci.com)

Lascaux 4176 Medium for Consolidation (http://www.kremer-pigments.com)

Golden Fluid Acrylic Paints (http://www.goldenpaints.com)

Wishab Sponges (http://www.conservationresources.com)

Magic Eraser, vulcanized rubber sponge (http://conservation-supportsystems.com)

Zip Strip (http://www.acehardware.com)

Rolling carts were made of plywood with lockable casters. They had a good working height of 37 in. Two people were able to move the rails on and off the lumber storage racks on which they were kept and onto the carts. The long rails were a tight fit in the room with the West painting, and having the ability to shift them around safely and efficiently was key.

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Stalker, J., and G. A. Parker. 1688. *A treatise of japanning and varnishing.* London: Oxford.

AUTHOR BIOGRAPHIES

ALLISON JACKSON a second-generation gilding conservator, received her BA in Studio Art from the University of Vermont in 2002. She subsequently trained with a master carpenter in Hawaii for two years. Upon returning to Massachusetts, she did freelance work for several well-respected furniture and gilding conservators, and for the Museum of Fine Arts, Boston. In 2009 she was hired to work in the MFA's frame conservation department where she became Assistant Frame Conservator. In 2012 she became the first Frame Conservator at the Harvard Art Museums' Straus Center for Conservation and Technical Studies. In 2016, she was awarded The Nigel Seeley Fellowship, by the Royal Oak Foundation, the American partners of the National Trust, UK, with a focus on gilding. Allison currently works as a freelance gilding and frame conservator for museums including The Harvard Art Museums, the MFA, Isabella Stewart Gardner Museum, the Davis Museum at Wellesley College, and The Rhode Island School of Design Museum, as well as private clients. Address: 33 Preston Rd., Somerville, MA 02143. E-mail: jackson.allison@gmail.com

ADELINE LUTTS received her BA in Studio Arts from Smith College in 2005, where she began her study of conservation at the Smith College Museum of Art. She worked as a frame conservator at the Museum of Fine Arts, Boston (MFA), taking classes in chemistry and woodworking before establishing herself as a freelance conservator of frames and furniture. She has recently rejoined the MFA as a conservation engineer in the objects department. Address: Museum of Fine Arts, Boston, 465 Huntington Ave., Boston, MA 02115. E-mail: adelinelutts@gmail.com

CAROLA SCHUELLER graduated from the University of Applied Sciences and Art in Hildesheim with a German Diploma in Conservation of Furniture and Wooden Objects. Prior to graduate school, she trained as a cabinetmaker. After graduation, Carola was a Sherman Fairchild Fellow at the Museum of Fine Arts, Boston. Subsequently, she worked as a furniture conservator at the Victoria and Albert Museum in London for 4 years. Since relocating back to Boston, she has been working closely with Christine Thomson on cross-sectional examination of historic paint and gilding. She recently started her own conservation business concentrating on the conservation of furniture, wooden objects, and frames. E-mail: schueller.conservation.service@gmail.com

WILLIAM B. ADAIR

To Fly or Not to Fly, That Is the Question: Conservation of a John Doggett Frame at Pilgrim Hall Museum

ABSTRACT—Frame conservators have often struggled with the removal of bronze paint and other accretions without disturbing the water-gilded surfaces. The delicate gold leaf is easily abraded in the conservation process; however, the typical protective coating made from parchment size is often the first element to be inadvertently removed. In the case of John Doggett's American Empire frame, substantial amounts of fly excrement on the surface were eliminated using organic enzymes.

1. INTRODUCTION

Gold Leaf Studios was contacted by AIC Fellow David L. Olin concerning the conservation of the John Doggett frame in conjunction with the conservation of the painting *Landing of the Pilgrims* by Henry Sargent. The studio made a preliminary discovery trip to Pilgrim Hall Museum to effectively determine the current condition of the frame and develop a recommended course of action for conservation.

Gold Leaf Studios discovered that the entire bottom rail and lower portions of the sides of the frame were covered in bronze paint, which had oxidized over time. The joint line between the two large members of the molding along the bottom rail was failing and highly visible. There were numerous areas of damaged gesso throughout the frame, and the original glue wash on the frame panel had been soiled by atmospheric debris, fly excrement, and numerous abrasions. The corner cartouches and tendrils, which had been carved and applied to the frame separately, did not line up properly and required adjustment. In addition, there were numerous areas of damaged ornamentation throughout the corner cartouches, notably along the edges and the exposed joint lines. The gilding over the wooden, hand-calligraphed nameplate had become worn over time, exposing the blue-gray gilder's clay.

2. TREATMENT

The cartouches were removed from the corners of the frame and transported to Gold Leaf Studios in Washington, DC, for conservation treatment. The next objective of treatment was to remove the bronze paint from the bottom rail and intermittent areas of the frame. The conservation team experimented with several gels and solvents to determine the safest method of paint removal. The paint was removed using a poultice of methylene chloride. This was followed by consolidating areas of loose and damaged gesso using a layer of shellac followed by a layer of rabbit skin glue.

All areas of major gesso damage were filled with gesso putty and sanded smooth to match the existing contours of the frame. The sides of the frame were painted with yellow ochre Japan paint, and the sides of the backboard were painted with raw umber acrylic paint. The joint line in the bottom rail was then filled with hand carved basswood adhered by PVA glue and reinforced with silk for stability. The joint was then re-gessoed and water gilded with 23.75-karat gold leaf over color-matched bole. Major cracks in the ornament, as well as all areas of damaged ornament on the cartouches and tendrils, were also filled with hand-carved basswood. The new carvings were affixed to the original ornamentation using PVA glue. The gilding for the stabilized and newly restored gesso areas were treated using a combination of burnished and matte finishes, then blended with a cotton swab and steel wool and toned to match the existing patina as closely as possible, with various reversible gold pigments.

The nameplate was removed from the frame before treatment, and a second, identical nameplate was discovered below. The curator at Pilgrim Hall Museum retained the second nameplate. The first nameplate was water gilded where necessary with 23.75-karat gold leaf over color-matched bole. The nameplate was then in-painted with black Japan paint to match the existing calligraphy.

3. NOTES

Upon removal of the painting from the frame, Gold Leaf Studios discovered that the frame could not be disassembled, packed, and transported to Washington, DC, as originally proposed. A workstation was set up in the museum hall, where a team from Gold Leaf Studios would proceed with the conservation on-site.

The cartouches were removed from the frame during the deinstallation process of the painting and frame. These were packed and transported to Gold Leaf Studios for photography and conservation and reattached to the frame during the reinstallation.

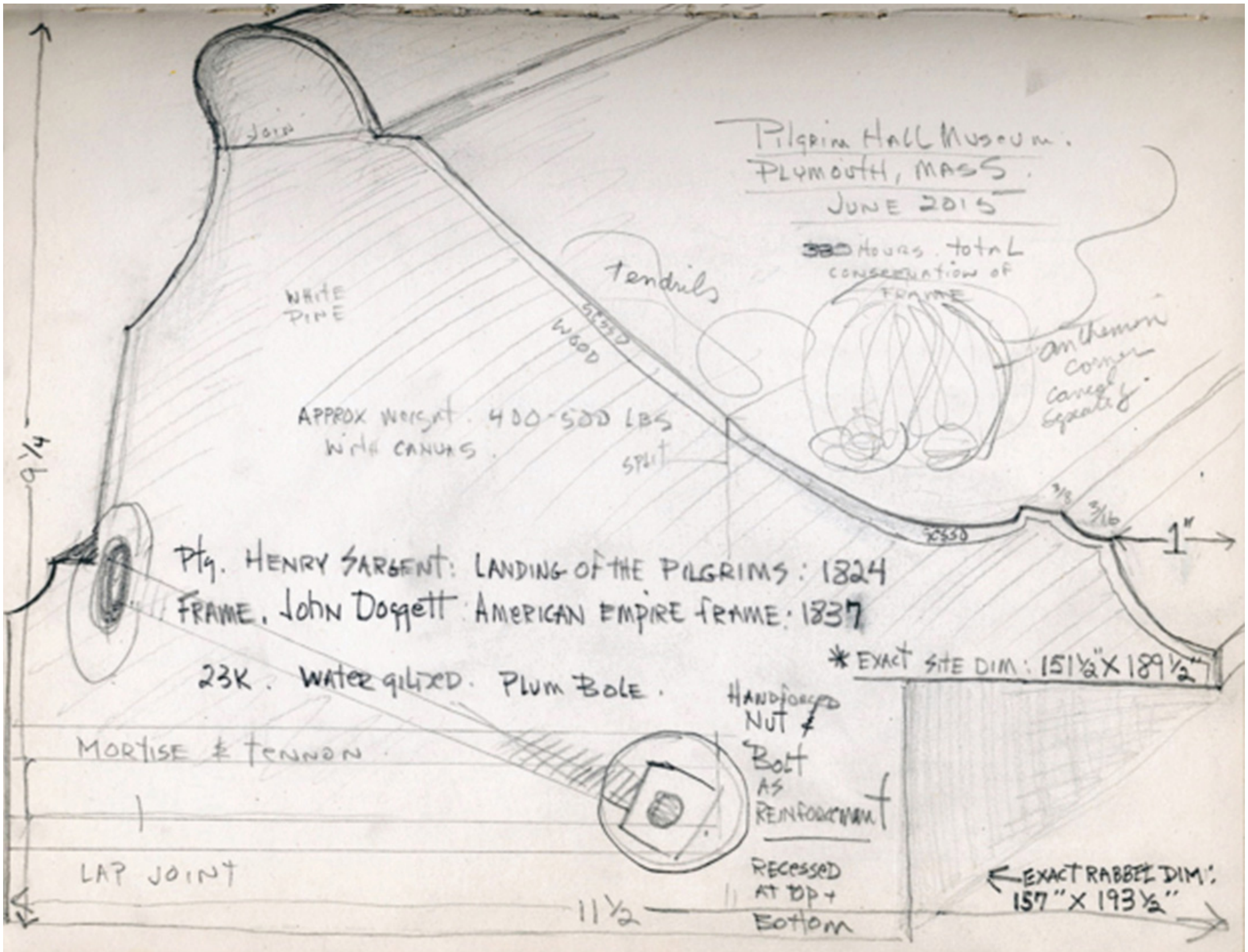

Fig. 1. Profile drawing by William B. Adair for the 19th-century American Empire frame made by John Doggett

Existing small fissures and cracks throughout the frame were not treated. These small fissures are typical for an object of this period and are considered part of the frame's patina.

The nail holes along the top, spaced every 3 in., and along the bottom were found to have fragments of lightweight fabric, most likely gauze, adhered to the metal. The fabric was found in the top and bottom of the frame only, indicating that the fabric may have been used as a fly abatement and protective cover.

A wood sample from the frame was analyzed and identified as *Pinus Strobus* (Eastern white pine) by Harry Alden, of Alden Identification Services in Chesapeake Beach, Maryland.

WILLIAM B. ADAIR is a frame conservator, frame historian, and master gilder. He began his career in frame conservation at the Smithsonian Institution's National Portrait Gallery, where he became fascinated with gilding and the history of frames. In 1975, the Smithsonian awarded William a grant to travel to Europe to learn about tools and techniques from the few remaining master gilders working in the Renaissance tradition.

Gold Leaf Studios was founded by William in 1982 and has become an internationally recognized authority on frame fabrication, conservation, gilding, and large-scale architectural gilding. The studio provides comprehensive framing services, including hand-carved reproduction frames of period styles and custom-designed modern frames.

Fig. 2. Intermittent sections of the frame were covered with bronze paint. The paint covering the entire length of the bottom rail and lower sections of the sides had oxidized over time.

Fig. 3. The joint line along the two large frame members was failing and especially visible along the bottom rail.

Fig. 4. The tendril ornamentation, attached by nails to the frame, did not line up properly with the cartouches at all four corners.

Fig. 5. Example of ornament loss found throughout the frame.

Fig. 6. Example of intermittent gesso loss found throughout the frame

Fig. 7. Current existing nameplate removal.

Fig. 8. Discovery of a second, identical nameplate hidden underneath the current nameplate.

Fig. 9. The Gold Leaf Studios conservation team removing the bronze paint from the bottom rail of the frame

Fig. 10. The Gold Leaf Studios conservation team removing the bronze paint from the ornament of the frame.

Fig. 12. Lower left corner before conservation

Fig. 11. Bronze paint is removed from the frame using organic solvents, exposing the original gliding and gesso loss along the frame.

Fig. 13. The lower left corner is covered with gesso and sanded down to match the existing contours of the frame.

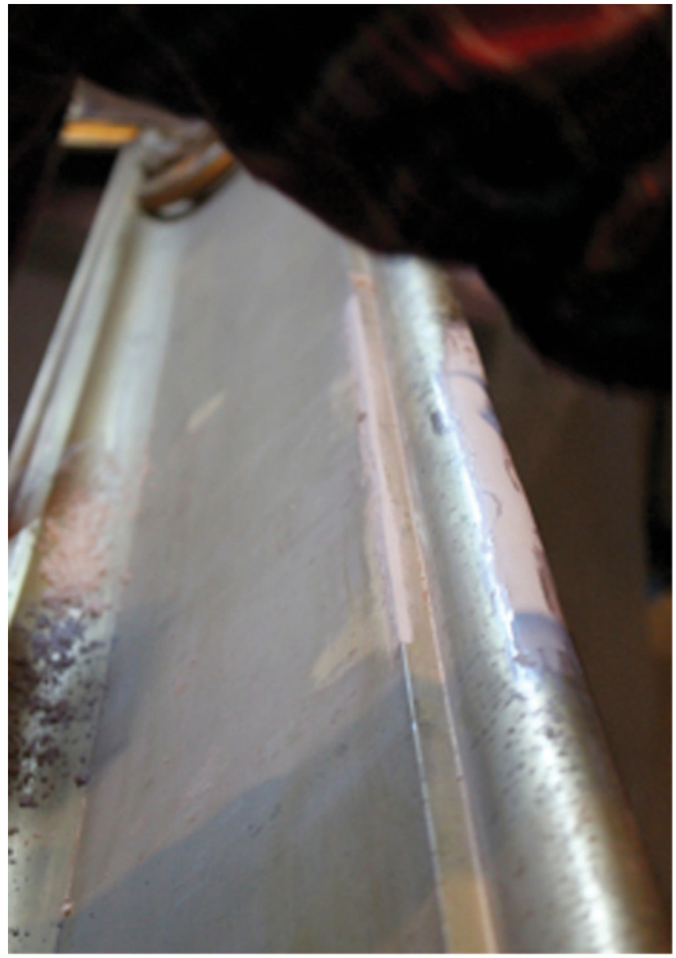

Fig. 15. Cracking and areas of loss along the frame were filled with putty and sanded down to match the existing contours of the frame.

Fig. 14. Cracking and areas of loss along the frame were filled with putty and sanded down to match the existing contours of the frame.

Fig. 16. Areas of missing ornament are filled with basswood

Fig. 17. The newly attached basswood was hand carved to match the existing contours of the ornamentation.

Fig. 18. A member of the Gold Leaf Studios conservation team coated newly restored areas in plum-colored gilder's clay to match the original clay color as closely as possible.

Fig. 19. Example of newly restored areas are coated in plum-colored gilder's clay.

Fig. 20. Chay Phung, senior conservator of Gold Leaf Studios, water gilding newly restored areas with 23.75-karat gold leaf.

Fig. 21. Close up of water gilding newly restored areas with 23.75-karat gold leaf.

Fig. 22. The circled area indicates examples of newly laid gold leaf. The gilding along the frame panel was blended and toned to match the existing patina as closely as possible. Newly restored areas along the outside rail are burnished with polished agate stones.

Fig. 23. The Gold Leaf Studios conservation team filling small cracks and minor gesso losses with gold pigments

Fig. 24. The Gold Leaf Studios conservation team filling small cracks and minor gesso losses with gold pigments

Fig. 25. A piece of basswood prepared to be affixed to an area of ornament loss using rods and PVA glue.

Fig. 26. Pieces of basswood are affixed to areas of ornament loss using rods and PVA glue.

Fig. 27. The basswood sections are hand carved to match the existing contours of the ornament.

Fig. 29. The top left corner is reattached in place before the frame is mounted to the wall.

Fig. 28. Lower left corner before (left) and after (right) conservation

Fig. 30. Small florets were carved and fit to each corner, covering the screw heads.

Fig. 31. Henry Sargent (1770–1845), *Landing of the Pilgrims*, 1818–1824, oil on canvas, 3.96 × 4.88 meters (13 × 16 ft), PHM 0039 after conservation and reinstallation. (Courtesy of Pilgrim Hall Museum, Plymouth, Massachusetts)

MARY-LOU FLORIAN

Branch Surprises: Anatomy, Identification and Conservation Concerns

ABSTRACT—The comparative anatomy of branches of coniferous and dicotyledonous trees and woody shrubs commonly used in making ethnographic artifacts has been shown to be useful in developing identification keys and to determine conservation care and curatorial issues. The anatomy of the pith was useful in the identification of the coniferous species studied. The delicate cellulose thin walls of the branch metabolic tissue suggest the fragility of the dried branch or withies. The ubiquitous presence of starch, sugars, and proteins, due to the metabolic activity in the branch or withies, presents a potential bio-deterioration problem impacted by climate change.

1. METHOD

Histological preparation of thin (5-μm) sections, stained with safranin and fast green, were prepared for light microscopy. Using a single-edge razor blade, thin freehand cross sections were made of hydrated fresh and artifact material and mounted in water for microscopy. Photomicrographs were taken from the eye piece of a microscope by a handheld camera.

2. INTRODUCTION

2.1. BRANCH MORPHOLOGY

Figure 1 shows the upward curve of branches, and figure 2 shows straight withies produced annually. The anatomy of these two branch types is different because of the need of the curved branch.

Branches that develop annually on specially pruned trees are called *withies*. Stems that develop annually on woody shrubs are called *ramets*. These usually develop on the roots or rhizoids of woody shrubs such as salal. They are annual growth and have branch characteristics with central pith. An example is the common salal (*Gaultheria shallon*), which has many utilitarian ethnological uses (fig. 3).

2.2. DESCRIPTION OF THE TISSUES OF THE CONIFEROUS BRANCH

Figure 4 points out significant tissue names. The phloem and secondary xylem in the branch are the metabolic tissue. The secondary xylem also functions for strength; in addition, note the asymmetry of the two sides: one is broader than the other. The right side of the image has a darker stain, suggesting increased density. This dense tissue is due to the presence of compression wood. It is produced on the lower side of this horizontal branch to push it upward and keep it in an upward or horizontal position.

The secondary xylem tissue is commonly used in artifacts with the outer bark removed. Either the branch or the secondary xylem may be split, leaving one piece that is much stronger and denser than the outer side. In making an artifact such as a basket, either the whole branch or a denser piece would be used in the warp as the structural component, and the less dense piece in the weft would be used for weaving.

Normal secondary xylem cells have thin walled cellulosic cell walls whereas compression wood has thick walled lignified cell walls (fig. 5). In preparing a branch or root for artifacts they are split in two in such a way as to separate the dense side from the less dense side. Their differences in tissue density will influence their use and conservation treatment.

2.3. ETHNOGRAPHIC USE OF TISSUES OF THE CONIFER BRANCH

In ethnographic objects the epidermis/cortex (outer bark) may be used in medicinal concoctions, dyes, imbrication and decoration on baskets, while the secondary phloem fibers (inner bark) are used in cordage, garments, and textiles (fig. 6). Secondary xylem was used in basket splints/withies, frames for baskets, and had structural use. The pith was used for corks, fishing games, and paper.

2.4. DESCRIPTION OF RAMET TISSUE

In Fig. 7 the upper two images show the triangular pith in the ramet stem of the woody shrub *Gaultheria shallon*. The bottom two images are shown at different magnification, the brown inner bark of the ramet. The continuous brown band is secondary phloem. The light colored irregular groups of cells below are primary phloem bast cellulosic fibers. These fibers run the length of the stem, and are used ethnographically as cordage. The brown color in the phloem and adjacent tissues is tannin.

3. RESEARCH

3.1. ANATOMY OF THE PITH IN CONIFEROUS BRANCHES USED FOR IDENTIFICATION

Figure 8 shows a cross section of the Sitka spruce branch. The purpose of the pith gives lightness in weight to the branch, allowing a horizontal position and flexibility. The pith cells are variable in anatomical shape of different species. Depending on the species, some are circular, elongated, and variable in size, attached only partly or wholly to each other.

Fig. 1. Curved branches of a Linden and western red cedar tree

Fig. 2. Annual, straight withies of a pruned tree

The scalloped margin of the xylem attached to the pith contains large primary tissue cells. It was attached to a primary embryonic tissue group that is no longer active. The margin has species-specific shapes that give the pith its characteristic scalloped star shape (fig. 9). This varies with different species and assists in identification.

3.2. COMPARISON OF CONIFEROUS BRANCH AND ROOT ANATOMY

Figure 10 shows the anatomical differences between branch and lateral root of Sitka spruce. A large pith is present only in the branch. Resin canals (RCs) are present in the cortex of both root and branch structures but only present in the primary and secondary xylem of the root. Both images show the presence of compression wood (CW) in the secondary xylem, but it is denser in the branch. The greater amount in the root keeps it close to the ground surface.

Fig. 3. Ramets of the common salal (*G. shallon*)

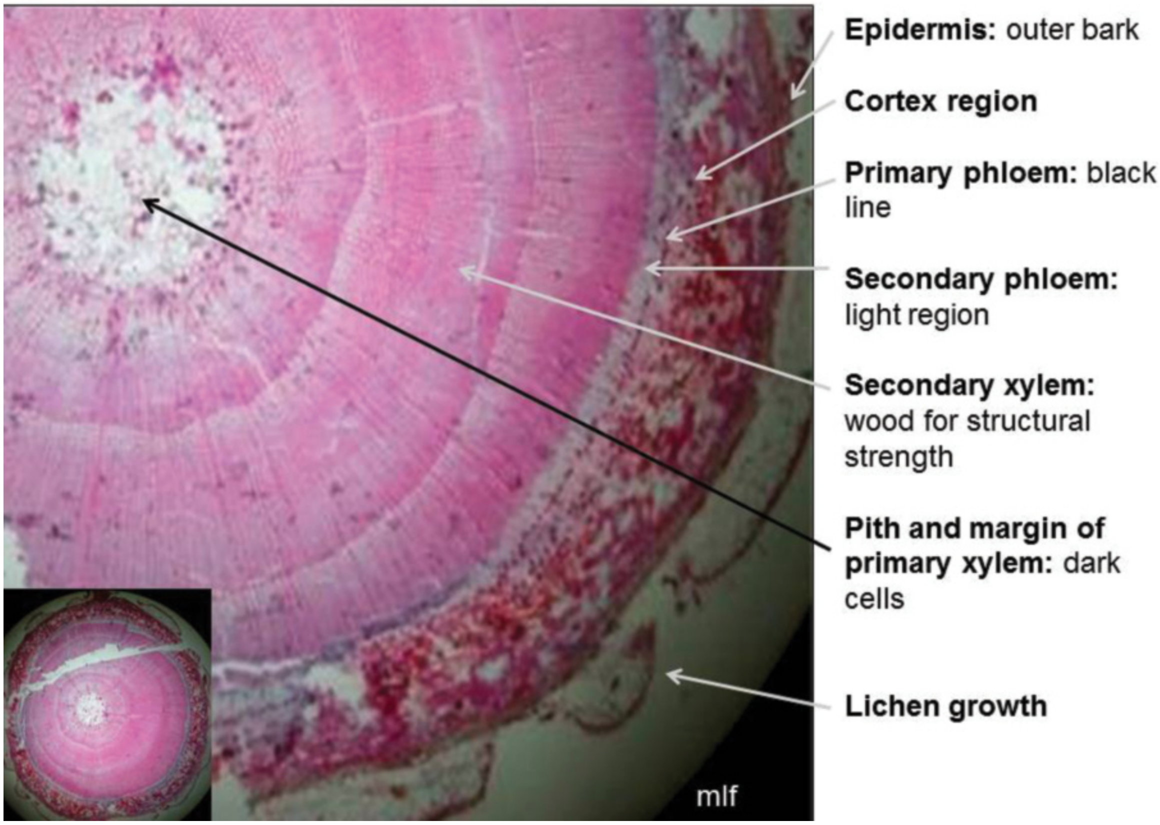

Fig. 4. Cross section of a Sitka spruce branch showing tissues

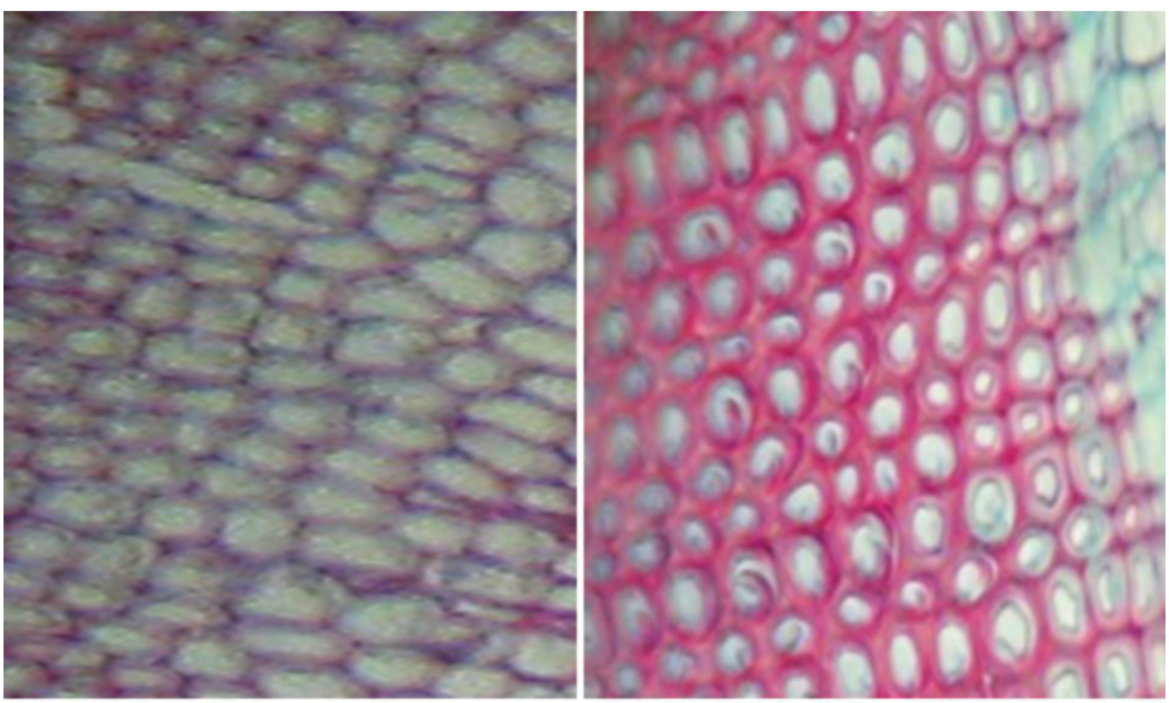

Fig. 5. Secondary xylem anatomical differences between normal (left) and compression (right) wood

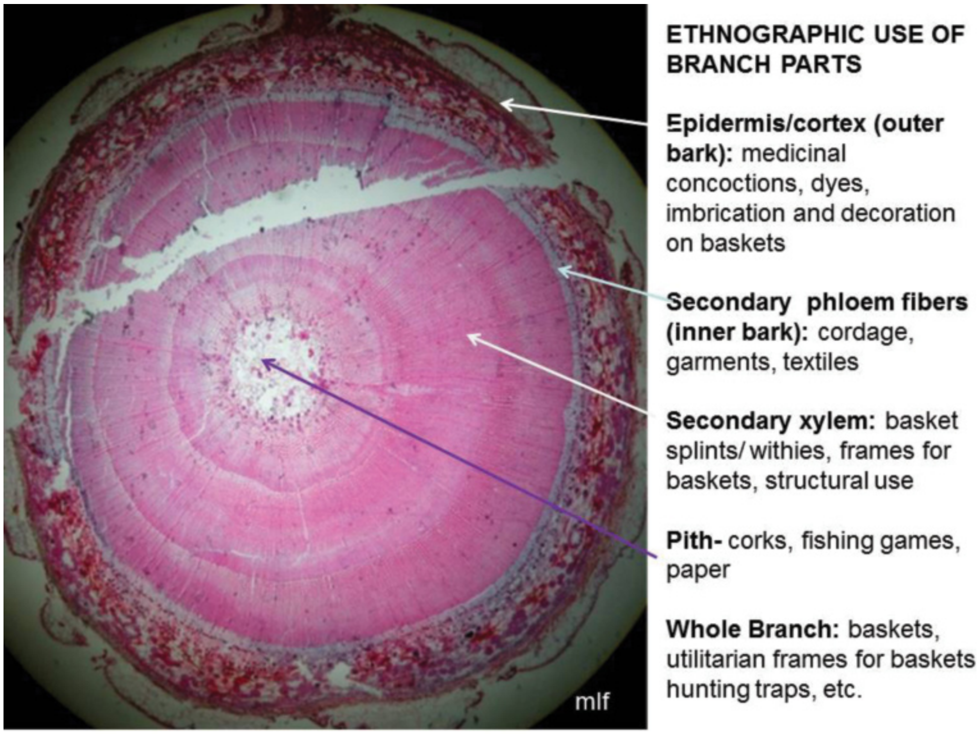

Fig. 6. Parts of tissue of the branch and their use in the construction of ethnographic artifacts.

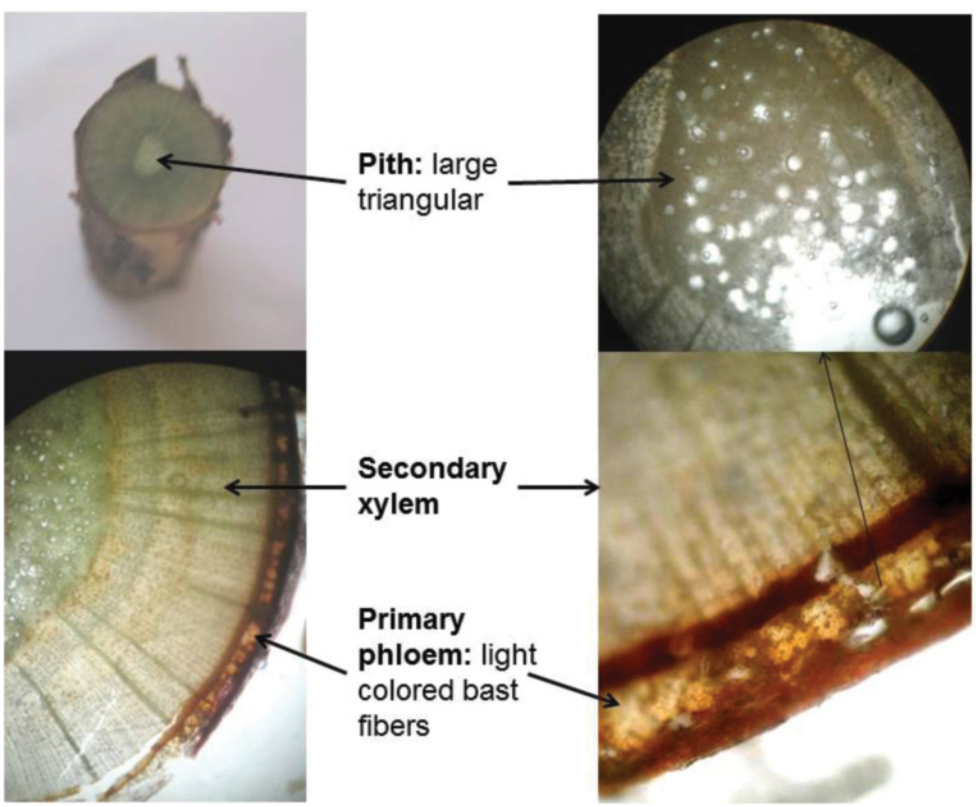

Fig. 7. Cross sections of the ramet of *Gaultheria shallon* (salal)

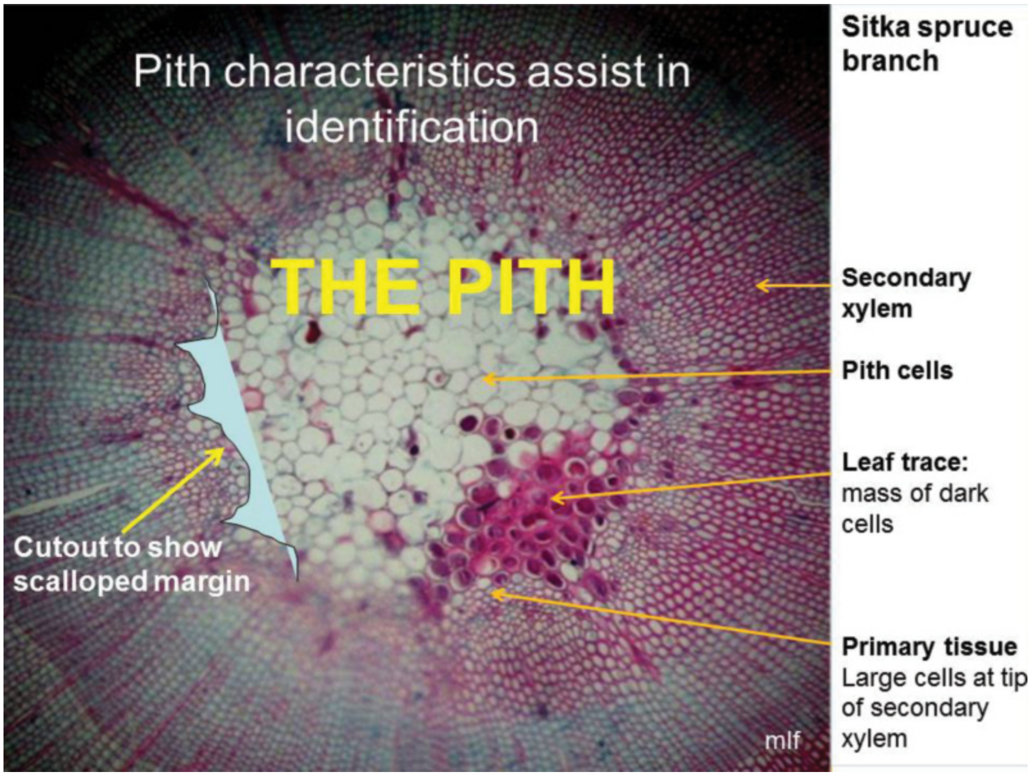

Fig. 8. Cross section of Sitka spruce branch showing pith characteristics

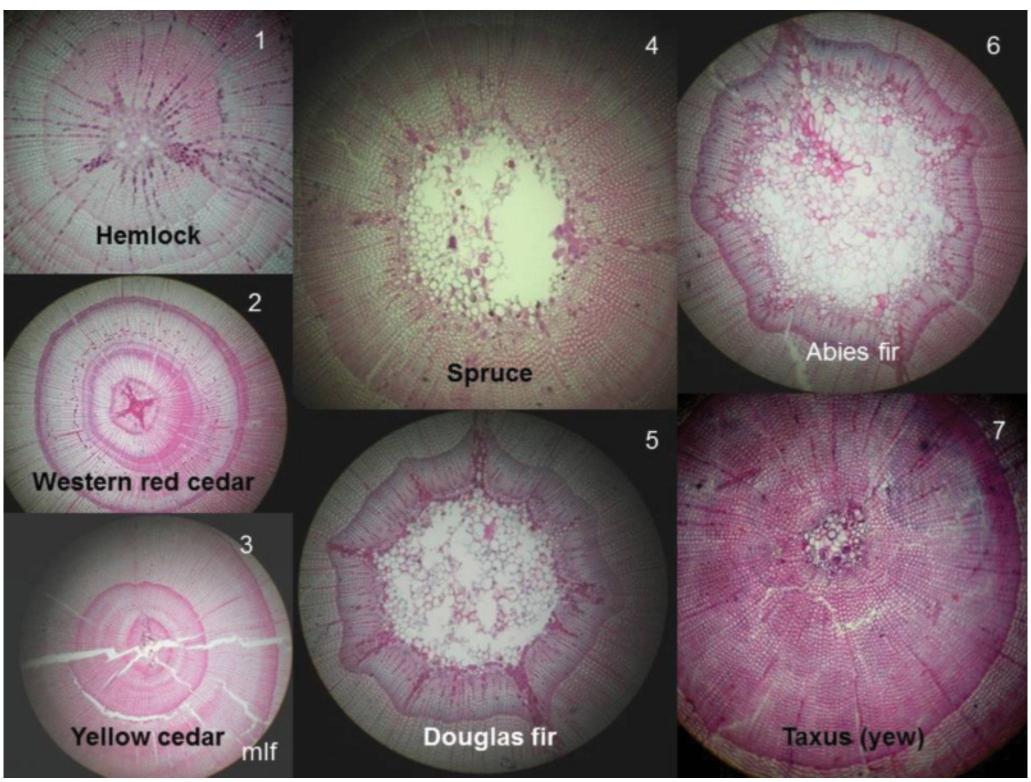

Fig. 9. A group of branches of Northwest Coast coniferous trees that show the usefulness of the pith characteristics for species identification

4. METABOLIC TISSUE: A CONCERN IN CONSERVATION CARE OF ALL BRANCH SPECIES

4.1. EXPLANATION OF THE FUNCTION OF METABOLIC PHLOEM AND XYLEM TISSUE

Figure 11 explains that the protoplasm in the living leaf, secondary phloem, and secondary xylem tissues contain water, proteins, minerals, and nutrients as a continuum in all tissues, with exception of secondary xylem tracheids, which bring water and minerals up from the roots. All cells are connected with pits, which allow universal flow of protoplasm, shown in Figure 12.

5. A NEW LOOK AT ARTIFACT BRANCH MATERIAL

The following list suggests characteristics that are significant with regard to potential problems of dried branch material:

- When dry, thin cellulose cell walls are readily adsorptive.
- Tissues have variable structural strengths.
- Cells are filled with proteins, minerals, sugars, and starches.
- Alterations in characteristics due to making and using the artifact or due to a history of environmental impact.

6. CLIMATE CHANGE POTENTIAL EFFECTS DUE TO HIGH HUMIDITY OR WATER

Dry branches may increase in size or shape due to humidity or water adsorption. On drying, the physical changes remain because they have no elastic memory. The whole branch may experience an increase in mold on the epidermal surface, wax bloom increase on basket imbrications, and beetles (mainly different furniture beetle species). Splits of secondary xylem and outer bark with phloem contain starches and sugars. Different species of beetles may increase due to human travel and environmental changes, and there may be physical changes due to adsorption. Cordage of outer bark with increased adsorption or drying, permanent physical changes occur.

FURTHER READING

Florian, M.-L. E. 2016. *Comparative anatomy of branches, roots and wood of some north American dicotyledonous and coniferous trees and woody shrubs used in ethnographic artifacts: Identification and conservation concerns*. Vancouver: University of British Columbia Digital Library. (A free download is available at https://open.library.ubc.ca/cIRcle/collections/ubccommunityandpartnerspublicati/52387/items/1.0306940)

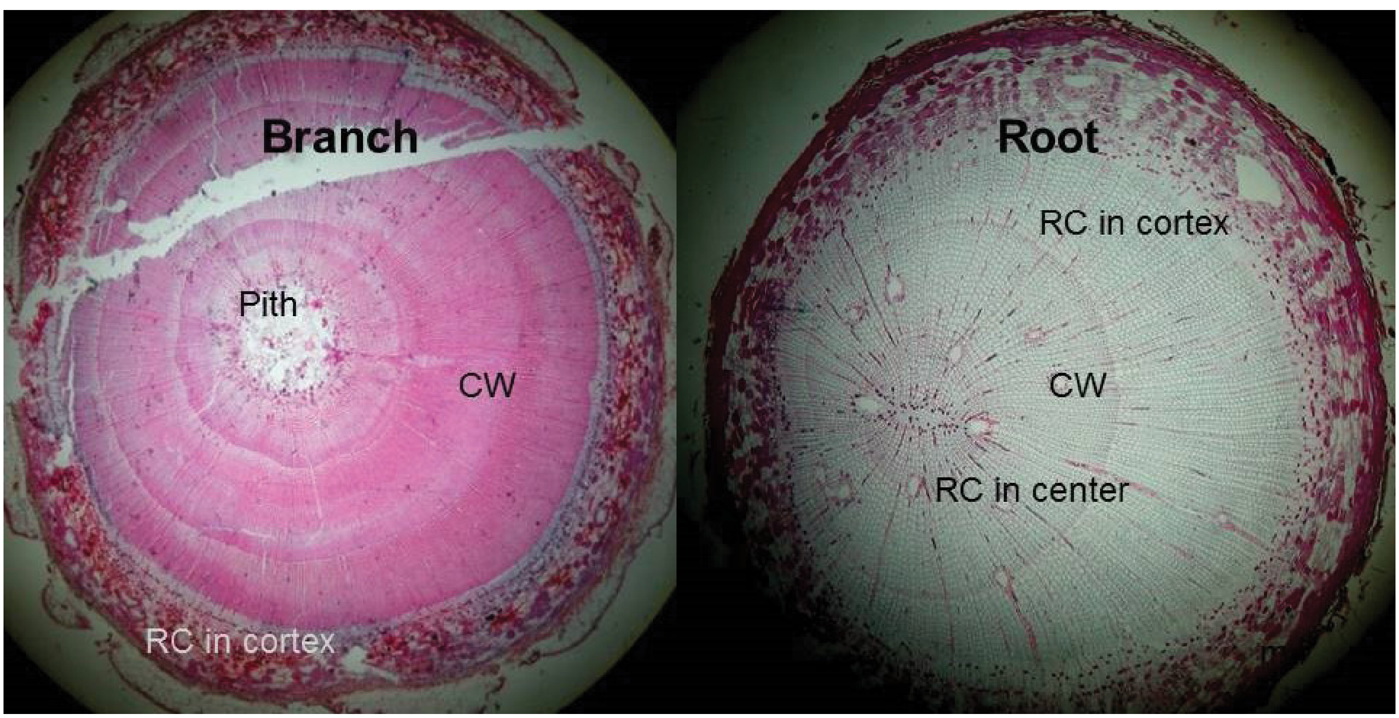

Fig. 10. Anatomical differences between branch and lateral root of Sitka spruce. Resin canals (RC), compression wood (CW)

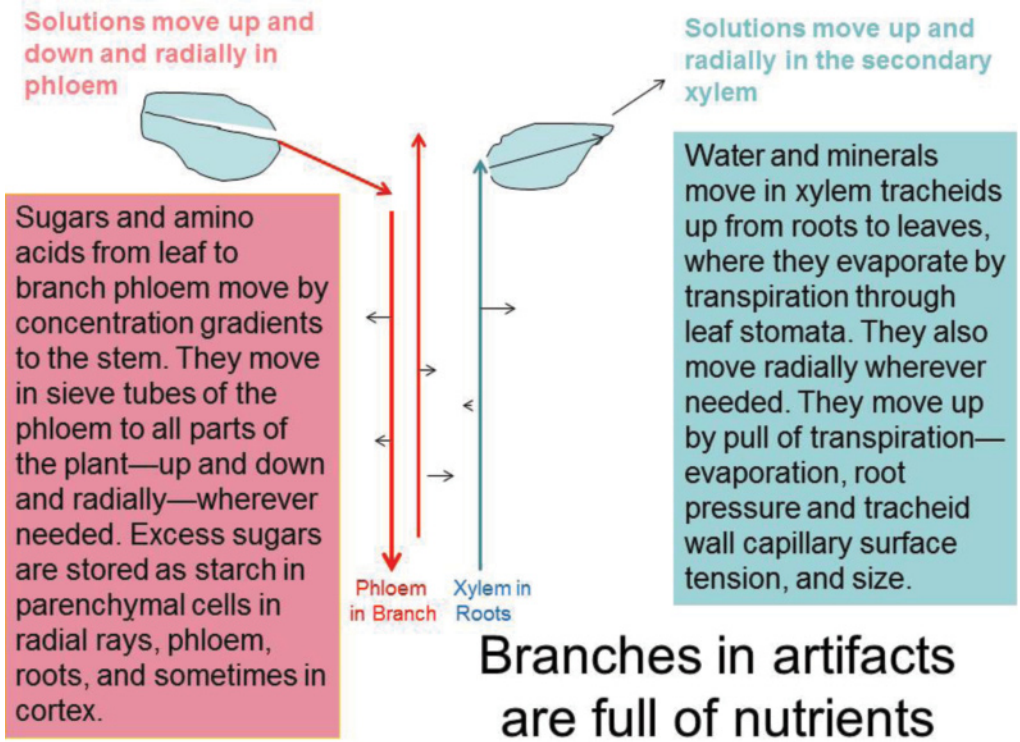

Fig. 11. Illustration and explanation of the metabolic function of the secondary phloem and secondary xylem

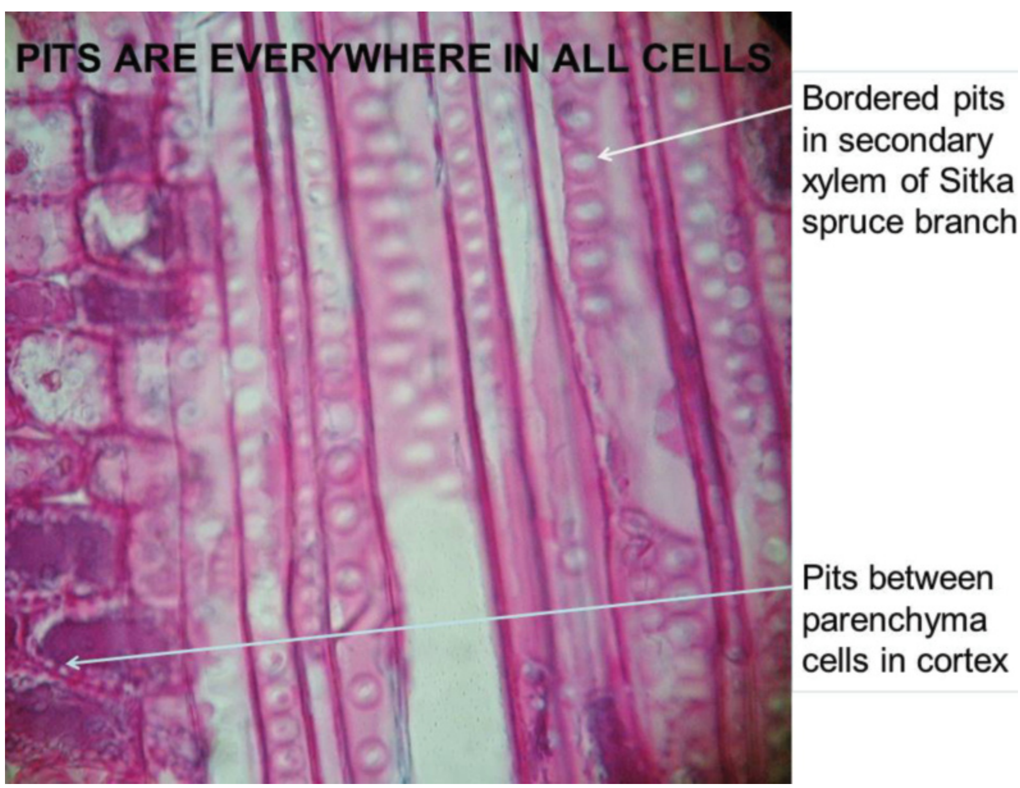

Fig. 12. All cells of the tissues have openings—pits or sieve plates—so the protoplasm and water can flow freely to wherever needed.

Fig. 13. The potential change

AUTHOR BIOGRAPHY

MARY-LOU FLORIAN possesses a BA and MA with concentrations in insect pests, fungi, and plant structure and taxonomy. In addition, she studied fine art at the university level for 2 years with a concentration in studio work, art history, and anthropology. Prior to working in conservation, she was a researcher, illustrator, and teacher. She performed biological research on contract at the National Gallery of Canada and was a senior research scientist at the Canadian Conservation Institute and the Chief Conservation Services division of the Royal BC Museum. During retirement, she undertook a multitude of conservation science—related papers, books, workshops, consultations, teaching positions, and contracts pertaining to insect pests, fungi, and plant structure and identification. She has received many honors for services in museum conservation, one being made an Honorary Member of the American Institute for Conservation (AIC). Her new book on branch and root anatomy of trees used in ethnographic artifacts was published in August 2016 in the UBC digital repository as a PDF for free downloading. At present, Mary-Lou is a retired research associate from the Royal BC Museum. Address: 133 Simcoe St., Victoria, BC Canada V8V 1 K5. E-mail: mflorian@telus.net

MELISSA MCGREW

In Situ Chelation of Waterborne Stains from Historic Unfinished Architectural Woodwork

ABSTRACT—New England's winter of 2014–15 brought a stunning build-up of snow to the region, and the circa 1681 Old Ship Meeting House (fig. 1), a National Historic Landmark in Hingham, Massachusetts, was not spared. Ice that formed at the exterior window heads melted and penetrated the wall surfaces, causing dark staining at the impressive, original interior wooden timber frame members (fig. 2). When testing was initiated 7 months following the initial damage, the stains proved to be intractable to simple water removal. Suspecting that this dark-reddish staining resulted from, at least in part, aqeuous interactions with ferrous oxides and corrosion from the nongalvanized building nails, the author designed and tested a custom-formulated dual-chelator gel cleaning approach. The procedure proved to be effective at significantly reducing the waterborne stains from the unfinished woodwork without causing any further damage. This article presents the properties and results of the cleaning treatment that the author utilized on the interior woodwork.

Fig. 1. Exterior view of Old Ship Church, south façade, 2014 (Courtesy of Building Conservation Associates Incorporated)

Fig. 2. Dark-colored staining on historic oak post, pew 38 area, 2015 (Courtesy of the author)

1. PROJECT BACKGROUND

As of March 23, 2015, Boston, Massachusetts, had received a record-breaking snowfall of 110.6 in., with most of this total falling within a 1 month period—94.4 in. fell between January 24 and February 22, 2015 (Erdman 2015). Subsequently, the city failed to reach 40°F from January 20 to March 3 (Erdman 2015). Therefore much of the snow was converted via partial melting and refreezing to large icicle formations hanging from building eaves. This immense volume of snow and ice led to interior water migration into the uninsulated, predominantly unheated interior of the Old Ship Meeting House—an extremely important historic building in Hingham, Massachusetts—and the subject of this waterborne stain removal treatment

2. BUILDING HISTORY

Old Ship Meeting House is the oldest church in continuous use as a house of worship in North America (Lindner 2007). The Meeting House's construction date of 1681 was so well provenanced that its timbers were selected for sampling for the creation of a dendrochronology master database for the dating of New England oak timbers (Steinitz 2002). It is also the only surviving 17th-century Puritan Meeting House in America and a National Historic Landmark (National Register of Historic Places 1975).

3. POTENTAL STAIN SOURCES AND TREATMENT RESEARCH

A review of the major locations of stains inside the Meeting House indicated that the likely sources of the staining included numerous campaigns of ferrous nails that attach the exterior sheathing layers and the plaster lathe. The early ferrous sprinkler pipes that were installed as part of the restoration work done in the 1930s were also a probable stain source (fig. 3). When air, water, iron, and wood are present together, there is the potential for formation of not only iron oxides but also the likelihood of a chemical reaction of iron with tannins in the wood, resulting in unsightly blackish discolorations (US Department of Agriculture 2007)—ferric tannin complexes. Both the hardwood (oak) and softwood (pine) building materials at the Meeting House contain a percentage of tannins present in the heartwood (Lewin and Goldstein 1991). After initially forming in the presence of water, these ferric tannins oxidize

Fig. 3. Ferrous metal sprinkler pipe and head (ca. 1930), contributing to adjacent wood waterborne staining, 2015 (Courtesy of the author)

to form non–water–soluble complexes (Bechtold and Mussak 2009). This helped to explain why the author's initial distilled water and water/detergent cleaning tests did not even slightly budge the dark-colored staining material.

4. TREATMENT DEVELOPMENT

Literature references to treatment of these types of iron stains were scarce, with only limited removal success reported. A primary consideration was to restrict the swelling of the cellulosic wood fibers by designing a cleaner that was not strongly alkaline (Florian et al.1990). Another primary concern was limiting the acidity of the treatment cleaner to prevent hydrolysis and consequent reduction in molecular weight of the cellulosic wood fibers (Mills and White 1987). Therefore, a hydrochloric acid treatment used for treatment of waterlogged iron-stained wood by McKerrell and Bryce (Unger et al. 2001) was discounted, as was a saturated solution of sodium bifluoride recommended for treating iron-stained wood (US Department of Agriculture 2007). Extremely low pH and health and safety concerns, along with the lack of a potable water source within the building, also ruled out the use of commercial "wood brighteners" containing oxalic acid. A cleaner with a pH of approximately 6 was selected by the author to optimize the preservation of the aged wooden surfaces.

5. EXPERIMENTAL TESTING AND RESULTS

As mentioned previously, the author's testing with the most conservative methods–water and water with a small percentage of nonionic detergent, utilized just above the critical micelle concentration—did not budge the dark wood stains. The Meeting House cladding nails and sprinkler pipes adjacent to some stains were identified as ferrous, and therefore a chelating agent was selected for the treatment. Incorporation of a chelator into the custom stain remover could bind potential metal ions within the stain to help solubilize them. Initially, solutions formulated with a single selected chelator (citric acid and ethylenediaminetetraacetic acid [EDTA]) and buffered with triethanolamine were tested. Of these two tests, only the EDTA even slightly moved the stains. Further research into utilization of citric acid as both a buffer for an EDTA solution (Lingeman 1988) and as an auxilliary complexing agent led to testing these two chelators in combination as a stain treatment. This approach, utilizing equal molar amounts of these two sequestering agents—citric acid and EDTA—achieved the most effective stain removal results (fig. 4). Having already selected a pH target of 6 as optimal for the safe treatment of the wood surfaces, citric acid proved to be a suitable buffer.

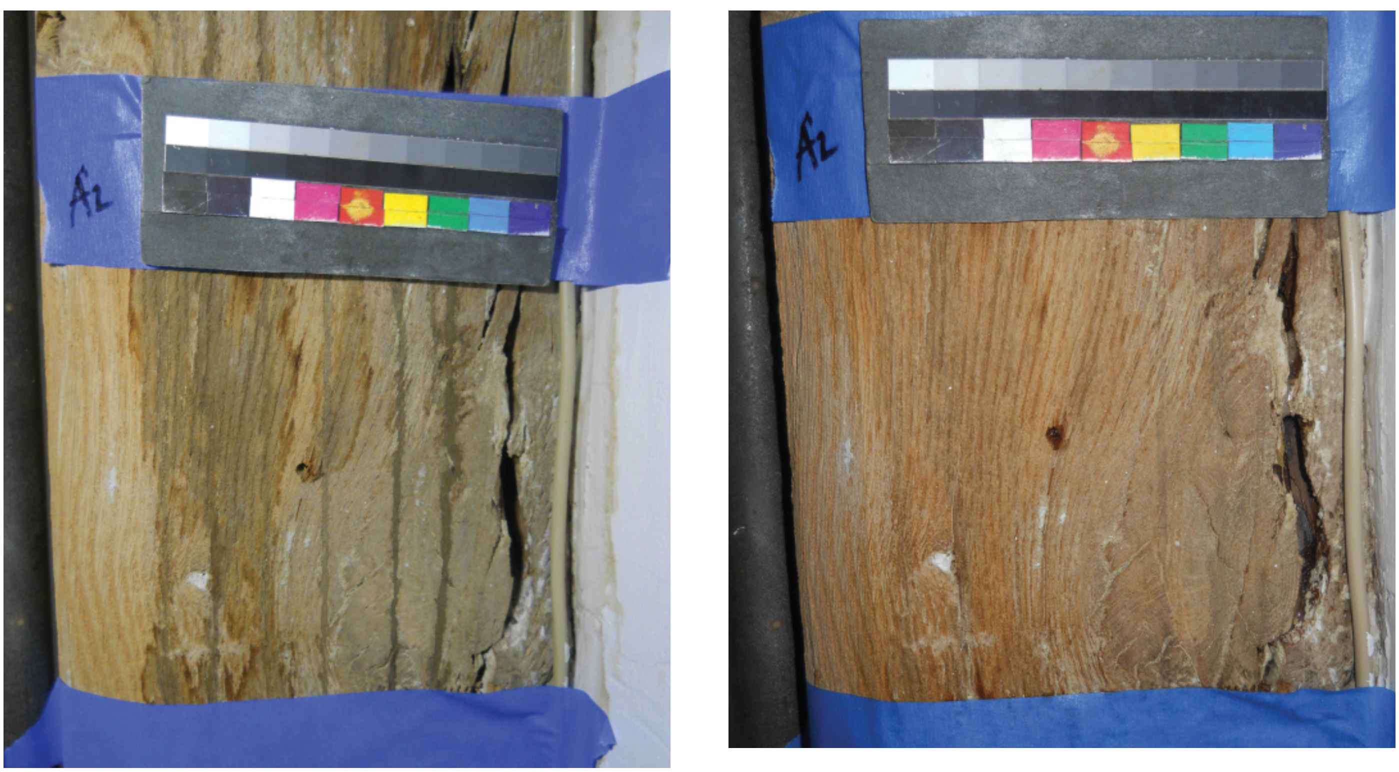

Fig. 4. (a) Post in pew 41 test area shown before dual-chelator cleaner application, 2015. (b) Post in pew 41 test area shown after dual-chelator cleaner application and clearance, 2015. (Courtesy of the author)

6. HEALTH AND SAFETY

Another signicant factor influencing the decision to utilize a custom cleaner was safety—there is no running water in the Meeting House, and therefore employing the least hazardous cleaning method to the greatest stain removal effect was the goal for this project. Several commercial cleaners were initially researched, but after clarifying that they contained strong acids, including nitric and oxalic acids (US Department of Agriculture 2007), they were deemed to be too dangerous for safe application to and removal from the high vertical surfaces of the Meeting House woodwork. Concerns regarding potential wood-damaging interactions also served to disqualify these strongly acidic commercial cleaners. Some conservation treatments researched recommend a pretreatment application of sodium dithionite prior to complexing the iron stains with EDTA (Pele et al. 2015). However, both the health and the reactivity hazards of this chemical (Sigma-Aldrich 2014) were considered too dangerous for safe on-site use. The treatment was scheduled for the hot summer months and the space is not air-conditioned, so volatility was also taken into consideration.

7. TREATMENT

The removal of the staining was achieved by application of the pH 6.3 gelled cleaner created with 0.1 M EDTA and 0.1 M citric acid solutions in distilled water. The pH of this solution was first raised to pH 5 with 1 Molar sodium hydroxide and then raised to pH 6.2 with 0.1 M sodium hydroxide added dropwise to reach the pka_3 of the citric acid (Dean 1999) without overwhelming its buffer capacity, then gelled with Pemulen TR-2 (15 g/L). The TR-2, an alkyl acrylate crosspolymer, provided sufficient viscosity (approximately 4,500 centepoise) (Lubrizol 2012) to apply the cleaning product locally to the stains located primarily on vertical surfaces (fig. 5). The gelled product was applied locally to the stain areas and left to dwell for 1 minute. Residual gel was intially gently removed from the wood surface with a plastic scraper and then blotted with two passes of distilled water applied on a lint-free cloth. In some cases where the staining was particularly dark, the cleaner was reapplied for a second or third dwell and removed as described previously.

Fig. 5. Dual-chelator cleaner gelled with Pemulen TR-2, viscosity demonstrated by full vertical support of a number two pencil (Courtesy of the author)

8. CONCLUSION

The primary goal of this treatment was to remove waterborne metallic (estimated) stains from the historic woodwork. Approximately 250 linear feet of stains were successfully treated during the course of the project. Results from physical testing together with observations before, during, and after treatment suggest that the application of the dual-chelator cleaner successfully removed the waterborne stains from both the pine and oak wood surfaces (figs. 6, 7). A return visit to the site 4 months after treatment indicated no reappearance/recurrence of the removed stains. The author revisited Old Ship Meeting House again in spring 2016 and observed no recurrence of the dark woodwork stains. The 2015–16 New England winter was notably milder, so the mechanisms that caused the previous widespread wood staining appear not to have occurred in this most recent cold season.

ACKNOWLEDGMENTS

The author wishes to thank Tom Willson of Old Ship Meeting House for retaining Building Conservation Associates (BCA) to perform the waterborne stain removal treatment; Andrea Gilmore and Lisa Howe of BCA for respectively obtaining the project and support of this article; Dave Webb of Webb Preservation for facilitating access to upper stain locations; and Richard Wolbers of the University of Delaware for discussion of buffers and chelators.

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Fig. 6. (a) Pine clad north gallery post shown before dual-chelator cleaner application, 2015. (b) Pine clad north gallery post shown after dual-chelator cleaner application, 2015. (Courtesy of the author)

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Fig. 7. (a) Oak post, pew 1 area, shown before dual-chelator cleaner application, 2015. (b) Oak post, pew 1 area, shown after dual-chelator cleaner application, 2015. (Courtesy of the author)

SOURCES OF MATERIALS

Citric Acid (CAS No. 77-92-9), EDTA (CAS No. 60-00-04), Sodium Hydroxide (CAS No. 1310-73-2)
Thermo Fisher Scientific
81 Wyman St.
Waltham, MA 02451
www.thermofisher.com
(800) 556-2323

Pemulen TR-2
The Lubrizol Corporation
29400 Lakeland Blvd.
Wickliffe, OH 44092
www.lubrizol.com
(440) 943-4200

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ANDREW FEARON, JEAN JANG, AND SHUYI YIN

Going Grey: Mitigating the Weathering of Wood in the Architecture of Louis Kahn

ABSTRACT—Louis Kahn's attitude toward natural materials was expressed in his documented preference to allow exterior wood siding to be left unfinished and weather to a silver grey. Influenced by vernacular architecture of the American and Canadian rural landscape, this reference to traditional construction has proved a challenge for stewards, as exposure to the elements is in the end consumptive. This article documents a full-scale, multiphase testing and treatment program for the exterior siding of Kahn's last residential work—the Korman House located in Whitemarsh Township, Pennsylvania.

1. INTRODUCTION

Within the context of heritage conservation, the integrity and value of a given site is most often connected to the retention of original or existing unaltered fabric. The material of wood subject to the exterior environment is vulnerable to an assortment of deterioration mechanisms principally related to biodeterioration and weathering. A holistic treatment that addresses both in response to these identified conditions provides the basis for a long-term sustainable maintenance program. Through a combination of preservative applications, the serviceable life of exterior wood may be extended as a preventive conservation measure. With proper cycles of maintenance, many species of wood may be preserved in an exterior environment for several hundred years or longer.

In 2014, a treatment program for Louis Kahn's Korman House was formulated based on field test panel evaluations and laboratory work conducted to specifically address the weathering and biodeterioration of exterior wood. The first cycle of treatment was implemented in the spring of 2016. This article details the testing program and implementation.

2. LOUIS KAHN

> *"The beauty of what you create comes if you honor the material for what it really is."*
>
> Louis Kahn, 1973

Louis Kahn (1901–1974) was born in Pärnu, Estonia. In 1906, he immigrated to the United States, where his family had settled in Philadelphia. After working in various capacities for several firms in Philadelphia, he founded his own atelier in 1935. While continuing his private practice, he served as a design critic and professor of architecture at Yale School of Architecture from 1947 to 1955. From 1955 until his death, he was a professor of architecture at the School of Design at the University of Pennsylvania.

Among his well-known projects are the following:

- Yale University Art Gallery, New Haven, Connecticut (1951–1953)
- Richards Medical Research Laboratories, University of Pennsylvania, Philadelphia, Pennsylvania (1957–1965)
- Jatiyo Sangshad Bhaban (National Assembly Building) in Dhaka, Bangladesh (1962–1983)
- Kimbell Art Museum, Fort Worth, Texas (1967–1972).

As Louis Kahn (fig. 1) remains a central figure in post-war American modernism, the extent of his contributions to the history of architecture are still being explored and understood. Although Kahn is most well known for his institutional and civic structures, nine of his house designs were built, all in the Philadelphia area. Recent scholarship evaluating these residential works places a group of Kahn's wood-clad structures into focus (Whitaker 2013).

Kahn's monumental vocabulary on a domestic scale incorporates a consistent attitude toward traditional materials, often drawing from the rural landscapes of New England and the Canadian coast. Like the weathered siding of an old barn, a commonality with vernacular structures evokes a timeless quality that links old worlds to modern. His philosophy dictating the application of materials is fully expressed in his documented preference to allow the exterior wood of these structures to weather naturally to a silver grey. Kahn states: "Natural wood as it greys is so marvelous. I think a yellow house and green leaves looks awful, but a grey house and green leaves looks absolutely marvelous. We have to ask nature to help us out." (Kahn 1974, 34)

Among this group of designs for houses with exterior wood are the following, which list specifications for finishing that are consistent with the architect's documented comments on the subject of weathered wood (per Outline Specifications in the Architectural Archive of the University of Pennsylvania):

Fig. 1. Louis Kahn and Steven Korman outside of Kahn's office, 1501 Walnut Street (Courtesy of the Korman family)

Genel House (1948–1951)
Wood Siding - Vertical T & G 25/32″ thick × 6″ nominal width in lengths to avoid end joints, clear western red cedar, tidewater red cypress, or clear heart California redwood. Exterior millwork and trim: clear tidewater red cypress
Finish: one coat of boiled linseed oil

Fisher House (1960–1967)
Exterior siding: T & G joint tidewater red cypress siding
Finish: two coats of natural (no color) wood sealer, Rez or equivalent

Honickman Residence (1973) Unbuilt
Exterior siding: 1 × 1 in. T & G cypress
Finish: none except for doors and shutters (two coats of colorless varnish—matte finish)

Korman House (1973)
Exterior Siding: 1 × 3 in. T & G cedar (cypress as-built) cypress
Finish: none except on doors and shutters (two coats of colorless varnish—matte finish).

Kahn's intent for finishing can be described as minimal or natural in the case of the Genel House, employing one coat of linseed oil, then later with the Fisher House (fig. 2), in which he used two coats of clear Rez (wood sealer) (fig. 3). For his final residential works, as seen in the Honickman and Korman houses, the architect omitted a finish entirely for the surface of the siding, limiting treatment only to doors and shutters. This suggests

Fig. 2. Fisher House, Hatboro, PA (1960–1967), photographed by William Whitaker, ca. 2010

Fig. 3. Rez Wood Finish, advertisement from *Popular Mechanics Magazine* 111 (6), June 1959

that the architect was determined to allow the siding to weather naturally; in addition, paired with documentation on the subject, it is clear that Kahn embraced the process of weathering. This sensibility and commitment to a natural phenomenon took priority over the slowly destructive dimension that would soon become problematic for the second generation of stewards.

3. THE KORMAN HOUSE

In 1973, a few months before his death, the Kahn completed Steven and Toby Korman's commission to design a six-bedroom house in Whitemarsh Township, Pennsylvania (fig. 4). The Korman House was his largest and last residential work, representing Kahn's unique vision for the American country house. As his last house, it may be considered his swan song that synthesized many of the themes of his career: the creation of space with structure and light, the clear distinction between materials, and a deep sense of order.

Kahn choose cypress, a species with which he had grown comfortable, having explored its attributes since the late 1940s and employed in both his Weiss House (1947–1950) and the Genel House (1948–1951). Bald cypress (*Taxodium distichum*), or Tidewater red cypress, specifically refers to the growth along the Gulf Coast found in tidal areas and is noted for its density and natural aromatic compound content that imparts decay resistance. In contrast, Inland cypress, often referred to as yellow cypress, is lighter in color, contains more sapwood, has a courser texture (particularly the more recent "new growth"), and is not as durable containing less natural extractive content. Inland cypress has been used as the primary replacement material for the Korman House and is more readily subject to common deterioration mechanisms.

3.1. CONDITIONS

In 2014, an assessment of the Korman House was conducted to address a list of problematic conditions, among them the general appearance of the following most recent campaign of coatings (fig. 5):

- Coating with a high solid content film-forming linseed oil alkyd-based product with trans-iron oxide pigments appeared dark orange.
- Accumulative layers of the coating trapped moisture/mold (was turning black in areas) looked heavy and were inconsistent with Kahn's intent for natural weathered grey.
- Mold/fungi and cubical brown rot fungi were noted.
- Consumed by deterioration, most of the exterior cypress had been replaced over the years with new cypress that was only moderately decay resistant.

4. WOOD DETERIORATION

Wood deterioration may be defined by one or several compounding mechanisms of degradation in direct response to a given environment. Discussed here are the primary natural agents of deterioration that exist for wood found in an exterior environment that are most relevant to exterior siding and related conditions addressed through the treatment program.

4.1. UV LIGHT

The energy per photon of UV fraction solar irradiance (295-400 nm) is high enough to break the chemical bonds of wood, particularly that of the lignin component (Williams 2012). Lignin has a phenolic structure that functions as a binder between micro-fibrils, the smallest unit found in cell walls. The mechanism of photodegradation is complex and occurs through different pathways (Georgea et al. 2005). A free radical is formed, and together with hydroperoxide, it causes a sequence of chain scission reactions to decay the polymeric components (Williams 2012).

On a macro-scale for softwoods, surface damage of bordered pits are one prominent structural phenomena of photodegradation. The torus forms cracks during early stages, and as exposure

Fig. 4. Korman House, Whitemarsh Township, PA (1971–1973), photographed by Jamie Ardiles-Arce, ca. 1974 (Courtesy of the Kahn Collection)

time is extended, pit domes begin to crack in a diagonal progression. As the aperture widens, pit domes thin and pit membranes fully degrade (Turkulin 2004).

4.2. Water

Drying and wetting cycles encourage a swelling rate that causes the degradation and extraction of hemicelluloses, extractives, and cell wall structure. Cross-checking and cracks on the tangential face can appear when the affected area of wood is subject to repeated drying (Ibach 2012). When wood is under the condition of high relative humidity and aqueous cycles together, cell wall polymers can disassociate, leading to a higher average moisture content (Rowell 2012). Regardless if a given substrate is coated or not, when wood moisture content exceeds 20%, wood-inhabiting fungi may propagate. In addition, many wood-destroying insect species, such as termites and carpenter ants, are active when the moisture content is high (Clausen 2010).

4.3. Wood-consuming organisms

Bacteria (single-celled organisms) colonize on the surface of wood. They are slow and weak deterioration agents that do not directly influence structural wood properties. Mold fungi and stain fungi primarily damage sapwood—although they do not change the strength of the wood, they may increase its absorptivity. Mold fungi can take the form of a superficial surface accumulation in various colors that can be brushed or easily washed away. Blue stain growing deep in wood is a more indelible fungi stain. Black-colored mold compounded with atmospheric soiling imparts color to the surface of weathered wood and together may be understood as the black fraction of the silver grey. The white fraction is cellulose, which is the result of UV degradation and loss of lignin that provides the pigmentation of wood (fig. 6).

Decay fungi are defined as single-celled or multicellular filamentous organisms and have enzymatic systems that deme-

Fig. 5. Korman House, before treatment, 2014

thoxylate lignin, produce endocellulases, and use a single-electron oxidation system to modify lignin and feed on wood. Their growth conditions include food from wood (cellulose, hemicellulose, and lignin), oxygen, and temperature (10°C–35°C) (Ibach 2012). Fungal spores are brought to moist wood by wind, animals, and insects. Hyphae spread through natural vascular network of wood xylem like a cancer. Fruiting bodies may evolve as a result of advanced colonization. There are primarily three types: soft-rot fungi, white-rot fungi, and brown-rot fungi. Wood starts to lose strength in the early stage of decay, which is followed by color change as the decay advances. Fungi affecting the cellulose of softwood typically forms a network of cracks referred to as cubical brown rot (Ibach 2012). Fungi often coexist with wood-consuming insects, including subterranean termites, Formosan subterranean termites, dry wood termites, beetles, carpenter ants, and carpenter bees (Feilden 2003).

5. METHODS AND MATERIALS

> *Nature is the maker. It is the giver of presences.*
>
> Louis Kahn, 1955

In an effort to formulate a program for maintenance, a multi-phased evaluation involving lab and field testing was employed. The natural environment was used as a primary treatment agent through a "weathering-in" process. The full treatment may be considered a stabilization of the weathering process that is sustained via maintenance cycles. The objectives of the research and laboratory testing program were to formulate a maintenance plan for the retention of the cypress siding defined by the following attributes:

- Promotes the greatest longevity of existing materials
- Minimally invasive without abrasive or chemical preparation
- Low VOC (<350)/low environmental impact

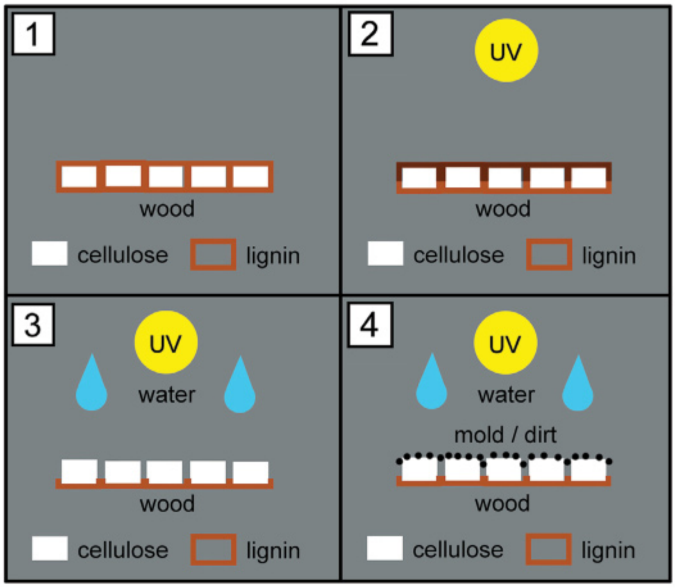

Fig. 6. Chromatic illustration of lignin degradation

- Re-treatable as part of a maintenance cycle
- Easy to implement/cost effective
- Sensitive to the architect's intent and finish history.

5.1. FIELD TESTING/FORMULATION

Ten Tidewater red cypress (*T. distichum*) testing areas were designated on the exterior siding of Frank Lloyd Wright's Pope-Leighey House (1939, Alexandria, Virginia) in 2011 and monitored for 4 years for the National Trust for Historic Preservation. To evaluate performance and appearance, the following exterior wood coatings were evaluated in combination with borates: Sikkens Cetol 1 clear (borate), Sikkens Cetol WB SRD (borate), Flood CWF-UV Clear wood finish, Amteco TWP 1530 Natural, TWP 1500 Clear, Benjamin Moore Arborcoat 637 and 636, and Howard Sunwax (two coats). An attribute-based scoring system was used to visually evaluate the performance with sensitivity to Wright's intent as an important defining criteria. Among different products, the TWP1500 series had the highest score in general (Kirschner and Fearon 2011) and was used as the basis for further onsite field testing at the Korman House.

To determine proper hue and transparency of the preservative system for the Korman House, TWP 1500 and TWP 105 were mixed in four different ratios. The mixture showing the least hue-altering effect is desirable. The experimented ratio of TWP 1500 to TWP 105 was 10:1, 9:1, 8:1, and 7:1. Among the tested ratios, 10:1 (TWP 1500:TWP 105) showed the most desirable effect in keeping with the grey tones of naturally weathered wood.

5.2. TESTING A PENTRATING OIL AND BORATE PRESERVATIVE SYSTEM

The lab-based program focused on qualitative and quantitative data of the weathering behavior of cypress (*T. distichum*) treated by aqueous diffusible borate preservative in combination with a penetrating oil-based wood-coating system with and without pigment additives.

The penetrating oil preservative tested (the TWP 1500 series manufactured by Amteco) is a mixture of linseed oil, paraffinic oil, alkyd resin, cobalt drier, calcium drier, and 3-iodo 2-propynyl butylcarbamate (IPBC) fungicide, available with and without pigment additives. To test the efficacy and performance of the oil-based coating to retain the borates, an accelerated weathering test (QUV, Q-Lab, UVB-313) was implemented for 800 hours in the lab to simulate approximately 1.5 years of natural weathering. Before and after QUV, SEM and spectrophotometer color test were implemented. A turmeric color dye method was also used to trace the penetration and movement of borate-based solutions. Agar plate tests were conducted on treated and untreated extracted mold/fungi cypress strains sampled from the Korman House.

5.3. QUV/WEATHEROMETER

At the University of Pennsylvania's Architectural Conservation Laboratory, 800-hour testing cycles of accelerated weathering exposure program with QUV were conducted, following the standard of ASTM G154. UV lamps (UVB-313) and water heat condensation and spray cycles were used to simulate natural weathering conditions. Photos were taken and colors were measured at 100-hour intervals to document the weathering process of the samples over time.

All samples were prepared with 120-grit sandpaper. Moisture content was measured with a Wagner MMC210 moisture meter to ensure that all samples were between 8% and 12% based on field conditions. Solutions of Bora-Care with Mold-Care and Tim-bor Professional were brushed with natural bristle on the tangential faces following the grain on two transverse faces and two radial faces. Moisture content was measured again to confirm that the samples were dry. Then TWP 1500, TWP 1516, and TWP 1530 were brushed on the dry borate-treated wood. Sections of the unweathered samples were reserved as controls for SEM and cross section observation. Spectrophotometer (Konica Minolta CM-2500d Spectrophotometer) readings were recorded of samples before QUV. UVB-313 lamps were used. QUV cycle selection followed an ASTM G154 cycle in which the UV temperature setting was 60°C and the condensation temperature was 50°C. UV irradiance was calibrated at 0.67W/m². The interval was 4-hour UV irradiance and 4-hour condensation with a 15-minute water spray for the thermal shock. At every 100-hour interval, samples were examined, photographed, and measured for color and moisture content.

5.4. SEM/SURFACE MORPHOLOGY

SEM was used to observe the surface morphology change of samples caused by deterioration agents (UV and moisture) and treatment procedures before and after QUV, as well as to detect and quantify the present inorganic preservatives. The imaging was conducted at Drexel University's Centralized Research Facility with a Zeiss VP 50. The microstructure morphology change observation and analysis was done through comparative analysis of the SEM imaging. The observation was focused on the middle lamella, defined as the lignin-rich region between primary lumen walls on cross section—a component known to absorb UV radiation (fig. 7).

5.5. COLOR MEASUREMENT/LIGNIN DEGRADATION

A handheld spectrophotometer color test measured the absorbance of particular wavelengths of light by a given surface.

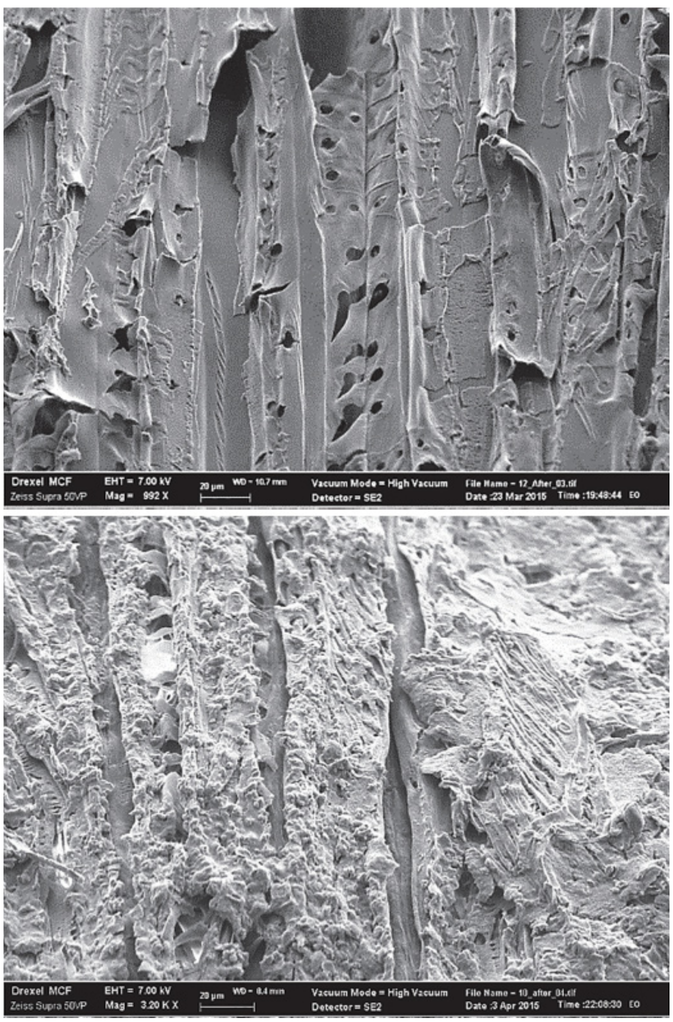

Fig. 7. SEM imaging of Korman House cypress untreated (top) and treated after 800 hours of QUV-B (bottom)

The test follows ASTM D 1536-58 (1964) and was run in the lab at each 100-hour interval using the Konica Minolta CM-2500d Spectrophotometer. Each time, the spectrophotometer was calibrated following the instructions and each sample was measured at the same spot at each interval. The color change among different samples was compared after 800 hours.

5.6. TUMERIC COLOR DYE/BORATE RETENTION

To trace the penetration of borate before and after the weathering test, a turmeric-based color dye test was performed following completion of the QUV program. The following reagents were made into two solutions and applied successively:

Solution 1: 10 g turmeric and 90 g ethyl alcohol mixed and then filtered to a clear solution

Solution 2: Dilution of 20 ml concentrated hydrochloric acid, 100 ml ethyl alcohol, and salicylic acid (about 13 g per 100 ml).

Solution 1 was sprayed on a sample surface and dried for several minutes. Then Solution 2 was added. The color change showed up a few minutes after application of the second solution. In the presence of boron, the yellow color of the turmeric solution turned red (AWPA A3).

5.7. AGAR PLATE/FUNGI RESISTANCE TESTING

To gauge the fungal resistance of the formulated preservative coating, an agar plate method was used. Wood substrate samples were prepared, which were taken from the actual wood siding from the Korman House. A sample exhibiting black mold fungi growth on the surface was cut into two pieces to provide identical conditions for test samples. A coating material was prepared with a mixture of TWP 1500 and TWP 105 in a 9:1 ratio. On one of two identical wood substrates, a TWP 1500 and TWP 105 mixture was applied with a brush in a controlled lab condition, and the other was left untreated. The two samples were allowed to air-dry for 48 hours, as both TWP 1500 and TWP 105 product data sheets specify. Then each was centered in agar plates (1% tryptone, 4% dextrose, 1.5 % agar) and placed in the oven, of which the temperature was set to a consistent 28°C. Both agar plates were observed and recorded on a daily basis until either the plates were covered with mold fungi or no fungi growth was observed; observation was completed on the seventh day of incubation.

5.8. DISCUSSION

The test results indicated that the oil treatment is effective on retaining the borates and reducing the effects of weathering. With the diffusion of borates from the surface of the samples, it is clear that the amount of borates retained is greater on samples treated with oil. Borates were mobilized inward or outward at a 2-mm surface of almost all samples on the exposed areas, whereas they were still present in the total cross section, as they were continually diffused from less-exposed areas. The positive test for borates apparent on all sample cross sections treated with the oil and borates combination translates to field construction such as tongue and groove siding, end grain, or cracks, and the borates that survive 800 hours of QUV-B, a very severe testing program, would likely survive an estimated 1.5 to 2 years of harsh natural weathering on very high exposure areas. Concurrently, the samples with metallic oxide particles retained more borates in comparison to those without, although the difference was not dramatic. SEM imaging shows quantifiable change in surface morphology when comparing samples before and after QUV weathering and most significantly the retention of the introduced coating on treated samples vs. degradation of cell wall anatomy visible on both tangential and transverse planes of untreated samples (fig.7). Through agar plates, the TWP 1500 with titanium dioxide was proven to be effective against mold/fungi-resisting spore propagation during the course of incubation in sharp contrast to untreated controls.

Linseed oil, extracted from flax seed (Andés 1903), was extensively used as an independent wood preservative before modern synthetic preservatives' application (AWPA 1916). Paraffinic oil has also been used in pest control and in the management of plant disease (Helmy et al. 2012). Paraffin is a solid combination of hydrocarbons acquired from petroleum fractions through solvent crystallizations. It mainly is made up of straight-chain hydrocarbons (Ash and Ash 2004). These two oils comprise the largest fraction of the product tested in conjunction with borates. Non-diffusible liquids can decrease the leachability rate of the diffusible preservation (Lebow and Anthony 2012). The addition of transparent iron oxides is an industry standard and were included in the testing as a prepared formulation (Wright 2000).

Alkyd resins are typically found as binders in organic coatings with good adhesion and drying properties (Nanvaee et al. 2009). When linseed oil and alkyd resins are combined, a branched polyester that has fatty acid side groups are formed. When the coating is applied to a given substrate (Nanvaee et al. 2009), linseed oil goes through a cross-linking reaction with oxygen. In a conventional wood-coating system with high solid content, the formation of this film typically sits above the wood cells and is prone to failure via delamination of substrate, as UV degrades the first layer of cells to which the film is bonded (Wicks et al. 2007). In contrast, a penetrating oil system like the TWP 1500 series relies on the principle that oil with a lower alkyd resin content cross-links within the first layers of cells (0.05–2 mm) and can receive additional coats through cyclic maintenance without invasive abrasive substrate preparations. This sustainable maintenance program allows for maximum retention of original material and is ideal for application in heritage conservation.

6. TREATMENT IMPLEMENTATION

Following the initial field testing, large-scale mock-ups of finish removal were implemented and further evaluated for effectiveness before full-scale removal in June 2014. The surface of the wood was then allowed to naturally weather for 2 years before application of the preservatives and coating combination in April 2016.

6.1. FINISH REMOVAL

A benzyl alcohol–based stripper (Smart Strip) was used to remove the existing dark orange coating layers. This procedure entailed applying a 1/8 to 1/4 in. layer of emulsion paste with a natural 4-in. brush and allowing it to dwell for 2 to 4 hours under 1-ml polyethylene sheeting, then gently removing the finish with a soft plastic spatula. This proved effective for removal of an estimated 98% of material. The residual was allowed to weather away through a natural process. The benzyl alcohol base material is considered non-toxic with a health rating of 1 and is ideal for large-scale work (fig. 8).

6.2. CLEANING

After 22 months of natural weathering, the surface of the wood was cleaned with D2, didecyl dimethyl ammonium chloride (DDAC), also referred to as quad-ammonium, a biodegradable surfactant-based biocide with a long history of use in building conservation, particularly for masonry. Its application for wood substrates provides an effective means for reducing superficial mold/fungi and soiling, and any used in the preservative combination to follow, which serves to help simplify the range of materials introduced.

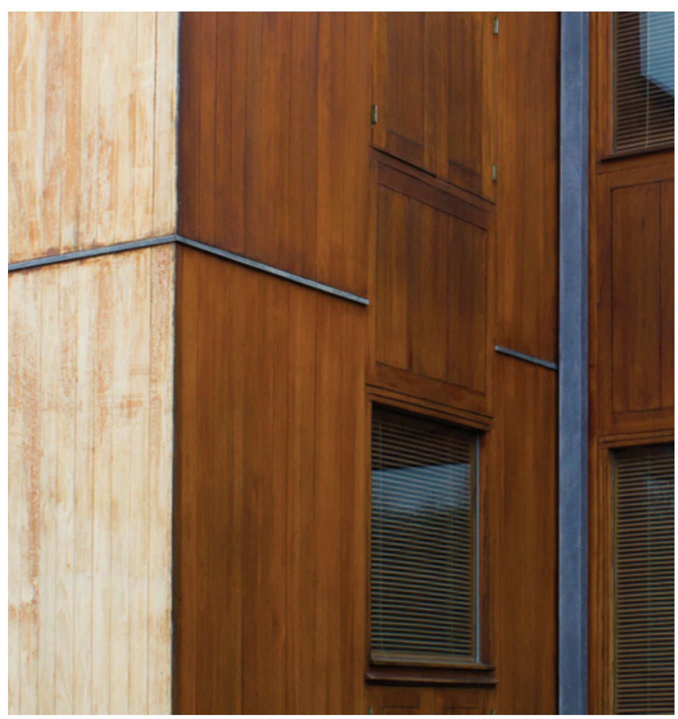

Fig. 8. During treatment, removal of existing finish (left area)

6.3. DIFFUSIBLE PRESERVATIVE APPLICATION

To deter a broad range of fungi species, including the brown-rot fungi and mold/fungi observed, a Bora-Care with Mold-Care combination of disodium octaborate tetrahydrate (DOT) and DDAC were applied in a concentration of one part concentrate to five parts water using a hand pump sprayer. Bora-Care contains a large glycol component that is hygroscopic and helps to distribute the DOT within the vascular network of wood. The borate treatment was applied at a moisture content of less than 10% and then allowed to dry for several days.

6.4. PRESERVATIVE COATING

TWP 1500 containing paraffin oil, linseed oil, IPBC, cobalt drier, and alkyd resin with the addition of titanium dioxide pigmented TWP 109 (Cape Cod Grey) was used as the final coating. The mixture (hand mixed on-site) was 10 gallons of clear TWP 1500 to 1 gallon of TWP 109—the full 11 gallons was mixed with an electric drill paint mixer for 10 minutes and then divided into smaller amounts, which were distributed to the crew as needed. The coating was applied with a brush that was found to yield the most control following the manufacturer's specifications, well below the average of 9% moisture content. One saturating coat was employed with careful execution to complete full elevations at a time. Any drips or heavy flows were cleaned up within 1 hour (figs. 9 and 10).

7. CONCLUSION

7.1. APPLICATION IN CONSERVATION

Wooden material in an exterior environment is a multidimensional problem involving hundreds of species of living organisms, compounded by agents of weathering: primarily UV and water. In heritage conservation, wooden materials must ideally serve an extended serviceable life while fulfilling requirements for appearance, stability, and surface integrity. The program tested employs two manufactured products that are readily available, sustainable, and easy to implement on a large scale through a minimally invasive, environmentally sound, cyclic maintenance program. Laboratory tests provide that the penetrating oil combination containing IPBC helps to retain the borates (DOT) and the DDAC-based preservatives for higher-order decay fungi while together also serving as an effective means to deter mold/fungi. The addition of titanium dioxide stain is necessary to prevent UV damage and is chromatically sensitive to Kahn's intent. The penetrating oil system is preferable to film-forming coatings, as it is sacrificial, re-treatable without substrate preparation, and economical to implement. The estimated service life of applications may range from 3 years in high-exposure areas to 5 years in low-exposure areas but require longer-term assessment to fully quantify data.

With the acknowledgment and value of the architect's intent, there is a need to balance the consumptive weathering process with an intervention that imparts material stability while visually keeping within Kahn's vocabulary. Works of the immediate past provide the opportunity to issue preventive conservation measures through proper maintenance to mitigate the onset of irreversible deterioration. As modernist architecture embraces a natural process, the problem is universally shared by a broad range of wooden-built heritage to which the treatment program may offer applicable solutions.

Fig. 9. Application of TWP (left area treated)

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Fig. 10. Korman House, after treatment, 2016

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2016 WAG Abstracts

Choices and Triage: The Impact of Early Decisions on Future Treatment Options.

Steven Pine, Senior Decorative Arts Conservator, The Museum of Fine Arts, Houston

After the water recedes or fire is extinguished important choices begin that can dramatically impact the nature of intervention, costs involved, and treatment options available to stabilize and restore collections in subsequent weeks or months. Many times these decisions are made by staff and consulting conservators under extra-ordinary stress and limited time for consideration. Though the hard decisions are made by collection management in discussions with conservators and insurance adjusters in due course and with time for deliberation many treatment choices are set in motion during the process of triage. This presentation will examine a range of decorative arts materials as they were found during or immediately following triage for water damage followed by a discussion that considers treatment options informed by hind sight from past disasters. The audience will respond to examples given with their preference for triage recommendations and potential treatment outcomes by using class room clicker technology. The resulting survey will be discussed and be published in the post prints as a reference tool for future disaster responders faced with similar choices. Better informed future triage will hopefully lead to improved outcomes.

Loss Compensation on Furniture: Traditional vs Modern Methods and Materials

Behrooz Salimnejad, The Elaine S. Harrington Senior Conservator of Furniture and Woodwork, Philadelphia Museum of Art

Behrooz Salimnejad has worked in the Furniture Conservation Department of the Philadelphia Museum of Art (PMA) since 1992 and has utilized both traditional craft techniques and modern conservation methodologies for loss compensation. In this presentation he will discuss the factors that led to choosing a suitable approach for different types of loss, including gilding, wood carving and turning. In some cases multiple methods were utilized on the same object. Highlighted treatments will include: replacement of missing feet and turned elements on a chair designed by Frank Furness (American, 1839–1912); compensation of abraded sections of gesso and gilding as well as missing carving on a sofa by John Linnell (English, 1729–1796); and carving of swags on a table by Sefferin Alken (English, 1717–1783).