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Conservation of the H.L. Hunley and its Associated Artifacts

James W. Hunter, III
Friends of the Hunley, Inc.

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ABSTRACT

Conservation efforts applied to *H.L. Hunley* during 2005 reflected recommendations outlined in the Conservation Plan submitted to the Naval Historical Center for peer review in November 2004. A critical first step to the conservation process comprised a thorough corrosion assessment of the submarine's hull. Results derived from this survey encouraged project conservators to expand *H.L. Hunley*'s preexisting cathodic protection system to the interior of the submarine's ballast tanks. Additionally, other tasks were carried out in preparation for the submarine's long-term stabilization and eventual conservation in caustic chemicals. Finally, a significant number of complex, fragile artifacts associated with the submarine were conserved.

CONSERVATION OF *H.L. HUNLEY*'S HULL, MACHINERY AND EQUIPMENT

Crew Bench, Depth Gauge and Miscellaneous Items

In order to properly—and safely—conserve the submarine's hull and its auxiliary equipment in caustics, project conservators had to remove a number of artifacts and structural features from the interior hull. Extensive x-ray analyses were conducted on a number of complex features prior to their removal from the submarine. These included the wooden crew bench, comprised of three 3.0-cm thick planks painted on their upper surfaces and attached to the hull via riveted brackets; a painted board that once supported the submarine's broken mercury depth gauge; a large piece of rubber trapped between the bench and the aft pump mechanism; and remnants of highly-degraded canteens that were placed underneath the bench by *H.L. Hunley*'s crewmen. Once removed, these problematic items were safely relocated to the conservation laboratory for storage, analysis and stabilization.

Viewports

Glass is typically unstable in strong alkaline solutions (i.e., sodium carbonate and sodium hydroxide) such as those that will be used to remove corrosive chlorides from *H.L. Hunley*'s iron hull. Consequently, project conservators initiated efforts to disassemble and remove glass components of *H.L. Hunley*'s viewports before the water pH in the submarine's storage tank is chemically altered later this year. Assessment of the entire viewport assemblage indicates two forms are present on the submarine. The first type is comprised of five pairs of viewports that straddle the centerline along the upper hull of the vessel's crew compartment. X-ray analyses and preliminary deconcretion of a single example has revealed this viewport type includes a hinged deadlight cover attached to the interior of the hull. The other form is only present in *H.L. Hunley*'s conning towers and consists solely of a glass viewport without a hinged cover.

The deconcreted viewport comprises at least four material elements, including cast iron, wrought iron, rubber and glass. Early in the conservation process, the team

determined that each viewport could be safely disassembled, removed from the hull and treated independently. The complexity of the task was exacerbated by severe corrosion of each viewport's cast iron elements, as well as the friability of its 8-mm thick glass components. Following delicate and lengthy deconcretion of each hull plate, all cast-iron deadlight covers were opened, all viewports disassembled, and their iron and glass components removed from the submarine. A number of cast-iron deadlight covers retained rubber gaskets on their interior face. Each gasket was thoroughly documented *in situ*, removed from its corresponding deadlight, and stored in chilled water.

Project conservators also disassembled the viewports in the forward and aft conning towers. Fragile viewport components, including cast-iron flanges, glass ports, and rubberized textile seals, were successfully removed from both conning towers. The conservation team deconcreted and documented the viewport in each of the submarine's cast-iron hatch covers, and removed its fragile glass element. The conning tower viewports appear significantly smaller, and differently designed and constructed when compared to the viewports installed along the vessel's centerline. A total of 16 viewports have been safely disassembled, removed from the submarine, and stored in the laboratory. During this process, 102 new artifacts and 64 samples were catalogued. The list of new artifacts includes multiple cast-iron deadlight covers, wrought-iron pins, rubber gaskets, glass ports and wrought-iron flanges. Project conservators entered all new documentation, such as photographs and artifact descriptions, into the Hunley Project archaeological database.

Hull plate CT3 was entirely deconcreted after its viewports were removed. This plate is very fragile, especially along its port side. The same trend was noted for hull plates CT5 and CT7. The conservation team conducted lengthy deconcretion of the interior of these plates in order to save as much of their original surface metal as possible. A wrought iron handle and its associated copper-alloy stuffing box (artifact number HL-3452) and nuts (HL-3450 and HL-3451) were disassembled and removed from CT3. Additionally, conservators located a rubber gasket (HL-3453) between the stuffing box and the interior hull plate. A silicone mold (Mold #22) of the complete handle assembly was created before it was taken apart and removed. Extreme levels of corrosion in hull plate CT7 created serious risk of its eventual disintegration and collapse; consequently, the conservation team fabricated a support cradle that enables them to move, store, and work on the plate without the risk of further damaging it.

A large patch comprising two different types of fabric (HL-3460) were embedded in the concretion surrounding one of the cast-iron deadlight covers (HL-3460) from plate CT4. A sample of this material (S6402) was sent to Clemson University for analysis and identification; the fabric types included wool and cotton. The latter was the first ever example found on *H.L. Hunley*.

Removal of Ballast Blocks and Iron Piping

Upon removal of the wooden crew bench, 12 iron ballast blocks remained fused to the iron hull beneath it. In addition, iron piping associated with the submarine's water

ballast tanks were located underneath the bench. The ballast block assemblage and iron piping were deconcreted and documented by project conservators, and digitally mapped by the archaeological team prior to being removed from the submarine. Since September 2005, 18 ballast blocks have been successfully excavated from *H.L. Hunley* (with the exception of four examples that will be removed upon disassembly of the submarine's aft ballast tank pump). Eighty-seven samples and two new artifacts were generated during removal of these items; the latter group included a wooden toothpick (HL-3411) and matchstick (HL-3412). Once removed from the submarine, the ballast blocks were deconcreted and placed in a dilute solution of sodium hydroxide. Other significant artifacts, including a tin canteen (HL-2159) fused to the hull, were documented, removed, and prepared for conservation.

Because of its exceptional fragility, the conservation team removed the concreted iron pipe that connected the forward and aft ballast tanks. The primary pipeline, as well as its associated quarter valves and other components were all recorded, carefully removed from the hull, and placed in a dilute solution of sodium hydroxide. During this process, several iron artifacts (HL-3381, HL-3404, and HL-3405) concreted to the bottom of the hull in submarine commander Lt. George Dixon's area were recovered, x-rayed and documented.

Structural Analyses

The effort to study and preserve *H.L. Hunley* has now entered a critical new phase. Currently, the submarine is suspended underneath its steel recovery truss via a system of support slings. The hull is oriented at a 45-degree list to starboard—the same inclination in which it was discovered on the seabed. Now that the excavation of *H.L. Hunley*'s interior is complete, the next phase of the project involves the removal of the concretion that has formed on its interior and exterior surfaces. To facilitate this task and access portions of the hull currently covered by the submarine's support slings and bags, some—but preferably all—of these slings must be removed. The project's overall conservation goals would be enhanced further if *H.L. Hunley*'s hull could be rotated and placed upright on its keel.

The forward and aft ballast tank pumps are riveted to the hull. Because both pumps are complex composite artifacts made of cast iron, wrought iron, copper alloys and rubber, they must be treated via special conservation methods that cannot be performed *in situ*. The pumps are a critically important element of the submarine's architecture and their removal will be a complex and delicate process. Project conservators have determined that removal of two of *H.L. Hunley*'s cast-iron keel ballast blocks would best facilitate removal of the pumps. However, each ballast block slated for removal is located at a critical junction in the submarine's hull where semi-hemispherical hull plates transition to riveted quarter plates. The conservation team need to know whether the removal of these two ballast blocks will affect the overall structure of the hull and any later attempts to alter its configuration, as well as what kind of support structure will be necessary if the blocks are removed.

However, before these and other proposed conservation protocols can proceed, a number of important questions regarding the submarine's structural integrity must be addressed. Consequently, project principals have proposed a thorough structural assessment of *H.L. Hunley* be conducted first. Among other things, this will require development of a finite element model of *H.L. Hunley* in its current state. The model will incorporate data attained from ongoing archaeological documentation (such as that used to develop a three-dimensional site map of the submarine), as well as information derived from future non-destructive evaluation and metallurgical studies of the interior and exterior hull.

CONSERVATION OF *H.L. HUNLEY*'S ASSOCIATED ARTIFACTS

Cupreous (Copper and Copper-Alloy) Material

The majority of cupreous artifacts conserved during 2005 comprised personal items, including uniform and clothing buttons (HL-3200, HL-3201, HL-3232, HL-3164, HL-3329, HL-3333, HL-3337, HL-3343, HL-3341, HL-3344, HL-3346, HL-3348, HL-3350, HL-3351 and HL-3368), three buckles (HL-2073, HL-3336 and HL-3349), and a thimble (HL-1354). One of the buckles (HL-3336) belonged to Lt. Dixon and contained important diagnostic markings, including the stamped or inscribed marks "Paris," "1860" and "SOLIDE," as well as as-yet unidentified maker's mark (Figure 1). Other significant copper and copper-alloy items include pins (HL-3172 and HL-3292), wires (HL-3174, HL-3290 and HL-3299), a nut associated with the bellows-snorkel box assembly (HL-3196) and two rings or grommets (HL-1679, HL-1309), the latter of which is associated with a Union identification tag discovered among the remains of crewman Joseph Ridgaway.

Figure 1: Copper-alloy buckle HL-3336 following conservation.

Iron Objects

For the past twenty months, *H.L. Hunley* Project conservators, in cooperation with materials scientists from Clemson University, have developed a new, groundbreaking

treatment for the removal of chloride (Cl^{-1}) from cast and wrought iron artifacts. The objective of this initial study has been to compare Cl^{-1} removal via this process to traditional methods, particularly alkaline soaking and alkaline soaking used in conjunction with electrolysis. To date, over 30 experiments have been conducted on rivets recovered from *H.L. Hunley*, as well as cast iron specimens obtained from an American Civil War-era Parrott shell. Initial results of this study were presented at the *Metal 2004* conference in Canberra, Australia.

The technique is based on the use of sub-critical water solutions as the media for the removal of Cl^{-1} from cast and wrought iron. By definition, sub-critical water is water at requisite pressure and heated to a temperature between 100°C and the critical temperature of water, 374°C. In the sub-critical region, the transport properties of water as a solvent media exist between those of liquid H_2O and supercritical H_2O. The hypothesis for this investigation states the employment of sub-critical water solutions could dramatically increase Cl^{-1} removal efficiency and significantly reduce treatment times. As evidenced in Figure 2, project conservators effectively used the technique to treat the nut (HL-502) and bolt (HL-511) that once held the submarine's spar assembly to the bow. Following sub-critical treatment, each artifact's exterior surface was cleaned with a low pressure, 50-micron sodium bicarbonate micro-abrasion unit.

Figure 2: Spar nut (HL-502) and bolt (HL-511) before and after sub-critical treatment.

Wrought-iron pins that once connected deadlight covers to their corresponding viewports were recovered from hull plates CT3 (HL-3429, DL-P) (HL-3430, DL-P) (S-6363, DL-S) (S-6376, DL-S); CT5 (HL-3400 and S-6328); and CT7 (HL-3436, DL-P) (HL 3438, DL-S). All of the aforementioned were treated via the experimental sub-

critical water technique outlined above. In addition, an iron spring from Lt. Dixon's gold pocket watch (HL-2909) was stabilized. An ongoing task slated for completion in the near future involves the removal of iron staining from within the pocket watchcase; this is expected to reveal stamps and other impressed diagnostic markings that are currently obscured by iron oxide.

Only one large iron object began treatment during 2005. A grapnel anchor (HL-2917) discovered during a magnetic survey of the *H.L. Hunley* recovery site in 2003 was completely deconcreted and placed in a caustic storage solution.

Organic Items

Waterlogged organic artifacts conserved during 2005 include three wooden pipe bowls (HL-1090, HL-1367 and HL-1798), one of which still retained its associated reed stem (HL-1471), wooden spacers from the submarine's force bellows (HL-3197 and HL-3199), cork canteen stoppers (HL-1362, HL-1580, HL-1584, HL-3043 and HL-3283), wooden canteen stoppers (HL-962, HL-1206, HL-2346, HL-2363 and HL-3294), and a variety of small wooden objects that have been tentatively identified as either toothpicks or matchsticks (HL-1865, HL-3225, HL-3226, HL-3282, HL-3293, HL-3302, HL-3324, HL-3353, HL-3354 and HL-3358). A number of unidentified wooden objects (HL-969, HL-2021, HL-2137, HL-2311 and HL-2428) were also treated.

Lt. Dixon's three-piece wooden seat (HL-1973) was cleaned, impregnated with polyethylene glycol (PEG) and subsequently vacuum freeze-dried (Figure 3). Of the wooden matchstick assemblage, several examples exhibited carbonized ends. These were successfully cleaned and conserved, as were the numerous wooden and cork stoppers associated with the crew's individual canteens.

Figure 3: Lt. Dixon's seat (HL-1973) following treatment.

Project conservators completed treatment of the remains of Lt. Dixon's binocular case (HL-2782) via PEG impregnation and freeze-drying. The treatment regimen included stabilization of numerous gilded wood fragments and reassembly of the surviving top and bottom parts of the case. Currently, several fragments of the case are still missing but may be embedded in sediments block lifts that have not yet been excavated.

Lt. Dixon's composite folding ruler (HL- 2784) was carefully opened, mechanically and chemically cleaned, and impregnated with PEG. It will be freeze-dried during 2006. Other organic items, including clothing buttons manufactured from horn (HL-2893, HL-3340, HL-3389 and HL-3390) were conserved in a similar manner. The conservation team also completed cleaning and stabilization of two leather belts (HL-1042 and HL-971) via PEG impregnation and subsequent vacuum freeze-drying. A significant number of miscellaneous leather artifacts associated with the shoe assemblage recovered from *H.L. Hunley* were cleaned, pre-treated with PEG, and freeze-dried. These items included artifacts HL-0902, HL-1426, HL-1482, HL-1502, HL-1531, HL-1546, HL-1547, HL-1581, HL-1600, HL-1684, HL-1707, HL-2186, HL-2323, HL-2410 and HL-2554, and 44 individual samples.

Surviving elements of the force bellows (HL-899) were processed during 2005. These included elements from the painted (Part A) and unpainted (Part B) portions of the artifact. Remnants of leather were carefully removed from the bellows; its two primary wooden components were impregnated with PEG and freeze-dried. The leather items removed from the bellows will be freeze-dried in 2006. A portion of leather upper from shoe HL-1211, containing five metal eyelets, shoelace material, and fragments of textile, is currently undergoing treatment in PEG.

Glass

Three glass clothing buttons (HL-3326, HL-3342 and HL-3345) discovered during excavation of block lifted sediment in 2005 were documented, cleaned and conserved.

PAPERS, PRESENTATIONS AND EDUCATIONAL EFFORTS

During 2005, members of the conservation team participated in various professional conferences and symposia. Between November 13 and 17, project conservators presented two papers at the *Conservation of Archeological Materials: Current Trends and Future Directions* conference in Williamsburg, Virginia. Both papers (entitled "New Perspectives Regarding the Stabilization of Terrestrial and Marine Archaeological Iron" and "Conservation of Waterlogged Cork Using Supercritical CO_2 Drying") will be published in upcoming conference proceedings. Project chemical engineer Nestor Gonzalez participated in the *Archaeological and Art Issues in Materials Science* symposium in Mexico and presented a paper entitled "Evaluation of New Technologies for the Stabilization of Archeological Iron." Clemson University associate Dr. Michael Drews presented his paper "Chloride Distribution Measurements and

Chloride Distribution on the *H.L. Hunley*" at the *Eastern Analytical Symposium* in New Jersey on November 14.

H.L. Hunley Project Senior Conservator Paul Mardikian was invited to attend a consortium meeting hosted by the Monitor Group in Norfolk, Virginia. The meeting, which included representatives from Friends of the Hunley, Inc., the USS *Monitor* Project, Clemson University, and Old Dominion University, presented results of current conservation research for large, iron archaeological objects recovered from marine environments. While in Norfolk, Mardikian also attended a Conservation Advisory Committee meeting to discuss efforts to conserve the turret and engine recovered from the American Civil War ironclad USS *Monitor*.

During 2005, members of the conservation team met with conservators from Parks Canada (the Canadian equivalent of the U.S. National Park Service) to examine 18th-century waterlogged corks treated at Clemson University with an experimental technique that utilizes supercritical carbon dioxide (CO_2). The results of these experiments were very encouraging, and the conservation team has initiated plans to treat a number of waterlogged corks dating to the 16th century (recovered from the Red Bay Wrecks in Labrador) with this technique. If the outcome of this next round of tests is successful, the cork canteen stoppers from *H.L. Hunley* will be conserved with the supercritical CO_2 method.

On December 13, members of the conservation and archaeological teams met with staff from the Naval Research Laboratory (NRL) to discuss the potential for future research collaboration between both groups. A presentation about the *H.L. Hunley* Project's subcritical research was presented to Dr. Bhakta B. Rath (Head, Materials Science and Component Technology Directorate, Naval Research Laboratory) and Dr. Keith E. Lucas (Center Director, Naval Research Laboratory Center for Corrosion Science and Engineering). Another presentation outlining the need for a thorough engineering study and assessment of the submarine's hull was also directed to attending NRL staff.