# met objectives

The Sherman Fairchild Center for Objects Conservation
The Metropolitan Museum of Art – Fall 2003
Treatment and research notes, Volume 5, No. 1

The Sherman Fairchild Center for Objects Conservation provides for the preservation and technological study of ten curatorial collections in the Metropolitan Museum. The activities of the Center encompass the conservation of archaeological objects, sculpture, furniture, ceramics, and glass, as well as investigative research related to mechanisms of deterioration, preservation treatments, and historical technology. More than thirty professional conservators, scientists, and installers conduct their work in modern facilities located in the Henry R. Kravis Wing. These laboratories are equipped for a variety of analytical and investigative methods, including electron microscopy, X-ray spectrometry, X-ray diffraction, Fourier transform infrared spectroscopy, ultraviolet-fluorescence microscopy, metallography, and radiography. Areas of research that are of special long-term interest to the Center's staff include the development and testing of methods for the treatment of deteriorated stone sculpture, the development of safe and effective methods for the monitoring and control of biodeterioration, and the evolution of metalworking technologies throughout the world.

Staff members also serve as adjunct faculty at the nearby Conservation Center of New York University, and the Fairchild Center is the site of seminars and internships for students from this and other graduate programs. Postgraduate fellowships are awarded annually to conservators and other researchers from institutions in the United States and abroad.

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## New Scientist in Charge

**Marco Leona** has been appointed Scientist in Charge of the Museum's newly formed Science Group and will join the Museum in January 2004. Marco received his doctorate in crystallography and mineralogy at the University of Pavia (Italy) in 1995. Before taking up his current position as Senior Conservation Scientist at the Los Angeles County Museum of Art, he was Research Scientist at the Freer Gallery of Art/Arthur M. Sackler Gallery. His work includes various studies of artists' materials and techniques, ranging from the introduction of European pigments in Edo period Japan, to the use of colored glazes and selective coatings in Tibetan thangka paintings, to the spectroscopic characterization of the pre-Columbian pigment Maya blue.

The Science Group will bring together Museum scientists **Silvia Centeno**, **James H. Frantz**, **Robert J. Koestler**, **Nobuko Shibayama**, **George Wheeler**, and **Mark T. Wypyski**, currently members of different conservation departments, in order to integrate and expand the Museum's capabilities for scientific analysis and research.

## Other Staff News

In recognition of his contributions to every aspect of the Museum's professional activities since he came to the Department of Objects Conservation in 1978, **Richard E. Stone** has been promoted to Senior Museum Conservator. He is the first to receive this title.

*We apologize for omitting mention of the work of David Erhardt, Senior Chemist, Smithsonian Center for Materials Reseach and Education, in "The Oddy-test revisited,"* met objectives, *vol. 4, no. 2 (Fall, 2002). Dr. Erhardt presented the prototype of the "three-in-one" Oddy test at a Smithsonian Institution seminar in 1993.*

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**Ranging in date from the late Roman period to the early nineteenth century, the four works of art discussed in this issue of *met objectives* all were acquired by the Museum more than fifty years ago, and until recently each presented serious problems related to physical and chemical stability, or elicited concerns regarding authenticity and integrity. Characterization of manufacturing techniques and the systematic study of alterations introduced during multiple restorations allowed a monumental Roman bronze and a fragment of wall paneling from an American colonial interior to be recognized as authentic works, and in the case of the latter could be used to confirm its provenience. A medieval *basse taille* enamel processional cross, described as being in deplorable condition already in an early-twentieth century exhibition catalogue, and the reverse-painted glass panels from an American sideboard, both suffer from glass disease as well as the ill-effects of inappropriate or ineffectual interventions. These works are discussed here in terms of damages they have sustained and the strategies implemented to ensure their preservation.**

## Examination of a Third-century Roman Bronze

In 1905 the Metropolitan Museum acquired a monumental bronze statue (*Figure 1*) identified as the Roman emperor Trebonianus Gallus (r. 251–253). According to an article appearing that same year in the inaugural issue of the Museum's *Bulletin*, the statue was discovered in Rome near the Basilica of San Giovanni in Laterano in the early nineteenth century, and subsequently was in the possession of four different owners. Furthermore, since its discovery, several campaigns of reassembly and repair have been carried out, resulting in a heavily restored sculpture with a distorted, disproportionately large body. The figure had not been closely examined until recently, when in preparation for installation in the Museum's Leon Levy and Shelby White Roman Court it became the subject of an in-depth technical investigation. Complementing an art historical analysis by Seán Hemingway, Associate Curator of Greek and Roman Art, the study focused on condition and manufacture, with the primary aim of establishing how much of the bronze is ancient, and how effectively the sculpture conveys its original attitude.

Visual examination using conventional and ultraviolet light sources led quickly to the conclusion that an opaque black coating

*Figure 1.* Trebonianus Gallus, *Roman, third century A.D. Bronze, h. 237.5 cm. Rogers Fund, 1905 (05.30). Modified digital image with lighter areas indicating modern restorations. The left foot may be from a different ancient figure.*

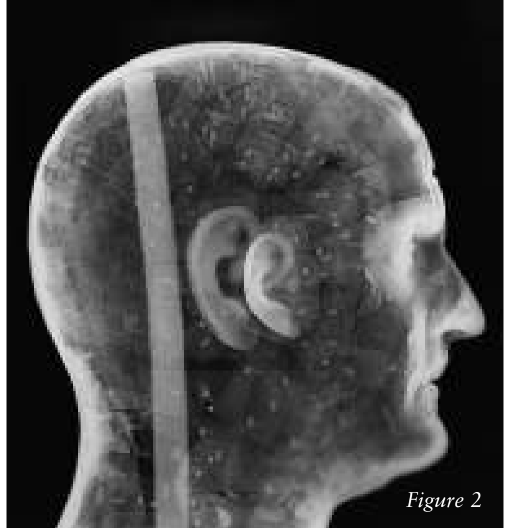

Figure 2

*Figure 2. Gamma-ray radiograph of head (Figure 1). Radiopaque spots and associated angular forms represent the numerous screws and straps used to reassemble the head fragments. The increased radiopacity around the facial features indicates where wax was built up during the preparation of the model. An iron armature added during one of the restoration campaigns appears as a vertical radiopaque band.*

had been applied to the entire figure, disguising an intricate patchwork of ancient fragments and modern additions. Once the coating was removed some of the newly exposed surfaces displayed obvious differences: ancient fragments still bearing archaeological corrosion contrasted with the bright, metallic or artificially patinated surfaces of modern restorations. In other cases it was difficult to distinguish between new metal and ancient fragments that had been stripped of corrosion products.

A radiographic study was undertaken to resolve questions left unanswered by these initial investigations. The sculpture is too large to fit in the Fairchild Center's dedicated radiography room and a commercial firm was contracted to carry out the work in a secured area using a portable unit. Because of the presumed thickness of the bronze walls, given the size of the figure and the volume of restoration materials anticipated, gamma radiation generated by an iridium-192 source was chosen over X-rays. The statue was further examined using an Everest VIT PLS 500D videoprobe lent to the Museum by its manufacturer on a trial basis. This long, flexible probe, mounted with a miniature digital camera and high-intensity light source, is able to transmit video and still images, providing invaluable visual access to cavities and interior surfaces of the statue.

Although the head appeared relatively intact even after the black coating had been removed, radiographs revealed a reconstruction from numerous ancient fragments held together on the interior with straps and screws (*Figure 2*). The most significant fragment preserves much of the face, and with use of the videoprobe, features related to the fashioning of the intermodel that are characteristic of the indirect lost-wax process could be observed on its inner surface (see *Indirect lost-wax casting*, p. 3). Finger impressions are present in the metal around the mouth, where separate strips of wax were applied to the inner surface of the model, and additional wax was also placed behind the eye sockets.

Although fragmentary and reconstructed with modern patches, much of the torso is original. The upper portion and left side of the abdomen are ancient, whereas the right side, including the navel, and the genitalia are restored (*Figure 1*). Radiography was useful for recognizing features that provide further evidence of how the wax working-model was assembled inside the mold. A seam between areas of differing radiopacity, visible along the lower edge of the left pectoral, suggests the joining of two large wax sheets (*Figure 3*). The porosity in the metal is similar on both sides of this apparent discontinuity, and both an ancient patch and large crack continue uninterrupted across it, establishing the seam as an attribute of the original wax model rather than a metallurgical join or a repair.

The drapery and the upper left arm are modern, as videoprobe examination revealed that they lack archaeological corrosion on their interior surfaces, and both are substantially less radiopaque than the ancient fragments. Excessive porosity and other manufacturing flaws, as well as the angular set-in patches used to repair them, all typical of Roman workmanship and seen elsewhere on the portrait statue, also are absent in the more recently-cast metal (*Figure 4*). A large opening in the upper chest and back, now covered by the modern drapery, was found not to represent a loss but an original feature of the sculpture, as indicated by the presence of cast edges. Such openings have also been identified on other large Roman bronzes and typically accommodate separately cast garments. It is possible that the original garment was larger and covered the shoulder, more of the torso, and most of the upper left arm, which may explain why no fragments of the shoulder, or of the arm from just above the elbow, are present. Given that the forearm is attached only to the modern upper arm, the accuracy of its orientation cannot be judged from physical evidence.

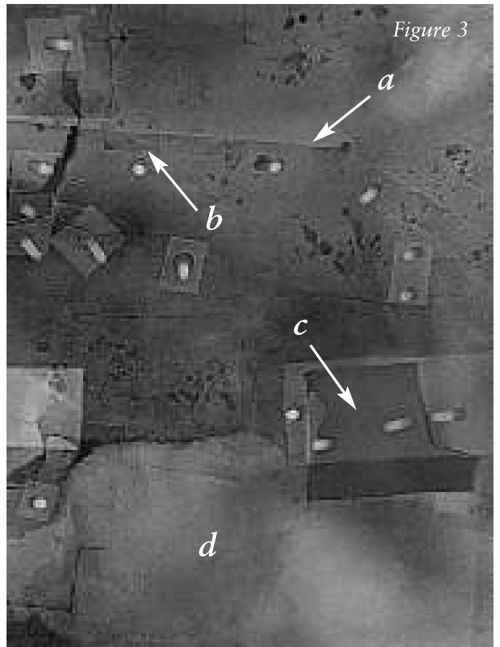

Figure 3

*Figure 3. Composite gamma-ray radiograph of left upper chest (Figure 1) showing features related to manufacture; a) discontinuity in radiopacity indicating where wax sheets were joined, b) ancient patch spanning discontinuity, c) modern patch, d) area of increased radiopacity, possibly due to the presence of a flow weld.*

***Sarah E. McGregor** is Assistant Conservator at the Sherman Fairchild Center, where she has worked on the Greek and Roman installation project since 1998. **Dylan Smith**, Assistant Conservator, joined the project in 1999, after two years at the Center as an Andrew W. Mellon Fellow, researching the materials and techniques of minai ware. Each received an M.A. in art history and a Certificate in Conservation from the Institute of Fine Arts, New York University. Sarah completed an internship at the Worcester Art Museum and two seasons at Harvard-Cornell Archaeological Excavations at Sardis (Turkey). Dylan was an intern at the Freer Gallery of Art/Arthur M. Sackler Gallery, and as a student also worked at Sardis, where he continues to participate as supervising conservator.*

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## Indirect lost-wax casting

**Lost-wax casting is one of the oldest and most versatile methods for producing irregular forms in metal. When using the *direct* lost-wax technique, the artist executes a model in wax, which is invested in a refractory mixture of clay, sand, and usually some organic matter. For hollow casts, a core is modeled from a similar mixture and then clad with wax and invested. Core supports called chaplets, generally made from metal rods, are hammered through the wax layer, where they engage and support the core once the wax is melted away. The *indirect* method allows the casting of multiples using the same mold. The original model is created from any convenient material, and from it, a piece mold. The mold is broken down and reassembled without the model. A so-called intermodel or wax working-model is poured or applied in sheets and the core poured or pressed inside. The mold is then removed, the model invested, and the core supports inserted. The piece mold can be reassembled and reused to create another intermodel, which, in turn, can be invested and cast.**

While the top surface of the right shoulder is a restoration, much of the upper arm itself is ancient, although, like the adjacent torso, it is largely reconstructed from fragments. On the upper interior surface of the intact right forearm several parallel ridges were found, starting from the elbow (*Figure 5*). Similar ridges, associated with a group of evenly spaced chaplets, have been observed inside the base of a Greek herm (79.AA.138) in the J. Paul Getty Museum. This bronze was examined by former Getty Conservation Institute scientist David Scott and Getty Museum conservator Jerry Podany, who suggested that these ridges are casting fins formed in cracks in the core that occurred when the core supports were introduced. In the case of the Museum's statue of Trebonianus, the absence of a similar arrangement of chaplets in the forearm indicates that an alternative explanation must be found; sequential pourings of wax used to produce the model, or the addition of reinforcing wax strips, replicated in the cast metal, might account for the ridges.

The ancient fragments that make up much of the upper thighs continue uninterrupted from the lower torso, confirming that the positioning of the legs is approximately correct. The feet, wearing ankle-high sandals, seem too small for the statue, although this may be a stylistic peculiarity, and both are joined to the calves using techniques not practiced in antiquity. The presence of impurities in the alloy of the left foot, however, does leave open the possibility that it is ancient, belonging to this or to another Roman sculpture. The right foot is divided fairly neatly into right and left halves by a radiotransparent line. It is not certain whether this feature relates to the use of a two-part mold or to a join between separately produced pieces, but either alternative implies modern manufacture.

Close to seventy-five percent of the Trebonianus figure is original, far more than first expected given the appearance of the bronze when the technical investigation was initiated. This fact takes on added significance since there are very few examples of large-scale Roman bronze statuary of the third century, and the Museum's figure is one of the rare three-dimensional representations of Trebonianus that survive. Still, many questions remain to be addressed. For example, if examination of its microstructure should indicate that the left foot is ancient, the technical and stylistic analysis of other Roman figural bronzes can help to determine whether or not it may belong to this statue. Similar investigation could also resolve uncertainties relating to the proper orientation of the left forearm and its original means of attachment.

Figure 4

*Figure 4. Gamma-ray radiograph of left upper arm (Figure 1). Clear distinctions can be seen between the modern upper part of the arm and ancient fragments just above the elbow that continue under the modern drapery (a). A modern sleeve (b), held in place with solder and screws attaches the upper arm to the forearm. Also visible are the cast edge of the torso (c) and part of a modern iron armature (d).*

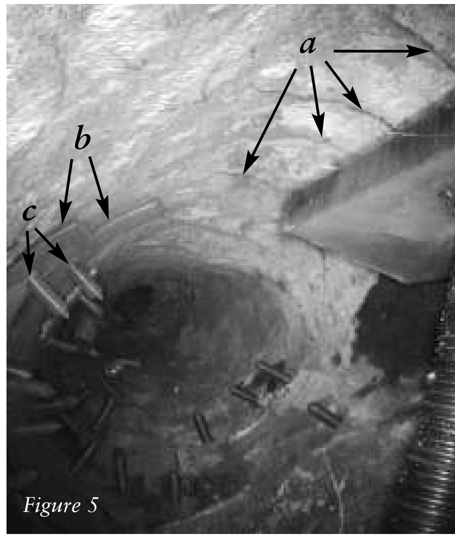

Figure 5

*Figure 5. Videoprobe image of the interior of the right forearm (Figure 1), looking into the hand. A series of ridges (a) is seen on the surface of the intact upper fragment, which is covered with archaeological corrosion. The surface of the lower portion is obscured by extensive modern repairs using brass plates (b) and screws (c).*

Figure 6

*Figure 6. Sideboard, American, 1795–1815. Mahogany, satinwood, silvered copper, reverse-painted glass panels, w. 226.1 cm. Joseph Pulitzer Bequest and Gift of Mitchel Taradash, 1945 (45.77). Before treatment.*

# Reverse-glass Paintings on an American Sideboard

Reverse painting on glass became popular in Federal America and was practiced mainly by foreign-born artists in Boston, Salem, Philadelphia, and Baltimore. For example, "Walker and Chandless, Painters, in General, from Dublin and London," advertised "Painting on Glass and Transparent Painting" in the *Maryland Gazette* in 1790. Such paintings, with subjects ranging from flowers and geometric designs to allegory, mythology, and scenic views, were usually incorporated into mirrors, clocks, and other furniture. Ten reverse-painted glass panels, varied in size and shape, can be seen on a neo-classical sideboard in the collection of the Department of American Decorative Arts (*Figure* 6) that had been commissioned by General David Van Ness (1743–1818) for his Maizefield estate in Dutchess County, New York. Major elements of the designs used on these panels, including urns, cupids, foliage, lyres, and masks, were derived from plates in Thomas Sheraton's *The Cabinet-Maker and Upholsterer's Drawing-Book,* first published in London in 1791. In an accompanying text Sheraton wrote: "These may be painted, inlaid, or gilt in gold behind glass, and the glass being then beded [*sic*] in the pilaster, it is secure, and has a good effect."

At the end of the eighteenth century, domestic glass manufactories in several major commercial centers were competing with imported crown and cylinder glass from England, and as such the origin of the panes used on the Van Ness sideboard cannot be assumed. Samples from two panels were analyzed using energy-dispersive X-ray spectrometry (EDS) and both were found to be potash-lime glass with a ratio of potassium to calcium of approximately two to one, containing only relatively small amounts of sodium, magnesium, and aluminum. These results may point to a domestic source, as glass with very similar composition is known to have been made by at least one eighteenth-century American producer, the New Bremen Glassmanufactory in Maryland.

Figure 7

*Figure 7. Reverse-painted glass panel from sideboard (Figure 6). The gold leaf was analyzed using EDS and found to contain 95.2 % gold, 4.0 % silver, and 0.8 % copper.*

Well-executed reverse-glass paintings do not reveal the complexity of their manufacture. Since the designs are applied to the back of glass panes they must be built up in reverse—starting with the foreground and working "backwards"—which makes corrections virtually impossible. The technique used for the glass panels on the Van Ness sideboard is called metal-foil engraving, although in technical and art historical literature it is often referred to as *verre églomisé.* Gold leaf was applied to the back of the glass with a size such as clarified egg white, gelatin, or gum, and then engraved with a stylus of metal, wood, or bone. The design was completed by applying a colored background with paint (*Figure* 7).

From an advertisement in a 1795 issue of the *Pennsylvania Packet,* it can be established that "White Lead, Yellow Ochre, Venetian Red, Spanish Brown, Lampblack, Verdigrease, Prussia Blue, &c. dry and ground in oil; Linseed oil raw and prepared, Spirits Turpentine, [and] Painters Brushes" were among the materials available to reverse-glass painters. The paint layers on the six smallest glass panels contain a mixture of Prussian blue and lead white, while the green oval fields within the decoration of the two larger rectangular panels were painted with verdigris (*Figure* 7). A transparent layer of verdigris was found directly behind the engraved gold leaf on all rectangular panels. Using Fourier transform infrared spectroscopy (FTIR) and EDS, linseed oil was identified as the paint medium used on the Van Ness sideboard, excepting the large oval panels. The engraved urns on these two panels are painted with a transparent Prussian blue in a pine resin binder, while the red background contains vermilion, lead white, and dragon's blood, a dark red palm-resin traditionally used in glazes. Based on the nature of the pigments identified, it can be recognized that the glass panels on the sideboard were originally far more intensely colored, but they have altered—with Prussian blue fading to blue-gray, and verdigris and dragon's blood turning brown and orange-brown respectively—due to the combined effects of exposure to light and the presence of potassium hydroxide, a product of glass corrosion (see *Glass disease*, p. 8). Something of this original brilliance can be seen in the saturation of paint layers where protected by the gilding (*Figure 8*).

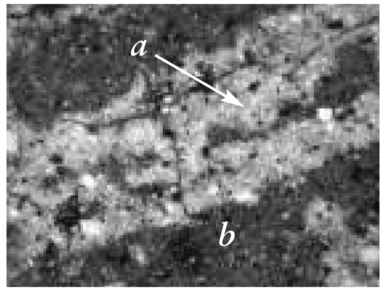

Figure 8

*Figure 8. Detail of reverse-painted glass panel from sideboard (Figure 6), illustrating the difference between deteriorated (a) and well-preserved (b) Prussian blue paint layers.*

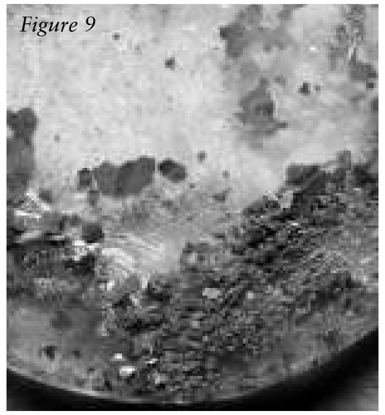

Figure 9

*Figure 9. Detail of the proper right oval glass panel from sideboard (Figure 6), with an opaque layer of saponified beeswax and detached red paint flakes.*

Delamination is a problem innate to the reverse-glass painting technique, since paint layers do not bond very well to smooth vitreous surfaces and begin to separate as the binding media deteriorate. At first, this process creates voids between the glass and the paint, and the difference between the refractive indices of glass and air cause the colors of detached paint layers to appear lighter. On the glass panels from the sideboard the adhesion of the paint was additionally adversely affected by the presence of potassium hydroxide. On several, this combination of detrimental influences has caused nearly ninety percent of the paint to delaminate, and on the proper right oval panel, for example, the damage progressed to the point where more than half of the red paint had fallen away from the glass surface, leaving hundreds of loose flakes that were recovered when it was removed from the sideboard (*Figure 9*). The oval panels were found to have a whitish opaque film on their reverse, both on glass surfaces exposed by paint loss, and on intact paint layers and detached fragments. FTIR analysis served to identify this substance as beeswax, which probably had been used as a consolidant during an earlier treatment. In the presence of potassium hydroxide the wax esters have saponified, causing further deterioration of the paint layers.

The first step in the treatment of the glass panels was the removal of the disfiguring opaque residue with deionized water and mineral spirits, although this method could be used only on exposed glass surfaces and where the paint layer is sufficiently stable. Since the size used to adhere the gold leaf proved to be water-soluble, only mineral spirits could be used in the gilded areas. For the consolidation of the reverse-glass paintings both artificial resins and waxes were considered. Dilute resin solutions are very effective because their low viscosity allows for deep penetration into spaces between the paint and the glass through capillary action, but air bubbles often form in these cavities when the solvent evaporates. Although more difficult to apply, waxes are preferable for the stabilization of reverse-glass paintings since they do not develop air bubbles, while offering the benefit of thermoplasticity, which makes it possible to reform the consolidant when necessary. Wax was the only option for treating the Van Ness sideboard panels because the beeswax residue makes it impossible for resins to adhere properly. TeCero Wax 30445, a microcrystalline wax chosen for its good adhesive properties, was applied with hot spatula to the reverse of the glass panels. The risk of using heat on the corroded glass was tolerable because the melting point of this wax is relatively low, and the use of a small tip on the spatula ensured localized and brief exposure. No effort was made to complete lost sections of the designs, but visual integration of losses was achieved by placing toned, acid-free paper behind the glass.

Given that the reverse-painted panels are affected by glass disease, their stability depends largely on climate control. Unfortunately, the ideal relative humidity specified for such glass is well below the levels required for wooden furniture, further complicating the preservation of the Van Ness sideboard.

*Simone Bretz has been active as a conservator of reverse paintings on glass in Munich since 1985, working with museums and private collections in Europe and the United States, including the Metropolitan Museum, where she has treated works of art on four occasions. After completing her training as a conservator of easel paintings, she acquired technical skills in the field of glass conservation and specialized in the treatment of reverse paintings on glass. Simone recently contributed her expertise to a research project on Swiss reverse-glass painting of the seventeenth century, and she has published widely on reverse-glass painting techniques.*
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## *Basse Taille* Enamel

An Italian, late-medieval processional cross in the collection of the Department of Medieval Art (*Figure 10*) is one of several related works that have not been exhibited for as long as five decades, largely because their *basse taille* enamel decoration has been severely affected by glass disease and other forms of deterioration. In order to identify the specific causes of decay and to establish safe methods for the treatment and preservation of these fragile works, a research project was designed, also with the hope that they can be safely displayed in the future.

*Basse taille* describes enamel work produced by firing colored glass frits onto a precious metal surface with chased or engraved decoration. Since light is reflected by the gold or silver substrate, the degree of color saturation within the translucent enameled fields varies with the thickness of the glass layer, a quality used to create a sense of depth and shadow. The Museum's processional cross is decorated, front and back, with scenes from the life of Christ and saints of the Franciscan order in *basse taile* enamel on silver plaques set into cast, gilded copper frames (*Figure 11*). Both faces also include a reliquary compartment with transparent rock-crystal cover, while the sides are covered with gilded latticework and embellished with rock-crystal and blue glass bosses.

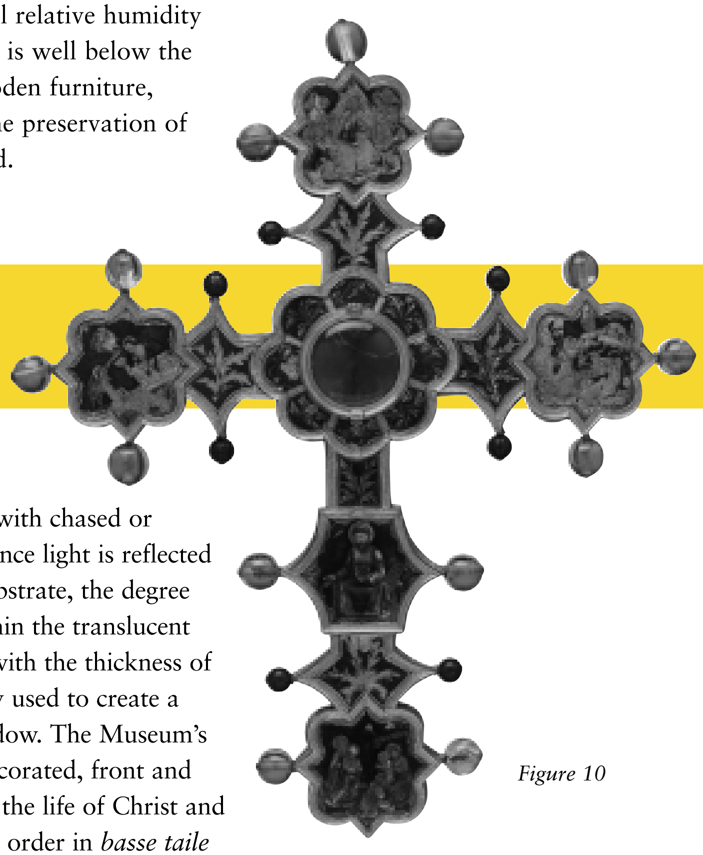

Figure 10

*Figure 10. Processional Cross, Italian (Siena?), last third fourteenth century. Silver and gilded copper over iron core, basse taille enamel, rock crystal, glass, h. 61 cm. Gift of J. Pierpont Morgan, 1917 (17.190.498).*

An important consideration in enamel manufacture is that the molten glass must wet the metal surface effectively during firing, and for this reason, its viscosity often is lowered by raising the concentration of flux. The resulting "high alkali-low lime" glass is inherently unstable, and with time becomes sensitive to moisture (see *Glass disease,* p. 8). Enamels deteriorate not only as a result of glass disease, but also due to the combined effects of several additional factors: the environment, stresses at the glass-metal interface, manufacturing flaws, and previous treatments.

Surface pitting can result from exposure to high levels of humidity, but may also appear during polishing, when gas bubbles trapped in the glass are exposed. Stresses occur in enamels for various reasons, including differences in the rates of contraction and expansion of the glass and metal, the characteristic softening temperature and viscosity of the glass, and curvature of the substrate. Depending on their source, the resulting damages to the glass can display distinctive patterns. For example, cracks caused by tension form in parallel lines (*Figure 12*), or may radiate outwards from centers of stress.

Errors occuring during manufacture that adversely affect the physical stability of enamels include uneven cooling after firing, which can result in cracks, chips, dimpled and pitted surfaces, and bare patches. In humid environments, outdoor pollutants such as sulfur dioxide accelerate deterioration of the enamels, while corrosion of exposed metal substrates weakens adhesion at the glass-metal interface. Similarly, noxious fumes from display and storage materials can generate formaldehyde or acetic acid that effect the stability of both the glass and underlying metal.

Among these possible deterioration processes, it is glass disease that has most severely affected the appearance of the enamels on the processional cross. As a result of surface depletion they have lost reflectance, and the viscous alkaline film formed in the process has trapped dust, dislodged glass fragments, and copper corrosion products. On the surfaces of the blue and green enamels, opaque, angular flakes are delaminating, leaving recesses where they have become dislodged. Although the thicker applications of yellow glass are relatively well-preserved, the thinner layers are highly deteriorated and have developed networks of microscopic cracks (*Figure 13*). In more advanced cases larger cracks have appeared, deeply fracturing these crizzled fields.

Small brown discolorations observed within the yellow and purple enamels can be associated with microcracks that have exposed glass below the surface to the environment. More progressed discolorations are present in severely hydrated yellow and purple enamels, where opaque, dark brown sections exhibit extremely porous surfaces. Since the compositions of both discolored and unaffected enamels do not differ significantly except in their coloring agents, it may be that the multivalent colorants present—iron oxide for yellow and manganese oxide for purple—become reactive in hydrated zones. Cobalt seems to play a

Figure 11

*Figure 11. Saint Francis receiving the stigmata. Basse taille enamel plaque on reverse of processional cross (Figure 10).*

*Ursula Kugler first came to the Fairchild Center as an intern in the summer of 1997, returning in 1999 as a Kress Fellow. Since that time she has worked on several projects, in the last two years in her capacity as Sherman Fairchild Fellow. After receiving her certification as a goldsmith, Ursula trained in the Metal Conservation Department at the Bayerisches Nationalmuseum, Munich, and subsequently worked there as a conservator of metal objects. In keeping with her expertise in the field of medieval enamelwork, she now specializes in the conservation of objects of mixed media.*
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## Glass disease

**Glass is an amorphous matrix of negatively charged silicate ions and metal cations. The main refractory ingredient is silica ($SiO_2$), to which alkaline substances such as potash ($K_2CO_3$) or soda ash ($Na_2CO_3$) are added as fluxes, together with lime (CaO) or magnesium oxide (MgO) as stabilizers.**

**The incidence of glass disease is directly related to the composition of the affected glass, and the deterioration that occurs can be thought of as a two-phase process. When high flux-low lime glass is exposed to a humid environment, the first step, known as alkali depletion, occurs as alkali ions contributed by the fluxing materials migrate to the surface of the glass matrix, where they are replaced with hydrogen ions present in water vapor. The resulting alkali-deficient, hydrogen-rich layer—the "gel layer" or so-called hydrogen glass—has a lower reflectance. The potassium and sodium hydroxides formed in this process react with carbon dioxide and sulfur dioxide from the air, and the resultant hygroscopic salts form a greasy, highly corrosive alkali-rich film on top of the depleted glass. In extreme cases, droplets form on the surface of the glass, a phenomenon known as "weeping". When glass affected by glass disease is placed in an environment with a lower relative humidity, the sodium and potassium carbonates form a white precipitate on the surface.**

**The second part of this process occurs due to the difference in size between the hydrogen and alkali ions. Replacement of the latter with smaller hydrogen ions causes surfaces to contract, leading to fracturing of the glass and exfoliation of the upper layers. Ion exchange will continue at the newly exposed surfaces of these breaks and losses, causing the damage to progressively worsen, eventually resulting in the disintegration of the glass.**

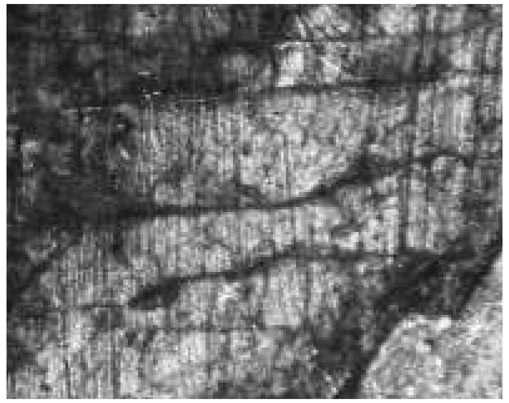

*Figure 12*

*Figure 12. Detail of processional cross (Figure 10) illustrating parallel stress cracks in enamel.*

similar role in the characteristic discoloration of the blue enamels, although in these cases the process appears linked also to the presence of sulfide corrosion on the silver substrate (*Figure 14*).

Gases exuded by materials used in vitrines or storage facilities have reacted with the gilded framing elements on the cross, forming hygroscopic corrosion products such as copper formate and copper acetate that migrated into fissures in the enamels, leading to further delamination, while the accumulation of hydrophilic cleaning agents in these recesses also accelerated the deterioration process. Several plaques were re-enameled in the nineteenth century and their positions changed, while in subsequent years various waxes and resins were used to fill other losses, stabilize cracks, and revive formerly reflective surfaces. Consolidation with synthetic polymers facilitated the formation of a concentrated corrosive alkali layer on the glass surfaces, while fracturing has resulted from the use of materials with a high glass-transition temperature.

Relatively new on the long list of natural and synthetic adhesives and consolidants applied to cultural materials is Ormocere®, an organic-inorganic polymer based on acrylic resins and modified silanes originally developed for the treatment of outdoor bronzes and exterior surfaces of painted glass windows. Recently reformulated specifically for the treatment of enamels, Ormocere® has now been used in several important collections in Germany. This blend of three low-molecular-weight polymers provided excellent results in laboratory tests with respect to adhesion, penetration, and long-term stability, and it has a refractive index very close to that of glass. However, the polymer does not form an impermeable barrier to water vapor, nor is it reversible, and it was ultimately rejected as a consolidant for the Museum's medieval *basse taille* enamels. The problem has now been addressed with a less-than-permanent solution, using a fully reversible consolidant and providing the works with self-contained, passivating environments that inhibit the free exchange of ions and will not cause the enamels to hydrate.

For this purpose a sealed Plexiglas® case was built in which the processional cross can be stored upright. Using silica gel, the relative humidity inside is stabilized at forty percent, just below the point at which potassium ions react with water vapor, while the inclusion of activated charcoal prevents the formation of silver tarnish. Treatment of the enamels included removal of the alkaline layer, silver and copper corrosion products, and old restoration materials, as well as the consolidation of unstable sections. Since a safe storage environment is ensured, Paraloid® B-72 could be used as the consolidant, offering the benefits of reversibility, excellent long-term stability, compatibility with alkaline materials, and a suitable glass-transition temperature. The acrylic resin was applied in a solution of equal parts xylene and ethanol, a mixture that penetrates well, with slow evaporation.

It is the wish of the Department of Medieval Art that in the future its entire collection of Italian medieval *basse taille* enamels will be displayed, and currently, two of the other works examined and treated in the past two years—a second processional cross and a crozier—can be viewed in the Medieval Treasury.

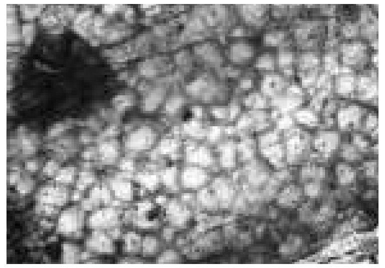

*Figure 13*

*Figure 13. Detail of yellow enamel on processional cross (Figure 10), showing a network of microscopic cracks.*

*Figure 14*

*Figure 14. Detail of blue enamel on processional cross (Figure 10). The black discoloration, oriented along a crack in the glass layer, is due to an interaction between the cobalt colorant and the tarnished silver substrate.*

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# Hudson Valley Wall Paneling

*Figure 15*

*Figure 15. Paneling, American (High Falls, N.Y.), 1752. Stained sweetgum, with period tiles, 237 cm x 499 cm. Rogers Fund, 1933 (33.110). Installation photograph, April 1934.*

Earlier this year the American Wing implemented a systematic program with the aim of improving the experience of visitors to its galleries. This project incorporates concerted efforts by the Museum's curatorial and conservation staff that focus particularly on existing period rooms, in order to evaluate them in terms of clarity of presentation and the authenticity of their architectural elements. Among the works that have benefited from this review is a fragment of an eighteenth-century domestic interior with English-style fireplace, two cupboards, and applied fluted columns, panels, and moldings (*Figure 15*). Acquired in 1933, the paneling was mounted in February of the following year in "A Loan Exhibition of New York State Furniture with Contemporary Accessories," and several months later became part of the permanent installation in the New York Alcove on the third floor of the American Wing. The source of the interior was said to be a colonial stone house near High Falls, N.Y., but this claim was never substantiated and in the intervening years many questions concerning stylistic and structural details of the paneling have been raised.

Built in 1752 by an unidentified owner, the High Falls residence was purchased in 1802 by Benjamin Hasbrouck (1764–1843),

Figure 16

*Figure 16. Hasbrouck house, original owner unidentified. Photograph by Margaret de M. Brown, from Helen Wilkinson Reynolds, Dutch Houses in the Hudson Valley before 1776 (New York, 1929), p. 275. The Metropolitan Museum of Art, New York, The American Wing Library.*

a member of the large Huguenot community in Ulster county, who expanded and modernized it in the neo-classical style in 1806 (*Figure 16*). Although the paneling had long been accepted as an early example of eighteenth-century Palladian design in the Hudson Valley, a prior study conducted by American Wing curators questioned whether it actually did originate from the Hasbrouck house. In any case, a comprehensive technical analysis was deemed necessary in order to address some inconsistencies, such as the large size of the fireplace in relation to the overall dimensions of the paneling, and the fact that the left-hand door opens in the wrong direction.

Examination of the paneling's construction and materials started with the strategic removal of several applied elements. With improved access it was possible to measure and document the complete work, including the pilasters, panels, and moldings. The wall paneling is divided visually and structurally into three parts, with the framework of each section consisting of two stiles that reach from floor to ceiling, connected by one or more rails with the use of pegged mortise-and-tenon joints. In turn, the three frames are joined with short rails concealed by fluted pilasters, each complete with base and capital (*Figure 17*). Like the construction techniques observed, the hand-forged iron nails—L-head brads to secure the pilasters and headless sprigs for the moldings—and the tool marks encountered on the paneling, are consistent with mid-eighteenth century traditions. Through microscopic analysis of wood samples it was confirmed that all of twelve different original elements examined are sweetgum (*Liquidambar styraciflua*), a species often used in colonial furniture from the Hudson Valley. Still, other evidence indicated previous structural alterations, such as traces of plaster found on the stile just left of the fireplace, which suggest this element once abutted a wall (*Figure 17*).

Figure 17

*Figure 17. Detail of architectural paneling (Figure 15), after removal of the pilaster to the left of the fireplace, revealing one of the replaced short rails joining adjacent frames, as well as traces of plaster at the edge of the right stile.*

Several features noted in the Hasbrouck house when it was revisited earlier this year provide clear evidence that it indeed is the source of the New York Alcove wall paneling. The two massive anchor beams still in place in the 1752 section of the house are also of gumwood, but more telling is the articulated profile of their edges. While rarely seen on anchor beams in colonial-period Hudson Valley houses, when encountered, profiles as such consist typically of a plain half-round bead over the corner. In this instance the design is much more sophisticated, combining an ogee pattern with a small bead, and this profile exactly matches the central section of the molding used to frame the cupboard doors on the Museum's paneling (*Figure 18*). Furthermore, the faint outline of the paneling's crown molding can still be recognized on the original ceiling boards in the west room of the Hasbrouck house, as well as nail holes from its original attachment.

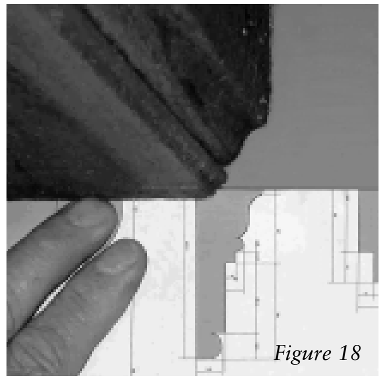

Figure 18

*Figure 18. Original anchor beam in the west room of the Hasbrouck house (Figure 16), compared in situ with a drawing of the molding profile on the door frames of the New York Alcove paneling.*

Particularly in the basement, many structural elements of the original dwelling remain in place two hundred and fifty years after it was built. The positions of remaining walls and chimney supports, augmented with newly recognized evidence of alterations to the floor plan, can be used to establish that the 1752 structure was divided into two rooms of approximately twenty-four by twenty feet, each with a fireplace in the center of the west wall (*Figure 19*). The original width of the house was determined from the length of the sill on top of the west foundation wall that survived the 1806 expansion, when the entire south wall was moved out several feet and the layout of the ground floor was modernized to include a central hall. At that time, a length of about eight feet was cut from the south end of the original oak floor beams, which were then extended to the new south foundation wall simply by resting new beams on top of the original ones. This solution accounts for an otherwise awkward step in the floor of the west room, to the left of the fireplace.

Based on evidence from both the Hasbrouck house and from the existing paneling, a highly plausible reconstruction of events can be proposed. In 1752, when the paneling was made, it likely consisted of two closets or cupboards on each side of a central fireplace and spanned the entire twenty-four-foot length of the original west wall. Unlike most examples of similar date, the frames of the paneling were secured by nailing the top ends of the stiles to the front of the westernmost anchor beam rather than the back. This accommodated the elaborate crown molding, and can explain why no evidence of the original attachment of the paneling could be recognized in the current installation. During the 1806 modernization, the complete south side of the original building up to the fireplace, and including the two left-hand sections of paneling, was removed in order to expand the house. Probably at that time, an interior wall following the step in the west room was built, which would have made the difference in floor height much less obvious, and accounts for the traces of plaster found on the stile just to left of the fireplace. The house was modernized once again in the early 1930s, when the surviving paneling, with two cupboards flanking the fireplace on the right, was removed and sold. In keeping with its Palladian design, the paneling was reconfigured to be symmetrical before it was first displayed at the Museum, although this truncated incarnation gives a distorted impression of the original.

With the technical investigation of the New York Alcove wall paneling completed, the next challenge lies in incorporating the newly acquired knowledge into the gallery reinstallation. Given that the paneling is incomplete and no information is available about its configuration to the left of the fireplace, each of the available options for display has limitations. The current symmetrical installation is flawed because of its inaccurate configuration, while "completing" the paneling would result similarly in a subjective interpretation, although it would evoke the original scale of the work. Placing only the extant elements in their correct order, with both doors to the right of the fireplace, would preserve the integrity of the surviving elements, but results in an asymmetrical and unbalanced installation. At this time the curatorial preference is to leave the installation as is, explaining the original configuration using photographic reconstructions and new label texts to communicate the results of this investigation.

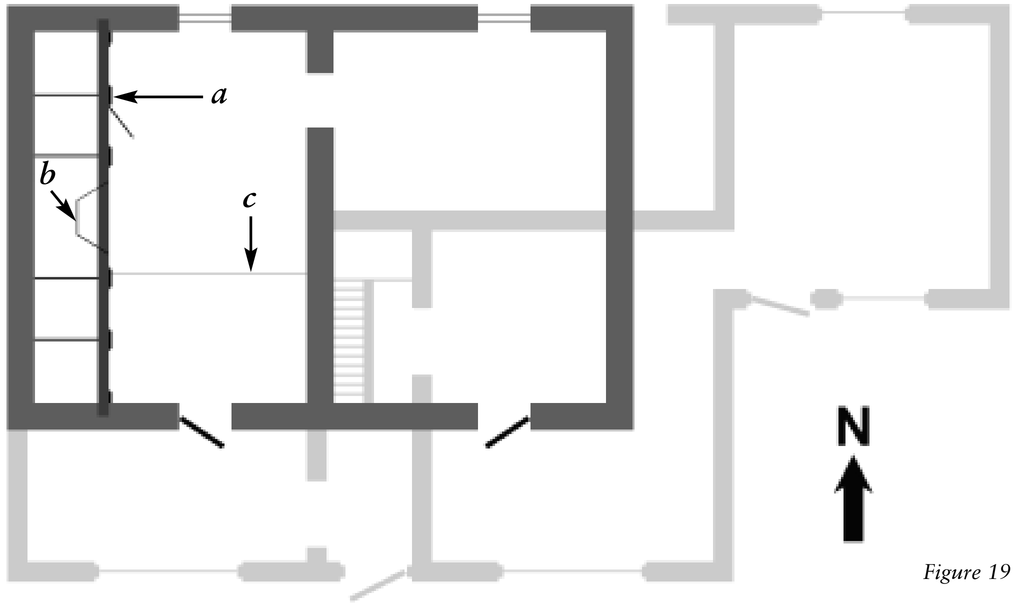

Figure 19

*Figure 19. Current ground-floor plan of the Hasbrouck house overlaid with a reconstructed plan of the 1752 building, indicating locations of the paneling (a), the fireplace (b), and the step in the floor currently in the former west room. The placement of the doors and windows of the original structure is hypothetical. Colonial dwellings commonly had a separate exterior door for each room.*

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