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FOREWORD

The 14th volume of Postprints produced by the Objects Specialty Group includes papers presented on April 19th in the morning ADG session and at the all-day OSG session on April 20th at the 2007 AIC annual meeting in Richmond, Virginia. The first ever Archaeological Discussion Group special half-day session was organized by Howard Wellman and included eight papers on the theme of Illicit Trade of Archeological Objects. The following day fourteen papers were given at the Objects session primarily on the general meeting theme of Fakes, Forgeries and Fabrications, although several papers outside the theme were also presented.

Perhaps due to the fact that most of the speakers invited to participate in the ADG session were not conservators, this group did not submit written versions of their papers for the Postprints with the exception of Sanchita Balachandran who submitted an abstract about the removal of Chinese wall painting to the Fogg Art Museum in 1924. It is unfortunate that this first ADG session will have no better written record.

Twelve of the papers presented the following day at the OSG session are included in this volume. Of the two missing Carol Grissom preferred to submit her paper, A Plaster Gladiator, Battered but Still Beautiful, to a professional journal read by curators. The paper, A Progress Report on the Oceanic Galleries Reinstallation Project at the Metropolitan Museum of Art, by Amy Jones, Beth Edelstein and Linsly Boyer was not submitted due to time constraints.

The enthusiastic response to the topic of fakes and forgeries, evinced both by the number of unsolicited proposals received and by comments of meeting participants indicate that this topic could and should be presented on a regular cycle at AIC meetings, perhaps once every five years or so. Although the papers in the OSG session covered a lot of ground including the consideration of fakes in the especially difficult areas of African and Pre-Columbian art as well as in the decorative arts and sculpture and medieval and Renaissance art, there is clearly room for much more. Highlights included Jane Bassett’s practical assessment of the use of thermoluminescence dating for European sculpture during the past 22 years at the Getty Museum as well as Katie Holbrow’s report on her study of the quarry provenance of Houdon’s marble busts. The important role of connoisseurship in detecting forgeries was emphasized in several papers. The range of materials covered was broad: bronze, terracotta, marble, wax, silver and gold, enamel, wood and plaster yet many other materials were not addressed. It became clear that there is a large gray area populated with objects that are not intentional fakes yet can’t be considered authentic either. This whetted the appetite of some participants for further opportunities to address fakes and forgeries.

Room was made in the program, however, for papers outside the theme. Annual meetings should allow a forum for presentation of current studies or projects regardless of theme. Conservators who are excited about their current work should be encouraged to present it in a timely fashion before the enthusiasm wanes. Thus, papers are included here on a new method of cleaning for marble, the treatment of a large topographical map and the documentation of endangered stela in Mongolia with computer models.

Many thanks to Howard Wellman for his good work organizing a terrific ADG session that should
be a model for the future. Helen Ingalls was invaluable for moral support. Sadly, this is Virginia Greene’s last volume as Postprints editor. She has been ably assisted by Pat Griffin and Chris Del Re and therefore leaves us in good hands. The OSG owes an enormous debt to Ginny for all her time and talents. She will be missed.

Ann Boulton, OSG Program Chair 2007
OBJECT LESSONS: THE POLITICS OF PRESERVATION AND MUSEUM BUILDING IN THE EARLY 20TH CENTURY
Sanchita Balachandran

Abstract

The preservation of cultural property is never a neutral activity. The question of who is to possess, care for and interpret artifacts is highly politically charged, particularly when cultural property is acquired or removed under imperial or colonial rule. This paper examines how preservation was used as a justification for the removal of not only movable artifacts but also pieces of immovable archaeological sites, and was therefore an essential tool in building museum collections. This study focuses on a collection of twelve wall painting fragments from the site of Dunhuang, China, which were removed by art historian Langdon Warner in 1924 for the Fogg Art Museum (now the Harvard University Art Museums.) The removal process resulted in significant damage to some of the painting fragments as well as to the site, calling into question what is preserved—an intact ancient artifact or an ancient artifact scarred by and embedded with its modern collection history? How do pedagogical institutions such as museums grapple with unsuccessful examples of preservation? This article also describes the early conservation efforts of the Fogg’s Department of Technical Research, and considers the contradictions in the conservation practices of Rutherford John Gettens and George Leslie Stout. Drawing from the Harvard collection as an example, this paper discusses the contradictions of early preservation ethics in China, and comments on the legacies of such policies for museums with these entangled objects as well as the sites from which they were originally removed.

FROM DELICIOUS TO NOT QUITE RIGHT: SUBTLETIES IN DISCERNING THE AUTHENTICITY OF AFRICAN ART

Stephen Mellor

Abstract

The nature of African art – its intended use, its intrinsic value within its culture of manufacture, its interpretation as ‘genuine’ by Western definitions, its route from maker, through runner and dealer, to collector, the impact of colonialism – can make declarations of authenticity complex. “Made and used within a traditional cultural group” and “void of the intent to deceive” are long-standing parameters for authenticity. However, nuances in form and condition that reflect cultural dynamics and collection history need to be considered, as well.

This paper discusses the formation of collections that can be referenced for provenance and pedigree information, reviews, by example, the limitations of traditional definitions of authenticity, and presents categories of conditions that are assessed to aid in determining the location of an African object on the authenticity continuum.

Introduction

The general subject of authenticity of African art is infrequently addressed, just as the subject of connoisseurship of African art is frequently avoided in museum exhibitions. One exception is the recent exhibition Object lessons: Authenticity in African Art (October 26, 2006 – June 3, 2007) at the Kent State University Museum. Innovative exhibitions such as ART/Artifact (January 27 – April 17, 1988) at the Museum for African Art in New York present a variety of ways to interpret African art, from perspectives ranging from that of the art historian to that of the anthropologist, which can affect the perception of authenticity (Vogel 1988). In addition, current authors challenge the oversimplification of theories of authenticity as presented in earlier literature (Kasfir 1992; Steiner 1994). Articles relaying the results of scientific analysis can be found in the literature, including studies that pertain to individual icons of African art, such as the Ife Olokun head (Fagg and Underwood 1949); corpuses of African material culture that exemplify the aesthetic and early technological sophistication of art production in Africa, such as Benin bronzes (Willet and Sayre 2006; Hornbeck 1998); and those that aid in the validation of authenticity for highly valued, yet unscientifically excavated archaeological objects such as Nok terracottas (Rasmussen 2006).

This avoidance of the general subject of the authenticity of African art is understandable considering the complexity and subjectivity of the topic, as well as the difficulty inherent in distilling a topic ripe with nuances, conflicting interpretations and vast amounts of scholarly research into a manageable presentation to the general public.

Determining the authenticity of African art is a particular challenge because much of the material is without clear provenance, cultural association, or collection history. In addition, the material
can be foreign except to fieldworkers and even then, external influences and the changes in cultural systems that likely influence art production may be undocumented. Associatively, a clear definition of authenticity is elusive due to the functional nature of African art and material culture, the use of diverse and newly acquirable materials, and the pervasive influences of market demand. And, of course, a thriving industry based on deliberate deception of the unwary consumer exacerbates the authenticity challenges.

Instead, the curator is more likely to formulate an exhibition which tells a unique and thoroughly researched story about indigenous aesthetics, authority and social control, religion, cultural change and dynamics or the like, and the exhibition highlights significant objects that are relevant to that story. The viewer is then free to assume that the objects on exhibition are authentic, garner pertinent data, maybe even a ‘circa’ date of manufacture, from the label copy and go about digesting a story about humankind as told through art.

This assumption of authenticity is not unreasonable because it is likely that curators, conservators, and scientists have already pooled considerable knowledge and resources to make that determination. In fact, the topic of authenticity of African art is considered, virtually on a daily basis, in institutions that acquire and exhibit this material. Of course decisions may change, the interpretation of formal characteristics or condition may evolve, and new historical information may come to light, but the following facts and types of information are to be considered when exploring the broad subject of the authenticity of African art.

**Known Provenance and Collecting History**

Colonialism left an indelible mark on Africa; however, this period produced the world’s great repositories of African art and material culture. These institutions include: the Royal Museum for Central Africa (Fig. 1) in Tervuren, Belgium, founded in 1897. Its collections contain material from the Kongo, Kuba, Chokwe and other cultural groups in what is now the Democratic Republic of the Congo; the National Museum of Ethnology in Leiden, Netherlands, initially established when King Willem I’s Cabinet of Curiosities was combined with the von Siebold collection and shown to the public in 1830 (Dongen 1987). Its collections include material from both West and Central Africa; and the Musée du Quai Branly which opened in Paris in 2006 and combines the extensive ethnographic collections of the Musée de l’Homme and the Musée des Arts d’Afrique et d’Océanien. Its collections contain material from North Africa, much of sub-Saharan Africa and Madagascar. Some of these early establishments began acquiring objects of curiosity from Africa to promote what were touted as trade and economic opportunities. They later evolved into scientific institutions which aggressively acquired African material to support comparative studies in anthropology and the natural sciences; they remain as research centers today (Verswijver 1995).
Objects in these early repositories are frequently accompanied by extensive written and photographic documentation regarding provenance, cultural use, and method of collecting, all of which can help to illuminate an indigenous perspective on form, aesthetic canons, use patterns, and importance of the object itself. These collections are frequently used as a database both for identifying objects and addressing authenticity issues for African objects that do not have clear cultural associations. It is common for museum curators to reference known pieces in these collections when considering the acquisition of a similar piece.

Similarly, early collections formed by ethnographers and missionaries contain objects that can be used for comparative purposes when addressing authenticity questions for unprovenanced material. For example, the Congo Expedition of 1909, sponsored by the American Museum of Natural History, was led by Herbert Lang and James Chapin. In 1915, they returned to New York with 4000 objects and 10,000 photographs from what was then known as the Belgian Congo, providing evidence of the breadth of art and technology in Africa. This material was exhibited and published for the first time in 1990 (Schildkrout and Keim 1990). Emil Torday, the Hungarian ethnologist, can be seen as a pioneer in the establishment of anthropology as a viable discipline. Rather than promoting the Victorian conceits of social evolution, Torday’s collection, made in the first decade of the 20th century, was intended to create an objective and documentary record of the people in the Congo State. His collection of over 3,000 objects in the British Museum is unparalleled (Mack 1990).

Missionaries in Africa are often credited with the wanton destruction of indigenous religious sculptures in their attempts to convert Africans to Christianity. However, confiscated material was, on occasion, sent to missionary headquarters (Fig. 2). A recent article in *African Arts* (Hart 2006), notes a missionary’s use of collected ‘idols’ to reinforce the importance of missionary work in Africa.
In addition, as in any field of art, there are benchmarks in western collecting history that provide a certain kind of pedigree for some African objects and thus answer some questions of authenticity. Often cited is the landmark 1935 exhibition African Negro Art at the Museum of Modern Art in New York (Sweeney 1935; Fig. 3). This is not the first time that African material was exhibited in the United States; however, it is the first time that it was exhibited without context and in a major art museum – beginning exhibition controversies that continue to this day. From pre-installation photographs and the associated portfolio of 477 individual images created by the photographer, Walker Evans, a corpus of objects considered both genuine and significant for the period can be identified (Evans 1935). The pedigree of many objects in this exhibition is further substantiated by the fact that many were on loan from the influential European dealers Charles Ratton and Paul Guillaume Rubin 1984. Some objects known to have been in the collections of these dealers and from other collections in Paris in the 1920’s and 1930’s still retain mounts presumably made by a Japanese mount maker, called Inagaki. Inagaki’s work is undocumented, though his chop mark on the bottom of mounts has been identified by collectors and referenced in auction catalogues for decades contributing an acknowledged, but curiously unsubstantiated pedigree.
Established private collections can also give context to African art objects. For example, Helena Rubinstein, of cosmetic fame, began collecting African art before World War I and her collection was dispersed at auction in 1966 (Parke-Bernet 1966). Objects that Madame Rubinstein purchased for modest sums in the early 20th century continue to set auction records today (Fig. 4). Katherine White, the sewing machine heiress, formed one of the finest collections of African art in the United States, second only to the Michael C. Rockefeller Memorial Collection at the Metropolitan Museum in New York (Newton 1978). She donated her collection to the Seattle Art Museum in 1981 (Seattle Art Museum 1984). Paul Tishman, a New York realtor, formed an authoritative collection of African art which was acquired by the Walt Disney Corporation in 1984 (Vogel 1981). Disney intended to install the Tishman collection in an Africa pavilion at Epcot Center in Florida. However, the pavilion was never built and the Disney-Tishman collection was donated to the National Museum of African Art in 2005 (Fig. 5; Kreamer 2007).
Figure 4. Heddle pulley, Baule peoples, Côte d’Ivoire (NMAfA 96-7-1). Ex-coll. Helena Rubinstein. Photograph by Franko Khoury.

Figure 5. African Vision: The Walt Disney-Tishman African Art Collection. Exhibition at the National Museum of African Art, Washington, D.C., 2-15-07 to 9-8-08. Photograph by Franko Khoury.
These kinds of exhibitions and collections were assembled under the knowledgeable advice of prevailing scholars of the times, and consequently contain objects that are considered icons of African art and authenticity. Objects in these collections, and the information about them garnered by researchers from a wide variety of sources, are frequently used for comparative purposes to elucidate the authenticity of similar pieces. One such scholar, Dr. Roy Sieber, received the first PhD in African art history in 1954 from the University of Iowa and subsequently trained generations of African art historians. Dr. Sieber would on occasion refer to a piece with unquestionable characteristics as ‘delicious’ (Sieber 1989).

**Literature and Definitions**

The subject of authenticity in African art is discussed comprehensively in a 1976 article in *African Arts* magazine (*African Arts* 1976). In this article, more than two dozen scholars discuss their perspective on the subject and many cite work by Joseph Cornet, originally published as Critique d’Authenticite et Art Negre (Cornet 1974), in which the author identifies three criteria for establishing the authenticity of African art. Naturally, in light of ensuing scholarship, Cornet’s work can be considered both dated and oversimplified. However, this work should be valued both as a culmination of the philosophy of collecting that preceded it and as a foundation to present the real complexities inherent in the authenticity of African art.

Cornet proposes that an object may be considered authentic when: it is created by a traditional artist; conforms to traditional forms, that is, exhibits meaningful canons that are recognized and accepted by individuals within a culture; and that it was created for a traditional purpose, or culturally used. From this definition one can proceed in a seemingly straightforward manner to look for the physical properties of authenticity: Is a Dogon figure modeled with the required reverent pose and iconography, and appropriately patinated indicating use on a shrine (Fig. 6)? Has a Kongo nkisi been sufficiently angered by the nails driven into his torso or provided with sufficient amulets to enforce a community based oath (Fig. 7)? Does the wear and multiple repaintings on an Olojo-Foforo mask indicate acceptance and continuous use among the Yoruba people (Fig. 8)?

Figure 6. Female figure, Dogon peoples, Mali (NMAfA 2005-6-41). Photograph by Franko Khoury.
Figure 7. Male *nkisi* figure, Kongo peoples, Democratic Republic of the Congo (NMAfA 91-22-1). Photograph by Franko Khoury.

Figure 8. Oloju foforo mask, Yoruba peoples, Nigeria (NMAfA 94-12-1). Photograph by Franko Khoury.
Today, it can be seen that Cornet’s criteria provide a limited number of easily understood, but frequently difficult to identify, elements that may satisfy the layperson’s inquiry regarding the authenticity of an African work of art. However, even a novice student of African art can immediately conjure images of objects that do not fit these criteria. One might ask: what about an object made by an artist in one cultural group but used by members of another group (Fig. 9); or an object made by an artist following accepted cultural canons, but sold before it is actually used (Fig. 10); or an object made after independence by a traditional artist using traditional methods but poorly manufactured to satisfy a Western perception of African technology (Fig. 11); or an object made in a traditional form and material but with European iconography specifically for European consumption (Fig. 12); or an object that was neither made within a cultural group, nor of traditional materials but is used and revered in a traditional context (Fig. 13); or an object, whose form is western but whose meaning has been transformed so that it becomes incorporated into a traditional culture (Fig. 14); or an object with clear cross-cultural attributes (Fig. 15)?

Figure 9. Throwing knife, Mangbetu peoples, Democratic Republic of the Congo (NMAfA 80-21-35). Made by the Zande peoples. Significant to the Mangbetu both in its acquisition and the act of eventually gifting it away. Photograph by Franko Khoury.
Figure 10. Beer vessel, Chewa peoples, Malawi (NMAfA 87-2-1). The pristine post fired resin decoration indicates that the vessel was never used. Photograph by Franko Khoury.

Figure 11. Rooster (back), Benin Kingdom, Nigeria. Before 1914, when the brass casting guilds were under the authority of the Oba of Benin, poor castings would have been unacceptable; this post 1914 casting is offered to a Western market (www.Ebay.com).
Figure 12. Hunting horn, Bullom or Temne peoples, Sierra Leone (NMAfA 2005-6-9). Commissioned of traditional craftsmen by Prince Manuel I of Portugal as a royal gift to King Ferdinand V of Castile and Aragon, 15th century. Photograph by Franko Khoury.

Figure 13. Plastic Ibeji, Yoruba peoples, Nigeria. The traditional carved wooden Ibeji represents a deceased twin sibling and is fed, bathed, and cared for to placate the spirit. This plastic doll is a modern replacement (Cameron 1996). Photograph by Eliot Elisofon. Eliot Elisofon Photographic Archives, NMAfA.
Figure 14. Crucifix, Kongo peoples, Democratic Republic of the Congo (NMAfA 2005-6-106). The Kongo people have adapted Christian iconography to represent the meeting of their physical and spirit worlds. Photograph by Franko Khoury.

Figure 15. Man’s ensemble, Yoruba/Benin Kingdom, Nigeria (NMAfA 2004-10-34). Fabricated from traditional strip-woven cloth by the Yoruba, the red and white stripes are characteristic of Benin royal regalia. This ensemble was a gift from Queen Ohan Akanzua intended for a wedding in New York City. Photograph by Franko Khoury.
The objects illustrated exemplify this dizzying array of possible attribute permutations and similar examples have been found in the early ‘cabinets of curiosities’ formed by European royalty in the 17th century to actively growing collections in today’s institutions. In addition, the parameters for attributes that are to be considered when assessing authenticity can indeed shift, depending on the assessor’s perspective: an anthropologist might be looking at objects as evidence of cultural change, an art historian might be looking at objects as evidence of artistic creativity within culturally accepted canons, or a collector might be looking at an object as a sound investment.

In consequence, it is customary for scholars to view the authenticity of African art as a continuum. It might be said that those objects with clear and documented provenance, that easily fit Cornet’s criteria, even though particular tangible attributes are as yet unexplained and even non-tangible attributes are likely undeterminable, fall at one end of this continuum; that objects made, manipulated, or presented with the deliberate intention to deceive, though the actual inception of this intent may be difficult to identify, fall at the opposite end of the continuum; the bulk of the continuum remains for those objects that may carry additional indigenous, Western, cross-cultural, personal, social, or temporal information.

**Other Considerations**

To aid in placing an object in its rightful place along the authenticity continuum, or help determine when an object is, as the National Museum of African Art’s curator, Bryna Freyer would say: “…not quite right,” (Freyer 2005) there are object categories, conditions, and information that need to be considered. The conservator’s keen sense of observation and potential use of analytical techniques can be beneficial in these areas. Many of these topics are familiar to the conservator and have been addressed in greater detail in other forums. They are presented here both as a reminder and to acknowledge some potential pitfalls in the interpretation of available data.

Tourist art is a category that is usually dismissed by many collectors; however, recent scholarship addresses it in the context of contemporary art production (Vogel 1991). It has its place on the continuum. These objects are found at the airport gift shop, along the road between African villages, and at the local ethnic art shop. From an authenticity perspective, these objects are likely mass produced, in workshops far from their presumed place of origin, solely for the tourist trade.

As examples, in Fig. 16 the figure on the left exhibits the pose, hairstyle and culturally accepted canons of a Luba shrine figure; her companion has the facial characteristics, distended belly and un-formed lower section of a traditional Songye power figure. Though formally correct, they were purchased at a local flea market and lack additional details, as noted below, that allow them to be placed further along toward the authentic end of the continuum.
In the absence of documented provenance information, objects are sometimes accompanied by adjectives or unsubstantiated associations that imply a false pedigree. ‘Rare’, ‘unique’, ‘imbued with ritual importance’, and ‘made for royal patronage’ are some buzz words that should trigger concern. The fact that the visual form of many African objects belies their true cultural function (a fly whisk might denote authority, a textile bundle might be used as currency) coupled with the collector’s unfamiliarity with such a wide range of object types and social customs make these false associations seem plausible. As an illustration, many African blacksmiths occupy a unique cultural niche due to the transformative nature of their work. Their products, even a simple hoe, can contain spiritual significance. Such simple, but significant hoes are used to fashion ceremonial staffs dedicated to the Yoruba deity, Orisha Oko (Picton in Vogel 1981 p.96; Fig. 17). However, in other circumstances, a hoe is simply an agricultural implement.
The category of materials and techniques of manufacture presents numerous examples to assess authenticity. A straightforward example can be seen in the Dogon primordial ancestor figure. The Dogon are undoubtedly the most studied and written about people in Africa (Ezra 1988). Their traditional, wood funerary sculptures have historical and anthropological precedent and are familiar to Western audiences; a wood sculpture would be considered ‘quite right.’ Though similar in form, the ivory sculpture in Figure 18 is a cultural anomaly and should be considered a fake. Virtually all African objects made of wood, are monoxylous – that is, made from a single piece of wood. A Yaka figure appears ‘quite right’ in form and surface, but x-radiography (Fig. 19) reveals its joined construction; this culturally aberrant technique implies a fake. Materials analysis can be useful, but it is not always conclusive. The stone figure in the NMAfA collection shown in Figure 20, is reported to be from the site of Great Zimbabwe. It has been determined that the stone is a metamorphic garnet serpentinite which could have formed along the Great Rift Valley in East Africa, but the material is not the same soapstone used to fabricate the famous Great Zimbabwe birds which are of known provenance.
Figure 18. Dogon figure for sale on internet auction site (www.Ebay.com).

Figure 19. X-radiograph showing joined construction (NMAfA 90-1989-1). Photograph by Steve Mellor.
Objects with formal characteristics that are anomalous to culturally accepted canons and aesthetics form a category that can be considered inauthentic: size and proportion are common mistakes. An informed stroll through any market selling African art will provide numerous examples. On figurative sculpture which has been deliberately faked, the wrong hairstyle, accessories that have been reversed from left to right, or distorted proportions may indicate that the object has been copied from a photograph of an authentic object. For example, it is likely that the *oshe Shango* in Figure 21 was copied from a photograph of the very well known object collected by Leon Underwood in Ogbomosho, Nigeria, in 1944 (Smithsonian Institution 1999) (Fig. 22). However, when looking at form, one has to be careful not to dismiss objects that are variants such that they still relay cultural information and are culturally accepted. Looking again at Yoruba dance staffs relating to Shango, the god of thunder, the staffs, with or without figures, are characteristically carved with two opposing triangles on the top. These triangles, made to look like Neolithic stone axes, represent lightening bolts hurled by Shango to indicate his anger toward wrongdoers. Shango is both aggressive and benevolent and he rewards the Yoruba with a high incident of twin births. In Figure 23, the triangular lightning bolt motifs have been supplemented with two heads representing twins. Referring back to Figure 22, the lightening bolts are stylistically represented as a distinctive hairstyle that also refers to Shango. On these two staffs, and other staff variations, the artists have selectively incorporated a variety of appropriate iconographic elements and produced authentic works.
Figure 21. Oshe Shango for sale on internet auction site (www.Ebay.com).

Figure 22. Oshe Shango, Yoruba peoples, Nigeria (NMAfA 88-1-1). Photograph by Franko Khoury.
Evidence of age and use and the resultant patination on African objects is integral to both scholarly research and aesthetic appreciation, and critically influential in determining authenticity. However, the accurate interpretation of this evidence is frequently complicated and ambiguous. Anecdotal stories abound about techniques that have been used to artificially age an object: burying it in a dung heap or termite hill, treating it with milk, motor oil, battery acid, or potassium permanganate. These stories challenge the conservator and make the scholar leery, but the assessor also needs to be informed of object specific details where evidence of age should be considered suspect. As examples, a *pumbu* mask, used to enforce authority, is valued by the Eastern Pende for its newness (Fig. 24); the famous Kuba king figures were used since the 18th century to maintain the royal lineage; however, copies, commissioned by several Kuba kings in the early 20th century as gifts to visiting dignitaries (Cornet 1975), would likely show less evidence of age.
Use and wear patterns must be appropriate to the anticipated use of an object. Headrests (Fig. 25) that have been ‘rocked’ into a comfortable position by the user may show preferential wear to the legs. Equal or random wear, and obviously, evidence of spurious tool marks, sandpaper or metal files, leave an object open to question. Of course, not all evidence of use is indigenous and creative latitude in the interpretation of this evidence may be necessary. For example, numerous, unanticipated breaks and mends to a figurative sculpture from the northeastern region of the Democratic Republic of the Congo were explained when information came to light that it was the favorite toy for the daughter of a colonial officer. An Ashante stool from the Helena Rubinstein collection that is currently being used as a plant stand will likely show evidence of this non-indigenous use.
When assessing the patination on African objects questions should include the following: is it congruous with the object’s manufacture, presumed age, and anticipated use, and analytically related to that on objects with known provenance? In addition, one should ask: could it reflect the known post-collection history of similar objects, that is, exhibit a ‘colonial patination?’ It is not uncommon to see objects from Belgian collections that have been refinshed like fine furniture, or objects from French collections that have been waxed and buffed to a high sheen (Fig. 26). Some of these objects may have been originally painted, encrusted with indigenous materials, or simply worn in ways that likely offended a Western taste, and thus were consequently ‘improved.’ Similarly, metal objects are frequently subject to ‘colonial patination’. Benin bronzes present classic examples of objects that have been repatinated, painted, coated with pigmented wax, or treated with motor oil to saturate or even out the surface, or act as a preservative (Fig. 27). These surfaces do not necessarily, though they might, expose an outright fraud. However, they do exhibit a shift from complete authenticity and allow these objects to find a location on the continuum.

Figure 26 (left). Female figure with child, Punu peoples, Gabon (NMAfA 96-9-1). Photograph by Franko Khoury.

Figure 27 (right). Plaque, Edo peoples, Nigeria (NMAfA 85-19-13) Ex-coll. General Pitt-Rivers, who purportedly treated it with neatsfoot oil (Fagg n.d.) Photograph by Franko Khoury.
African objects that have been altered or dismantled to suit a particular aesthetic, remove damage, or increase marketability create a category for authenticity considerations. Objects are frequently adorned, either during manufacture or use, with a wide variety of materials. A Wee mask (Fig. 28) is rare in its completeness: the pigment represents face paint worn by women at ceremonial events; the tacks suggest scarification; hair, bells, and metal teeth give it an imposing presence.

Figure 28. Female spirit mask, Wee peoples, Côte d’Ivoire (NMAfA 2005-6-57). Photograph by Franko Khoury.

Knowing what is appropriate, inappropriate, or absent can aid in determining authenticity. The egregious dismantling of wooden objects occurs, for example, with chairs and staffs so that the small carved figures can then be distributed individually (Fig. 29, 30). Ivory and metal pieces are not exempt from this kind of alteration. The exquisitely carved ivory tusk from the Loango coast, in Figure 31, retains its mother and nursing child finial. A similar, spiral carved tusk in Figure 32, from the same region, tells the story of birth, life, and the return to the home of the ancestors but the message is incomplete since the finial has been removed; the detached finial likely sits on a fireplace mantel somewhere. Individual figures from elaborately cast copper alloy figural groups, particularly from the Kingdom of Benin, are found in museum collections. This is a particular authenticity issue where the object is real but not as originally intended and these objects have their place on the continuum. And of course, this leaves open the possibility for the deliberate forgery of one of these small, highly collectible objects for which there is no known indigenous precedent.
Figure 29. Chair, Senufo peoples, Côte d’Ivoire (NMAfA 67-5-2). Photograph by Franko Khoury.

Figure 30. Figure, Senufo peoples, Côte d’Ivoire (NMAfA 73-7-117). Photograph by Franko Khoury.
Conclusion

No general, universally applicable definition of authenticity for African art can exist. Instead, each object must be viewed with an eye on cultural context, dynamics and change, as well as history, condition and aesthetics. In addition, these factors cannot be isolated from each other, but instead, must be viewed synergistically, simply because the understanding of one is likely to be affected by the interpretation of another. One certainly has an easier task of dismissing an
object as inauthentic, particularly when a clear cut case can be made that there has been a deliberate intention to deceive. Conservators can surely devise an appropriate treatment for an object in their care, but an additional challenge, working in concert with the curator, is to identify a place on the continuum for the myriad of products that result from African thought and creativity. Then we can say that we have directed our complete attention to discerning the “sacred truth” (African Arts 1976; 73, comment by Lehuard) of African objects.

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THERMOLUMINESCENCE DATING FOR EUROPEAN SCULPTURE: A CONSUMER’S GUIDE

Jane Bassett

Abstract

Thermoluminescence (TL) dating is one of many tools used for the authentication and technical study of works of art within the Department of Decorative Arts and Sculpture at the J. Paul Getty Museum. This paper considers the lessons learned through attempts to use the TL technique to date seventy-one European objects attributed to the Renaissance through the 18th century, including: glazed and unglazed terracotta sculpture, faience, majolica, and glazed earthenware, as well as clay-based and plaster-based bronze casting cores. When considering whether or not TL dating should be attempted for a work of art, issues such as material type, object history, sample size, and error limits should be taken into consideration. Examples of European materials that are difficult to date using the technique are given. Recommendations are made for safely taking and handling samples, and for choosing a TL lab. The results have been categorized and illustrate that in certain circumstances, TL dating has proven to be a pivotal aspect of our authenticity studies. Optically Stimulated Luminescence (OSL), a related technique that shows promise for greater precision, is briefly described. In summary, we have found that when approached with deliberation and caution, thermoluminescence dating can be a very useful addition to a broad-based sculpture study.

Introduction

The J. Paul Getty Museum began acquiring Renaissance and later European Sculpture in 1982. Since that time, authenticity studies have been an integral part of every purchase. Although archival, art historical, and provenance research have always been the backbone of these studies, over the years technical investigations have played an increasingly important role in acquisitions. Technical investigations are approached from many directions, including evaluation of whether or not the methods and materials used to construct a work of art under consideration are consistent with the attribution. When the investigator is lucky, reliable period treatises on technique are available for comparison. Alternatively, it is sometimes possible to compare the work we are studying to technical data from other, well-attributed works. Quite often though, little such comparative material is available. For this reason, direct dating methods such as radiocarbon dating, dendrochronology, and thermoluminescence (TL) dating can be an important tools in authentication studies.

The author has had the opportunity to use the technique, both for authenticity studies for acquisitions, and for general technical studies of sculpture in both the Getty and other collections. In the last twenty-two years, conservators at the Getty have sampled seventy-one objects for TL dating. The Getty does not have in-house facilities for the technique; over the years samples have been sent to seven different labs located in Germany, England, Italy, Denmark, and the US. TL dating is used for objects that contain clay that has been heated during
manufacture, for glazed and unglazed terracotta sculpture, faience, majolica, and glazed earthenware, as well as clay-based and as plaster-based bronze casting cores. Porcelain can also be TL dated (Stoneham 1983), but the Getty has never attempted it due to the large size of the core bit needed for sampling (at least 1/8” outer diameter).

TL dating has a mixed reputation in the art historical community; it is relied upon without hesitation in some quarters, yet completely discounted in others. The Getty has taken the middle road, approaching it with full knowledge of its strengths and possible weaknesses. Because of the complexity of the technique, the fact that it is not done in-house, and the important roll the results sometimes play in the assessment of objects, care has been taken to study the fine details of the methods and procedures. The following is a summary of what has been learned about when and how to most effectively use the technique, including how to anticipate, and sometimes avoid, problems.

The Thermoluminescence Dating Technique

The phenomena of thermoluminescence – in which a material gives off light when it is heated – has been known for centuries. It was used primarily as a method for mineral identification until the invention of the photomultiplier, which allowed measurement of very small amounts of light. In the 1950’s, thermoluminescence was first suggested as a method for dating geological and cultural materials; methods for applying the technique to archaeological materials were developed in the 1960’s (Aiken 1985).

TL dating of clay-containing materials is possible because crystalline components contained in clay absorb energy over time. The amount of energy that is stored is relative to the number of years since the clay was last fired. The energy that is stored comes from many sources, primarily radioactive elements that naturally occur in the clay (potassium-40, thorium, and uranium at concentrations of a few parts per million). As these radioactive elements in the clay decay, they release energy that is absorbed and stored by neighboring crystalline materials, primarily quartz and feldspar. By the time clay is mined to make a ceramic object, the crystalline minerals in the clay have stored a significant amount of energy. When the ceramic object is fired in the kiln, all of this stored energy is released. From this so-called zeroing-out point, the clay starts absorbing energy again. When a sample of the ceramic is removed for TL dating, the sample is heated, this time in the laboratory, and the stored energy, released in the form of light, can be measured with a photomultiplier. The relationship is linear: the more energy that is stored, the more light that is emitted. With calculations, the amount of light released will indicate how many years have passed since the ceramic was made, and therefore the date it was fired, as shown in the equation in Figure 1:

\[
\text{Age} = \frac{\text{Total amount of energy stored since firing or casting}}{\text{Amount of energy stored each year}}
\]

Figure 1. Equation showing the relationship between light emission and the age of the ceramic.
Although the basic concept of this simplified model is straightforward, in reality many factors complicate the calculations, making the technique particularly labor intensive and therefore costly. This is one reason why, in archaeological settings in which a variety of materials are available for analysis, radiocarbon dating (carbon-14) has often been preferred over TL dating. C-14 dating of the specific materials under consideration in our department is often impractical however, due to the absence of carbon.

**Error Limits**

Approximately twelve components are included in the calculations undertaken in TL dating. Each of these components contains uncertainties that combine to determine the error limit of the results. The errors have many sources, including random errors due to imprecision of the instruments, and systematic errors that arise when the data is taken from calibration curves, rather than measured directly. The laboratory results are reported to us as a date plus or minus a range of years. This ± value reflects the error limits or accuracy of the date. As stated by Aitken (1989, 156) and observed in the results that we have received over the years, “…in most cases it is possible to determine a TL age to an accuracy of around ± 20%”. For example, a faience plaque attributed to the Alcera Factory, circa 1755, was sampled for TL dating as part of a pre-acquisition authenticity study undertaken in 1998 (Fig. 2).

Figure 2. Alcera Ceramic Factory, *Plaque Depicting Jacob Choosing Rachel to be his Bride* The J. Paul Getty Museum, Los Angeles, 99.DE.10
The plaque received a TL date of 1783 ± 22 years (1761-1805). This date indicates that the plaque had been fired 215 years previously, give or take 22 years - a degree of uncertainty of ±10% of the overall age. This date range falls outside of the 1755 attribution. As is standard practice for many labs though, the TL date was reported with one standard deviation, indicating there is a 67% likelihood that the plaque was fired between 1761 and 1805. To increase the likelihood that the actual date falls within the reported date range, the results can be read with two standard deviations. To do this, the plus-or-minus uncertainty must be doubled – in this case plus-or-minus 44 years. By increasing the date range to 1739-1852, there is a 95.4% chance that the date of facture falls within this range. Indeed, in this example, the attribution of 1755 does correspond to the TL date at two standard deviations. This example has been given to make two points: first that it should be clarified with the lab how their results are reported, and secondly that the results cannot be simply accepted as the final word without scrutiny and, at times, interpretation.

**Problematic Materials**

Certain types of European sculptural materials can be difficult or impossible to date using TL. Light colored French 18th C terracottas are well known to cause problems. This may be due to the very fine grain of the pastes and/or the high calcite content of the clay (Goedicke 2000). We have encountered problems with pieces by Clodion (Claude Michel, French 1738 - 1814) as well as Philippe-Laurent Roland (French, ca 1780 – 1790) (Fig. 3).

![Figure 3. This work is one example of a light-colored 18th century French terracotta that is unsuitable for thermoluminescence dating. Philippe-Laurent Roland, Allegorical Group with the Bust of an Architect (The J. Paul Getty Museum, Los Angeles, 87.SC.9).](image-url)
In addition, the light-colored paste of the 16th century lead-glazed earthenware by Bernard Palissy is not suitable for TL dating approximately 50% of the time (Stoneham 1987), as encountered with this Palissy plate in the Getty collections (Fig. 4).

![Figure 4. Lead-glazed earthenware by the French 16th C. artist Palissy is often undatable using TL. Bernard Palissy, Oval Basin (The J. Paul Getty Museum, Los Angeles, 88.DE.63).](image)

Although the Getty has had considerable success in dating clay-based casting cores (Bassett 2008), many European lost wax bronze casts were made using plaster-based cores. As plaster alone cannot withstand the heat of casting, temper is added to the core material. Clay and sand added to the plaster as temper often allow TL dating of the bronzes but occasionally problems are encountered. Dating of ten different bronzes with plaster cores has been attempted; of these, dates were not achieved with three of them. It may be that plaster cores can be difficult to date due to the occasional presence of thermoluminescent crystalline forms of gypsum, and to the fact that standard TL calculations are based on a clay, not plaster, matrix which affects the amount of radioactive materials in contact with the sample during its history (Goedicke 2000).

Incomplete heating during manufacture can also be the cause of inaccurate results. If the sculpture was never fired or was not heated high enough for a long enough time when it was being made, there may be no zeroing out of the geologic energy dose. The time and temperature necessary to completely zero out a dose will vary according to the size of the object. When such an object is dated, the resulting age will be far too early [1].

Another problem is that objects that have been radiographed will not receive an accurate TL date. X-ray radiation will alter the stored TL dose, increasing the TL age [2]. Although attempts have been made to calculate how much affect a single exposure will have, estimates vary from a
single exposure adding five years to the TL date of an object, all the way up to a single exposure adding 50 or 100 years to the age. As x-ray intensity falls off markedly over distance, such factors as the distance from the center of the beam to the sample location, and the amount of attenuation of the beam within the object will affect the amount of radiation absorbed by the sample, greatly complicating an accurate estimate of the date shift due to radiography. Regardless the amount of alteration of the dose, the effect of radiography on early archaeological material will be far less than the effects on younger post-Renaissance material. For this reason, we always sample before an object is radiographed. Because it is occasionally necessary to remove a second sample during the dating process, it is ideal to postpone radiography until a firm date has been achieved. In some instances, during authentication studies for acquisition, objects not yet owned by the museum are not radiographed, even with a firm TL date in hand. Should the museum decide at the last minute not to go through with a purchase, the X-rays will alter any TL dating results attempted by a future owner. Although the results of all studies should stay with the object, once it has left the museum there is no guarantee that this will occur. This is of course, an ideal, as radiography may be an important contingency for acquisition, but it acts as an illustration of the care that should be taken in undertaking such studies.

If an object has been exposed to heat some time after its creation, a sample from the object will yield a TL date of the reheating rather than of its original date of manufacture. The degree to which the accumulated TL dose is damaged through later heating will vary according to the temperature and the exposure time, in general terms the stored TL energy will be damaged at temperatures above approximately 350 degrees Celsius (Fleming 1971). The surface must be carefully examined for signs of exposure to heat in the years after it was first fired, including the object having been in a fire, or restoration steps such as refiring of ceramics, solder repairs, or bronze repatination. Incorrect dates of manufacture will also occur in the case of unfired clay sculpture such as bozzetti [preliminary sketches] which have been fired decades or centuries later in order to preserve them.

**Sampling for TL Dating**

It is essential that specific procedures be followed when sampling for TL dating, both to cause as little alteration as possible to the object, and to ensure that the sample is not damaged or contaminated as it is being removed. The surface, the structure, and the overall condition of the work of art must be well understood. The location must be carefully chosen and documented. The sample site is chosen with many points in mind, and it should be as unobtrusive as possible. Even when drilling on the reverse or bottom of an object, surface features should be avoided such as finger or tool marks that may suggest how the surface was worked. At times, minor surface damages such as old chips or losses may provide an ideal location for drilling. However, it is important to understand the structure of the object, in order to avoid drilling in unstable areas, and to avoid contaminating the sample with restoration or mounting materials. Although samples are often taken from the bottom or reverse of an object, both terracotta sculpture and bronze casts are often hollow, sometimes allowing sampling from the interior.

The sample site is photographed before drilling. Written documentation includes the sample location, the rational for sampling, the drilling technique, type of drill bit, size of sample, date,
and person taking the sample. Because bright light will damage the TL signal, drilling should be undertaken in a room that can be darkened completely, using a safelight such as a Kodak lamp with a 6B filter made for darkroom use (Fig. 5).

Samples can be removed as chunks (only practical for core material) or they can be removed with a drill. Tungsten-carbide bits should be used; diamond drill bits must be strictly avoided as diamonds may contaminate the sample and are highly thermoluminescent. The sample size for TL dating is quite large; at least 100 mg are needed, sometimes more. To limit the size of the entry hole, a narrow, deep hole is often preferred. A typical 100 mg sample will result in a hole that is approximately 0.25 cm wide x 1 cm deep. A test can be run on a non-artifact fired clay material (such as a flower pot), to determine approximately how deep the hole will have to be in order to get the required amount of sample for the diameter of drill bit being used. The depth of the hole can then be measured and tape placed on the sampling bit to help indicate when the appropriate depth has been reached. Although a cordless power drill offers the most control when removing a sample, the smaller size of a hand-held rotary tool (Dremel) is sometimes preferable. Two other tools have been particularly helpful in taking samples from the interior of sculptures with restricted access. When there is just enough room for a hand to pass into the inside of the sculpture, a pin vice has proven useful (Fig. 6).
A second tool has been used in two instances to remove core material from inside of bronzes with severely restricted access. The tool consists of a hollow tube with rough teeth cut into the end. The relatively soft core is cut by the teeth. The sample remains inside of the hollow tube and is trapped by a solid rod attached to the bottom end (Fig. 7). Alternating sections of hollow and solid rod can be attached to one another, extending the length of the sampling tool. Using this system, it has been possible to remove core samples remaining in small pockets at the top of nearly life-sized figures through small access holes in the feet.

![Figure 7. A sampling tube can be used to remove core material from bronzes with very limited access to the interior.](image)

Light-tight sample vials are then prepared. Glass bottles with snap-top lids are covered with foil and slipped into plastic film canisters to ensure that they are protected from the light (Fig. 8). The empty vial and canister are then weighed.

![Figure 8. Light-tight sample vials are labeled and weighed before drilling begins.](image)

The work of art must be secured in the dark room at an angle such that it can be safely drilled and the sample contained. Catching the sample may be very straight-forward or quite tricky. Folded weighing paper is most often used to catch the samples. When working in a restricted
area, “envelopes” can be carefully configured so that they will stay taped in place deep inside of a cavity during drilling, yet can be removed when needed without spilling the sample (Fig. 9). When the layout is tricky, a practice run for sample removal, with the lights still on, is recommended.

Figure 9. A folded envelope attached inside a hollow sculpture will catch the sample as it is drilled.

The surface that is first removed when drilling is contaminated by light exposure and must be discarded. Working under safelight, the light-exposed surface is pre-drilled to a depth of approximately 2 mm, using a bit of a slightly larger diameter than the one used for sampling. This pre-drilled material is then set aside for elemental or other analysis. The larger pre-drilled hole gives some extra room to keep light-exposed material out of the sample, should there be minor chip-outs or should the bit wander a little at the entrance hole.

The object is then drilled to the depth marked on the bit. The removed powder is placed in the vial, placed in the light-tight film canister, then weighed.

Once the desired sample weight is achieved, the canister is placed in a fully addressed inner envelope marked DO NOT OPEN IN THE LIGHT. This inner envelope is then placed in an outer rigid shipping box that is similarly labeled. To date, samples have been shipped to the lab using DHL. It is likely that x-ray screening of packages would affect the samples, but as yet there is no indication that DHL [3].

Choosing a TL Lab

The choice of which lab to use is an important one. Many factors should be considered.

1. Communication: It is important to work with a lab that welcomes inquiries, including questions regarding the procedures, questions about sampling (particularly problematic pieces), and – if necessary – further explanation of the results.
2. Experience: Only a small number of labs offer the technique. The lab must have experience with authenticity dating of artifacts, rather than geologic dating. It is ideal if the lab has experience with the general time frame and the type of object under investigation.

3. Sample size: For some objects, sample size is of primary importance. Each lab has a sample size that they require to achieve a result, which can range from 100 mg all the way up to 1 gram. Although some of the labs carry out more steps with a larger sample, resulting in a more precise date, this is not always the case.

4. Available techniques: TL dating involves numerous steps that vary according to the characteristics of each sample. Two steps that can be useful for European sculpture -- thermal pre-treatment for certain types of clay behavior and the pre-dose technique, a method for measuring the amount of energy stored over time that is particularly useful for recent objects such as those in consideration in our laboratory -- are both particularly time consuming techniques. For this reason, not all TL labs offer these steps; labs that offer both are preferred [4].

5. Turn-around time: It has taken anywhere from two weeks to twelve months to get a single result. This is not always an issue in choosing a lab, but it can be very important for acquisition studies.

**TL Results and Discussion**

Figure 10 shows the distribution of the eighty-two results from seventy-one objects that the Getty has sampled for TL dating (as explained below multiple samples were taken of some objects). When the TL dates are compared to the curatorial attributions, the results received over the years fall into four categories. Forty-eight of the results - the vast majority - correspond to the curatorial attribution. Of the eighty-two total results, five samples received TL dates that were even older than the attribution dates, and fourteen samples received dates that were more recent than the attribution. Over 20% of the samples (fifteen of them) received no date using the technique. The fifteen samples that could not be dated fall into three categories:

1) Problems with the samples occurred seven times (either the sample was too small, the lab refused to date it as the object had been radiographed, or, as occurred most often, the sample yielded a “geologic dose”. The latter results indicate either insufficient heating at the “zeroing out” point when the piece was manufactured, or that the sample was taken of material other than the original fabric).

2) In six instances, the lab reported that the material of which the samples were composed was not suitable for TL dating, including light-colored French clays and plaster casting cores.

3) In two examples, the lab never responded with a result.
The numbers in Figure 10 total more than seventy-one, as occasionally more than one sample was taken from an object. Twice initial attempts were made to achieve a date using smaller samples than the lab requested; both times it was necessary to go back into the holes to drill more material in order to get a result. It is now clear that either a full sample must be taken, or dating should not be attempted. In six other instances that were considered particularly important or difficult acquisitions, samples were sent to more than one lab. In all six instances, the results were in agreement with one another. In one of the six examples, a potential acquisition arrived in the conservation lab with results from an earlier TL test that corresponded with the Renaissance attribution. This earlier TL work had been done by a lab we did not know. To be careful, we sent further samples to our trusted labs, all of which came in with a 20th century date, and the acquisition was declined.

Figure 11 illustrates the end result for the thirty-two potential acquisitions that have been dated using TL. Of the thirty-two results, nineteen objects received TL dates that correspond with the attribution. Of these, the vast majority of objects were acquired (sixteen) and three were not, even though they received the anticipated TL date. When the TL date was older than the attribution, the results were mixed: three objects were purchased and one was not. When no TL result was possible, the majority of the pieces were purchased regardless, without confirmation of the date by TL. These three categories - a) date corresponding to the Curatorial attribution, b) dates older than the attribution and d) no date received - indirectly illustrate that most often TL dating is only one of many factors taken into consideration for acquisition. In category c), however, in which the TL date came in more recent than the attribution, all of the acquisitions were declined, suggesting that in these instances, TL dating has proven to be a pivotal aspect of our authenticity studies.
Optically Stimulated Luminescence

A technique related to TL shows great promise for authenticity dating. Referred to as Optically Stimulated Luminescence (or OSL), it offers many advantages over TL. OSL is similar to TL except that the stored energy from the decay of radioactive elements is released by exposure to light, rather than heat. Given the same sample size as that used for TL, the technique offers greater accuracy and less error. In addition, it is more reliable than TL for dating very low-fired materials, and can be used for dating unfired materials such as mortar, stucco, gesso, and earthen walls (Feathers 1995). At least two labs are working on the adaptation of the technique to the dating of artifact materials; hopefully their research will prove fruitful.

Summary

The advantages of the thermoluminescence dating technique are significant:

1. It is one of only a few direct dating methods available for cultural materials.

2. There are independent laboratories that will test single samples, some of which have a considerable amount of experience in authenticity dating of artifacts.
Yet the potential problems with the technique are not insignificant:

1. A large sample is needed (at least 100 mg).

2. Relatively high error limits (generally around 20%).

3. Some clays are not suitable for TL dating. Lack of suitability cannot always be predicted beforehand.

4. The technique involves many steps and is therefore expensive.

5. The sample must be taken and handled with care as the TL signal can be damaged with exposure to light, heat, and ionizing radiation (such as x-rays).

One of the most important steps when considering TL dating is to identify the questions it is hoped to answer. Due to error limits, this may be particularly important for Renaissance and later material. For instance, when TL is used for authentication, it is important to know when copies or outright forgeries would have been made to determine if there is enough time between authentic and copy to get a clear answer. Distinguishing a late-17th century original from a mid-19th century reproduction should be possible by TL. Separating the work of father from that of the son is not.

In closing, the Getty has found that when approached with deliberation and caution, thermoluminescence dating can be a very useful addition to a broad-based sculpture study. It is considered an important tool in our authentication and technical studies, and the museum looks forward to the further development of OSL as a dating option.

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Endnotes

1. Theoretically, a **plateau test** undertaken during TL dating should indicate whether or not an object’s geologic dose was fully “zeroed out” at the time it was made (Aitken 1989, p.150).

2. There is increasing concern that artifacts may be intentionally exposed to x-rays in order to artificially create a false TL date. It may be possible to determine that an object has been exposed to x-rays by examining the behavior of the TL curves. See, for example, Lo 2004; 24.

3. An investigation of the effects of x-rays from airport security scanning has shown a measurable influence on the TL signal of quartz included in slag matrix (Haustein et al. 2003). The author would like to thank Mark Rasmussen for directing her attention to this article.

4. Thermal pre-treatment and the pre-dose technique are succinctly described in Aiken 1989, p. 155 – 156.

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ONLY TIME WILL TELL: EXAMINATION AND ANALYSIS OF AN EARLY GERMAN WATCH

Meg Loew Craft

Abstract

The authenticity of a small early German watch (WAM 58.31) in the collection of the Walters Art Museum was questioned. In preparation for the reinstallation of the Renaissance and Baroque galleries, research, examination and analysis of this watch were undertaken to determine the provenance, construction, condition and composition in an attempt to resolve questions about the watch. Problems were encountered evaluating the watch, a functional object where wear, repairs and alterations to improve accuracy are expected. A great deal of information has been discovered but a final conclusion may never be determined.

1. Introduction

William Walters (1819-94) and his son Henry (1848-1931) collected fine and decorative arts objects during the second half of the 19th century, and into the early 20th century until Henry Walters’ death (Johnston 1999). Their intent was to amass a comprehensive collection of art throughout the ages, which was bequeathed to the City of Baltimore in 1931. The museum opened to the public in 1934. Included in the collections are nearly 300 horological objects, primarily watches, dating from the late 15th century through the very early 20th century. In keeping with the Walters’ love of decorative fine arts, the focus of the horological collection is aesthetic and visual merit rather than the quality of the movements. The provenance of many of the watches is unknown. Receipts in the Walters’ archives frequently do not describe the watches adequately enough to associate the paper trail with specific watches in the collection.

In preparation for the reinstallation of the 1908 Italian Palazzo-style museum in 2005, the watch and clock collection was surveyed. One discovery was the existence of a gilt brass spherical watch with an iron movement dated 1530 that once belonged to Philip Melanchthon (1497-1560), a German reformer and contemporary of Martin Luther (Figs.1 and 2). Although once recognized and documented, some time after Henry Walters’ purchase in 1910 from the Parisian dealer Jacques Seligman, the significance of the watch was forgotten (Gahtan and Thomas 2001). The spherical shape, also called a musk ball or Nuremberg egg, is one of the earliest forms of a watch. Probably made in Augsburg or Nuremberg, both centers of early watch production, the watch is not signed or marked by the maker. Also rare is an inscription appropriate to Melanchthon’s religious avocation, “PHIL[IP]. MELA[NCHTHON]. Gott. ALEIN. DIE. EHR[E]. 1530.” (Philip Melanchthon, to God alone the glory, 1530) engraved on the bottom of the watch. While watches were known to have been made in the late 15th century from surviving documents, no dated or documented examples have been discovered, making the Melanchthon watch the earliest recognized dated watch. Until this rediscovery, the commonly cited example was a German watch dated 1548 and marked “CW”, possibly Caspar Werner of Nuremberg, in the collection of Wuppertaler Museum, Wuppertal, Germany. The Melanchthon
watch moves the date back 18 years. Given the great significance of the Melanchthon watch, attention was directed to other early watches and clocks that had not been carefully studied.

Figure 1 (left). Spherical watch (WAM 58.17). South German. Engraved on the underside: “PHIL[IP]. MELA[NCHTHON]. GOTT. ALEIN. DIE. EHR[E]. 1530.” (Philip Melanchthon, to God alone the glory, 1530). Gilt brass case and dial, blued steel hand, iron movement. 4.8 x 4.8 cm. Walters Art Museum, Baltimore, MD.

Figure 2 (right). Iron watch movement with verge escapement, gut line driven fusee and foliot oscillator. Spherical watch (WAM 58.17).

An enameled gold and rock crystal German pendant watch (WAM 58.31) came under scrutiny, encouraged by wildly varying evaluations ranging from a rare 16th century survivor to modern forgery from visiting dealers, scholars and collectors (Fig. 3). The provenance of the watch was uncertain at the outset of this examination. Archival records indicated only that the watch was part of the collections bequeathed to the City of Baltimore after Henry Walters’ death in 1931. Therefore, curatorial research, conservation examination, and scientific analysis were warranted. Initially, a basic examination was undertaken to confirm methods of manufacture, basic condition and to review past information and comments in the object’s record file.
Figure 3. Pendant watch (WAM 58.31). German, Nuremberg (?). Marked “HK” and “HK 15+60”. Gold, champleve enamel, gilt brass, brass, iron alloys. Case: 4.5 x 3.1 x 1.8 cm. Movement without dial: 3 x 2.5 x 1 cm. Walters Art Museum, Baltimore, MD.

Figure 4. Illustration of the watch in Bode’s 1890-1892 La Collection Spitzer, Volume 5:54, Montres #5.

2. Provenance

As a first clue, an image of the watch was found in a photograph album of objects dating no later than 1915 in the archives, proving that Mr. Walters acquired it prior to 1915 (Walters Archives).

Research has revealed that the watch was in the collection of Baron Frédéric Spitzer (1815-1890) and was sold in 1893 with the dispersal of his collection (Fig. 4) (Bode et al.). Mr. Walters acquired several objects directly from the Spitzer sale that are documented in the Walters archives, but the watch is not mentioned. Spitzer, a dealer and collector, had 4,000 objects in his home in Paris that was known as the Musee Spitzer. His collection is noted for objects of rarity.
and importance, such as the George watch now at the Metropolitan Museum of Art, and, at the same time, for notable forgeries and pastiches (Leopold and Vincent 2000). The illustration of the Walters watch pictured in the catalogue La Collection Spitzer shows a frontal view of the watch but without a hand, suggesting that there may have been an intermediate owner since all images in the Walters show the watch with a hand (Bode et al.). Where Spitzer acquired the watch and its prior history is unknown at this time, but Spitzer acquired many objects from other established European collections, including those of Prince Soltykoff and Alessandro Castellani.

3. Description of the watch

3.1. Case

The oval pendant watch would have been worn as jewelry, typically suspended on a ribbon or chain as a necklace or from a belt (Fig. 5). The suspension loop is circular with a dark translucent blue enamel band on each face. The pendant, the stem connecting the case to the loop, is decorated with a white enameled multi-lobed bow. The watch case is a rock crystal cylinder (see below, Section 3.4) with enameled gold mounts. The case without the pendant and suspension loop measures 3.6 high x 3.1 wide x 1.8 cm. deep. The gold rim mounts on the case are decorated with transparent blue running lozenges alternating with transparent green ovals executed in champlevé enamel. The gold end pieces or straps at the top and bottom of the case are decorated with fruit and floral motifs covered overall with transparent green, blue and opaque white, yellow, green and turquoise enamels. The end pieces are cast with applied fruits secured by pins or dowels.

Figure 5. Oval rock crystal case with champlevé enameled gold mounts. German watch WAM #58.31.
The cover is hinged to the lower part of the case, or ‘cup’, which holds the movement. The movement is not hinged to the case but is secured in the cup by spring clips located at 12:00 and 6:00, or north and south, as opposed to the more common 3:00 and 9:00, or east and west directions. The movement is wound through a hole in the back of the case.

3.2. Dial

The gold dial is decorated with dark blue-black, transparent blue and green champane enamel (Fig. 6). The outer hour chapter ring has a dark blue-black enamel background with gold Roman numerals I through XII. The ‘4’ is represented as IIII as opposed to ‘IV.’ An inner hour ring is gold with dark blue-black enamel Arabic numbers 13 through 24. The Arabic 2 is formed as a z. S-shaped scrolls or dots indicate the half hours. Since the marking of hours during the day was not yet standardized, this system of numbering allowed the telling of time using the Italian system of 24 hours starting at sunset and the two sets of 12 hours used by most of Europe in the 16th and 17th centuries (Bruton 2004).

![Figure 6. Dial of German watch (WAM 58.31). Gold with champane enamels.](image)

The blued steel hand is an appropriate style and may be of the period, although it is not original to the watch since no hand was present when the watch was sold in the Spitzer sale (Bode et al). As all watches without a balance spring, the watch was not a good timekeeper and probably had to be wound at least once a day. Some contemporaneous watches included a compass and sundial to correctly set the time. Minutes, and hence the need for a second hand, were not commonly measured until after the introduction of the balance spring in about 1675.
The center of the dial is decorated with a sunburst having alternating straight and wavy gold rays on a translucent dark blue ground. The arcs at the top and bottom of the dial are filled with scrolls executed in dark blue-black and transparent green enamel on the gold support.

The dial is secured to the front or dial plate of the movement by two lugs attached to the back of the dial that pass through holes in the dial plate. Swinging iron clasps mounted on the underside of the dial plate catch indentations at the ends of the lugs.

3.3. Movement

The movement is housed between two mercury gilded plates, the dial plate and the back plate (Figs. 7 and 8). Measurements of the size of the movement (max. 2.96 x 2.42 x .96 cm.) and the thickness of the plates (plate thickness range .72-.96 mm.) are not uniform based on the metric system established in France in 1799. Some 19th century forgeries have been identified by a 19th century craftsman’s consistent adherence to the metric system (Stone 1998). Prior to the introduction of the metric system, a myriad of non-standardized measurements were used in different European cities or regions (www-history.mcs.st-andrews.ac.uk/HistTopics/Measurement.html). Use of the metric system would prove manufacture of the watch some time after 1799. The metric system was finally fully adopted by France in 1840, northern Germany in 1868 and in the U.S. in 1866 but employment was never made mandatory.

The back plate is chased and engraved overall with interwoven leafy vines and scrolls. In a tear-drop shape, conjoined initials “HK” are engraved at the bottom of the plate. An “N” is included in the center of the overall decoration near the opening for the foliot or dumbbell balance. “HK˚ + 1560” is scratched or incised on the dial plate between the plate and the dial. No oil sinks, introduced in the early 1720s, are present on the plates (www.horologia.co.uk). An oil sink, a shallow well drilled in the plate to keep the oil lubricant in place at pivot points, improved performance and reduced pivot wear. Oils sinks were included in manufacture and often added during repair of functional watches after the 1720s. The absence of oil sinks is a feature that suggests a pre-1720’s watch that was not updated or heavily repaired over time or a watch made later as copy or forgery based on style rather than functionality. The plates are held apart and supported by three gilt brass pillars, two waisted baluster pillars and a rectangular pillar that provides a pivot point for the escape wheel shaft (Figs. 9, 10) (Smith 1975). This tapered pillar is rectangular, not round in section, and decorated with S-shaped scrolls and diagonal hatching.
Figure 7. Back plate of watch (WAM 58.31). Engraved initials “HK” at bottom of plate. Chased and engraved gilt brass.

Figure 8. Dial plate, located under the dial of watch (WAM 58.31), engraved with initials and date “HK 15+60”.
Figure 9. Movement of the watch (WAM 58.31) showing the mainspring barrel with failed lead solder repairs. The cone-shaped fusee, which functions to even out the power from the mainspring, now has a chain connecting to the barrel, which was originally a gut line.

Figure 10. Movement of watch (WAM 58.31) showing the contrate wheel of the going train. The third pillar functions as an adjustable arm providing a pivot point for the escape wheel shaft.
“HK” is unidentified and may be either a maker or an owner. Two known watch and instrument makers working in the late 1500s with the initials HK are identified as Hans Koch and Hans Kiening. Both are listed in the Adler Planetarium’s Webster Maker Database (historydb.adlerplantarium.org). The marks on the watch do not match the accessible known marks of either maker. If the watch is later in date than 1560, a likely scenario, the initials may belong to an owner. It was popular in the early 19th century to hide the name or initials of the owner or maker within the decoration, such as in the pierced work on the cock, a decorated bracket on the back plate with a pivot for a shaft. This conceit may be a clue to the watch’s origin that has not been fully explored.

A steel mainspring housed in a brass barrel provides power for the movement. The barrel is currently attached to the fusee by a steel chain, similar to a bike chain (Fig. 9). The conical-shaped fusee acts as a pulley to even out the power coming from the mainspring. When tightly wound the mainspring supplies more power and as it winds down less power is transmitted. Correspondingly, the chain moves down the fusee to give greater mechanical advantage as the mainspring winds down. The mainspring barrel was attached to the fusee in the earliest watches by a gut line. The 6-turn brass fusee was originally designed to be driven by a gut line. Spiral grooves on the fusee were originally curved or c-shaped to carry the round gut line but have been crudely distorted by the replacement rectangular chain. The gut line was reactive to changes in temperature, relative humidity, and was not as strong or long lived as a chain. Chain began to replace gut sometime after 1600. Conversion from a gut line to a chain was a common modification during the 17th century (Bruton 1999).

The going train is the series of interlocking gears that transmit power from the mainspring to the escapement, where the beat or pulse is produced (Fig. 10) (Bruton 1999). The watch has five large gears or wheels, most with three arms, in the train: fusee great wheel, second, third, contrate and escape wheels. The wheels are interconnected by smaller gears or pinions with five leaves attached to the opposite end of a shaft shared with a wheel. The barrel and fusee are yellow copper alloy, which was not analyzed but is usually brass, but the train wheels, pinions and arbors are made entirely from iron alloys, white metal alloys attracted to a magnet. Very early movements are made entirely from iron, as is the Melanchthon watch discussed in the introduction. Later movements are primarily made of brass, with only steel arbors and pinions (Leopold and Wayland 2000, Smith 1996). If authentic, this movement appears to be transitional with both brass and steel.

The movement has a verge escapement (www.horlogia.co.uk/escapements.html). Alternative escapements were not widely introduced until the 18th century; all early watches originally had verge escapements (http://en.wikipedia.org/wiki/Verge_escalation). The verge, an arbor with two palettes or flags set at slightly less than 90° to each other that engage with the teeth on the escape wheel, passes the power from the mainspring to the oscillating foliot creating the beat of the watch. The foliot, which looks like a dumbbell visible on the back of the watch, is controlled by a bristle regulator that consisted of a hog’s bristle set into a movable blued steel j-shaped arm on the back plate. The hog’s bristle acts like a spring to reverse the direction of the foliot. A blued steel, reverse s-shaped cock provides the pivot point for the verge and foliot.
4. Condition

At the Walters Art Museum conservation treatment of watches is currently being kept to a minimum until study and research is complete. Old repairs, wear and damage are part of the watch’s history to be preserved unless threatening the stability of the watch. Preservation of past use is necessary to study the watch’s condition and for authentification. No watches function while on display. The Walters lacks the manpower to wind watches and clocks, does not focus on the operational aspects of movements as part of its interpretation of horological objects, and does not have a horologist on staff. Watches are stored at ambient conditions of approximately 70˚ F and 50% RH in cases or drawers with acid free, conservation-quality housing materials. Tarnish inhibitors, such as Pacific Silvercloth, are kept in the cases and drawers to reduce and slow tarnishing of silver. Minor treatments are undertaken on cases, for example, to remove fingerprints, stabilize flaking enamel, inpaint minor losses in enamel or to remove tarnish or polish residue on silver elements.

No treatment records exist for the watch. The case is in stable condition with minor losses to the enamel. The movement is fragmentary and nonfunctional. The movement fits snugly in the case; the edges are not filed or altered to fit. The cover is slightly sprung and does not close tightly.

The cover on the case has been damaged and heavily restored. The bottom or cup of the case is rock crystal, confirmed by visual examination for flaws and inclusions and checking between crossed polarized filters (www.olympusamerica.com/files/seg_polar_basic_theory.pdf). When positioned between two polarizing filters, the crystalline structure of rock crystal alters the path of light passing through it. The cover proved to be glass, probably a restoration. Although not common until the 17th century, the cover and bottom of the case would have been made both of rock crystal originally; glass was not used until 18th century (Bruton 1999). When examining the glass, air bubbles from manufacture are visible and light was not diverted when the glass is placed between crossed polarized filters, indicating the amorphous structure of glass. The glass is held in a recess as opposed to being secured by clips or prongs projecting from the bezel, more common in early watches. The bezel is split, having an intentional opening, at the hinge. This may have been done originally, or more likely, as part of the repair work to replace the cover glass. The hinge has also been repaired.

The enamel on the case mounts has suffered losses. Damage is most severe on the straps or end pieces with encrusted en ronde bosse enamel work, where opaque and transparent enamel are applied over the gold relief surface (Fig. 11). The strap is a cartouche with applied fruit or floral elements. The cartouche is covered with transparent blue and green enamel which has suffered extensive losses, especially on curved surfaces, the outer perimeter and highpoints. The fruit and floral decorations are executed primarily in opaque colors: white, yellow, turquoise and apple green. At the bottom of the case in the center of the cartouche, a finial or drop has been lost (Fig. 12). A pearl or gold and enamel drop may have once hung down from the bottom of the case; file marks are present where there was once an attachment (Britten 1932, Zagorodnaya 1997).
Figure 11. Dial of the case of watch (WAM 58.31). Enamel originally covered most of the gold strap or end piece. The pendant and bow are also covered with en ronde enamel.

Figure 12. Bottom of the case of watch (WAM 58.31). In the center, a ring for suspension of a drop or finial has been filed off. The enamel has suffered losses, especially on curved surfaces and high points.

The back of the rock crystal case is scratched. Small chips are present around the winding hole and under its protective gold collet on the back of the case. Usually 16th century cases were hinged on the front and back to allow easy access for winding. Gold mounts were used as a manufacturing technique to secure the cover and to avoid drilling into the rock crystal, which is
easily chipped. The winding hole on the reverse may be an alteration or design change. Without the hole, the movement would have to be removed from the case for winding causing excess handling and wear, especially given the small size of the watch. This is an awkward and non-functional design feature not common on early watches.

Conservation treatment was cosmetic only. No treatment of the movement was undertaken. No corrosion is currently active. Losses have occurred to the dark blue enamel inside the chapter rings requiring minor cosmetic treatment (Fig. 13). The losses were inpainted using Primal WS-24, a colloidal acrylic dispersion made by Rohm and Haas, dry pigments and Golden Fluid Acrylic Colors (Fig. 14). The inpainting was carefully leveled using acetone and micromesh abrasive papers.

Figure 13 (left). Dial of watch WAM #58.31 with damages to the enamel before inpainting.

Figure 14 (right). Dial of watch WAM #58.31 after inpainting.

The movement appears to be earlier than the 18th century in date, based on the gut-driven fusee and early wheel work. The many elements of the movement are worn and heavily repaired. Given the functional nature and age of the watch, damages, repairs and replacement elements are expected. The dumbbell foliot is a crude replacement. The lug of the reverse s-shaped cock below the back plate interferes with the movement of the escape wheel, indicating a nonfunctioning later replacement or restoration. The top and bottom of the spring barrel, originally held with mechanical tabs, have been very crudely repaired with lead solder that has failed in several spots, leaving one end of the barrel detached and held in place by the arbor only.
The iron alloy elements have minor rust. The brass elements have a few spots of green organic copper corrosion products present from past oil lubricants, traditionally from the jaws of porpoises and other animal products, which contain organic acids and attract grime. No additional conservation work will be done on the movement until all study and research options are exhausted. Fingerprints or grime are removed with odorless mineral spirits or ethanol.

5. Scientific Analysis

Analysis of the mercury gilded brass plates undertaken by Jennifer Giaccai, Scientist at the Walters using micro-X-ray spectrometry and by Dr. Philip Piccoli, Associate Research Scientist in the Geology Department, University of Maryland, using wavelength dispersive X-ray spectrometry (WDS) in the scanning electron microscope. These studies revealed that the dial and back plates are high zinc brasses but of slightly different compositions (Piccoli 2005). Both contain less than 30% zinc and traces of arsenic and/or antimony. In Europe during the 16th and 17th centuries, brass was made by the cementation process, which prevents the zinc content from exceeding 32%. Had the zinc content been much greater than about 30-32%, the brass would date to the 19th century or later after co-melting of copper and zinc was developed in Europe (Newbury et al. 2005).

Analysis of the enamels was undertaken by Mark Wypyski, Conservation Scientist at the Metropolitan Museum of Art using a combination of energy dispersive X-ray spectrometry (EDS) and wavelength dispersive X-ray spectrometry (WDS) in the scanning electron microscope. From his report: “The translucent enamels from both the watch face and the case were found to be essentially identical, allowing for some variation due to heterogeneity in the enamels mixtures. The overall compositions as well as the colorants used in all of the enamels from the watch were found to be consistent with previous analyses of other well-dated 16th and 17th century European enamels” (Wypyski 2005). However, Renaissance enamel compositions continue to be used, despite technological changes, until the early to mid 19th century. By the mid 19th century, compositional differences including increased lead content and the use of different colorants and opacifiers, were in use that may distinguish these later enamels (Wypyski 2002).

Scientific analysis determined that the composition of the brass and the enamels is technically feasible for a 16th or 17th century watch (Wypyski 2005, Piccoli, 2005). From the enamel analysis, results suggest a manufacturing date earlier than mid-19th century even if the watch is a complete fake or forgery. The analytical results do not preclude the use of Renaissance enamel compositions in the 16th or very early 19th century, or the assembly and reuse of older elements. While analysis was a useful tool, it did not provide a “smoking gun.”

6. Comparative Study

The making of watches probably began in the late 1400s. The earliest reference to a watch is made by Johannes Coeleus in 1512 in reference to small timepieces made by Peter Henlein, a locksmith in Nuremberg. Currently the Melanchthon watch, dated 1530, is the earliest known
dated survivor. If original and not added at a later date, the incised date of 1560 on the dial plate is extremely early. Relatively few early watches survive, making comparisons difficult (Thompson 2008). Without a direct comparison, the initial reaction is to dismiss the object.

One image of a very similar watch was located (Fig. 15). In F. J. Britten’s *Old Clocks and Watches & Their Makers* (Britten 1932), a watch from the Prince Soltykoff collection is discussed. The description in the Britten text, which seems to be derived from the 1858 catalogue of the Soltykoff collection by Pierre Dubois, indicated that the author had not personally seen and did not know where the watch was at the time of writing (Dubois 1858). Although not discussed in Britten, the initials “HK” are clearly visible at the center top illustration of the back plate. Britten only notes an N probably for Nuremberg. This watch is clearly by the same unidentified “HK” maker, owner or forger. The current location of the illustrated watch once in the Soltykoff collection is unknown.

A second related watch is in the collection of the Mathematisch-Physikalischer Salon, Dresden (Willsberger 1975). Inquiry regarding this watch has not been completed. Both of these watches have been dated to the late 16th or early 17th centuries.

![Figure 15. Similar watch illustrated in Britten’s *Old Clocks and Watches and Their Makers* (Britten 1932; 78).](image-url)
7. Discussion

The art market demand for antiques, especially Renaissance objects including watches and clocks, exceeded the supply in the 19th and early 20th centuries (Hackenbroch 1986, Stone 1998). The result was the proliferation of pastiches and outright forgeries that entered the market. The distinction between a heavily restored old watch, a pastiche of old and 19th or 20th century elements and a clever forgery is a difficult one to make. This distinction is more difficult with a functional object than with a strictly decorative object that would not have suffered wear and subsequent repair and continued updating over its useful life.

Frédéric Spitzer, the earliest documented owner of the watch, knowingly and dramatically altered objects, was involved in the production of forgeries and pastiches and sold them to other collectors (Hackenbroch 1986). The association with the Spitzer collection casts doubt upon the watch but, at the same time, his collection also contained many superb works of art including watches (Leopold and Vincent 2000). Further clouding the issue is the lack of provenance prior to the Spitzer collection.

The lack of a body of accessible technical and conservation information about early watches complicates comparative study. In this case, scientific analysis did not affirm or condemn the watch, but left the question of authenticity open. The watch is probably not a late 19th century forgery, based on brass and enamel analysis and the publication of the similar Soltykoff watch by 1858, but it could date from any time prior to the mid-19th century. The existence of two similar watches deserves further study.

The date “15+60” and HK on the dial plate could easily have been added. If the date is not original, could the watch be from the first third of the 17th century? Certainly, rock crystal cases were fashionable in the 1620s but were used earlier (Tait 1983). The 17th century is noted for the development of highly decorative cases, including rock crystal, glass and other stones for cases, painted enamels, gold chases and embossed cases, and form watches in the shape of crosses, hearts, skulls, books and animals. A date in the early 1600s is more feasible than the mid 1500s.

Additional study is needed. Questions remain to be answered. How does the Walters’ watch compare to the watch in Dresden? Are both plates of the watch hammered, and not rolled or cast? Can anything be learned from the composition of the gold mounts? At this time, the watch seems not to be a late 19th century forgery, but no other possibilities have been ruled out. The date of 1560 seems too early given the case style and materials. An 18th or early 19th century pastiche of old and new elements or an early 17th century watch with many alterations and an added date on the dial plate seem more plausible. Only time will tell.

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**Other Sources**


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REFINING THE DATABASE FOR WHITE MARBLES: ISOTOPE ANALYSIS OF 18TH CENTURY MARBLE BUSTS BY JEAN-ANTOINE HOUDON

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Abstract

This study examines the quarry provenance of marble sculptures by the French master sculptor Jean-Antoine Houdon (1741-1828), using light stable isotopes of carbon and oxygen in combination with petrographic techniques. Houdon’s famous portraits of heroic figures from the French and American Revolutions have enjoyed immense popularity for centuries, and have been copied so extensively and expertly that accurate attribution by art historians can be very difficult. However, documentary records from the Archives Nationales in Paris and the Académie Française in Rome reveal that marble for these sculptures was carefully selected from a limited group of Italian quarries. Using this information, 25 new samples were collected from the Torano valley quarries at Carrara and added to the pre-existing quarry database to provide a more accurate basis for comparison. Samples from thirty-one sculptures attributed to Houdon were compared to this expanded and improved database, and the comparison shows that a) the isotopic signatures of both groups fall within an extremely narrow range and b) the two groups are closely aligned. The results suggest that in circumstances where quarry sources are well documented historically, isotopic provenance determination may be useful for authenticating artwork of specific artists and periods.

1. Introduction

This study examines the marble sculptures of French master sculptor Jean-Antoine Houdon (1741-1828), using light stable isotopes of carbon and oxygen in combination with other techniques to identify marble quarry sources and thus to assess groups and trends.

Houdon’s work provides an ideal test case for examining the usefulness of isotopic and petrographic techniques. A large body of marble sculpture work attributed to Houdon is available for study, as well as numerous contemporary and later copies. The extent and quality of the copying, by Houdon’s atelier, contemporaries, and others since, are extraordinary. His choice of thinkers and politicians of the enlightenment for subjects, and his individualistic, intimate treatment of features and expressions struck a chord with the public and engendered wide demand. Houdon’s renderings of Franklin, Jefferson, and Washington speak so effectively of the ideals of American independence that they remain, literally, the symbolic currency of the nation.

Within the last few decades, instrumental techniques have been developed that can fingerprint calcite on an isotopic level, allowing scientists to match marble samples from sculptures with known quarries, and thus trace a sculpture’s primary source (Craig and Craig 1972; German et al. 1980; Herz 1985; van der Merwe et al. 1995 and others). As the technique of isotopic analysis becomes more widespread and the instrumentation more advanced, attempts have been made to apply the method, originally developed to identify Greco-Roman quarry sources, to
more recent works of art (Black and Nadeau 1990; Herz et al. 1995; Holbrow and van der Merwe 1997). Is the database relevant to later works such as white marble sculptures from rococo and neoclassical France? Is other information useful in conjunction with quarry source data? A fresh approach seems necessary to address these different circumstances.

Examination of such relatively recent works as Houdon’s provides an opportunity to integrate detailed examination of the sculptures themselves with historical research and isotopic analysis. Primary resource documents on marble quality and availability, quarrying and purchasing procedures, the role of the Académie des Beaux Arts in Rome and other related subjects are available from scholarly publications and the Archives Nationales in Paris. This information allows more precise quarry sources to be selected and sampled for comparison with Houdon’s sculptures. Using the improved database for comparison, thirty-one works attributed Houdon were sampled and analyzed using x-ray diffractometry and measurement of the stable isotope ratios of carbon and oxygen.

2. Individualism and replication in the work of Jean-Antoine Houdon

To make chronological sense of a large body of highly finished white marble sculptures that are attributed to a single artist, similar in treatment and often repetitive in subject matter, can be a particularly difficult task for art historians. The sculptures of Jean-Antoine Houdon form one such group. Traditional art historical assessment of the artist's style combined with documentary research on provenance can answer many questions. In the case of an artist as popular as Houdon, however, the best-known works are so widely and continuously reproduced that technical and scientific analyses become necessary to augment historical research. For example, Houdon's famous portrait of Thomas Jefferson is circulated nationwide from the U.S. five-cent coin, and the artist's idealized busts of young children continue to be reproduced in all media and sizes today (Figs. 1 and 2).


While many of these renditions are easily distinguishable from the originals, other copies are expertly conceived and may be contemporary in date. Like many artists of his time, Houdon frequently reproduced his own works. In addition, students and lesser artists made copies for study and for sale, in recognition of Houdon’s skill. As early as 1794, Houdon himself complained that copyists were cutting into his profits: "...people are constantly copying my works, distorting them and putting my name on them; while others, still less honest, simply copy them and put their own name on them... defrauding me thus of my labor." (Arnason 1975, Appendix 3).

This situation has made attempts at art historical classification difficult, and it is perhaps for this reason that no catalog raisonné of the artist exists. Louis Réau, whose two-volume treatise on Houdon was published posthumously, collected primary source documents to begin the task (Réau 1964). H.H. Arnason suggests that more than 2000 works of all media by Houdon are thought "very likely" to exist; he presents and thoroughly discusses a group of approximately 330 works, of which 116 are marble. The "incredible proliferation of duplicates authorized and supervised by the artist," Arnason points out, requires a canon to establish standards for authenticity and provenance. (Arnason 1975, vii and 36) A number of scholars have made efforts to trace the provenance of a specific work or group of works and efforts are currently being made to address the need for a catalog raisonné, but scientific and technical contributions lag behind.
In a period when uniqueness of manufacture was not a virtue and all sculpture was reproduced, portraits were the most replicated. They functioned not strictly as fine art, but also as snapshots do today. Several of Houdon’s works were aimed at the broadest possible market, as for example the portraits of the philosophers Voltaire, Diderot and Rousseau. Houdon's contract for the bust of popular actress Sophie Arnould survives, committing the artist to the production of thirty plasters as well as a finished marble version (Fig. 3), while as many as 100 busts of Voltaire may have been produced by Houdon (Arnason 1975). Others, such as the portraits of the Brongniart children or Houdon’s own daughters, use individual likenesses as ideals of childhood innocence, giving them popular appeal to a much broader market.

![Figure 3. Jean-Antoine Houdon, Sophie Arnould, 1775, marble. Louvre Museum, Paris.](image)

Houdon's massive output was made possible, in part, by the hierarchical workshop system in place in France at the time. In an 18th-century sculpture atelier, a number of technicians typically worked beneath the master sculptor. Technicians or *practiciens* contributed heavily to the finished products, roughing out the forms from a model produced by the master and completing as much of the marble work as ability (and wages) would allow, before a final "*réparé*" by the artist (Le Normand-Romain 1981; Réau 1964). Three technicians accompanied Houdon on his trip to the United States, to assist with the sculpting of *George Washington*. Some of these minor sculptors worked simultaneously for more than one artist as well as for themselves. Vincent Mazetti, who claimed in a letter to d'Angiviller to have "executed" Pajou's *Bossuet*, and "worked the figure" for Houdon's *Marechal de Tourville* (Réau 1964, 53), signed as a witness on Houdon's marriage certificate (Arnason 1975, 78).
3. 18th-century French marble: preferences and availability

3.1 Statuary marble and Carrara

Before such analytical techniques as isotopic fingerprinting can be usefully applied, a database of sample marbles must be available for comparison. Many isotope samples have been collected and published, and a master database was available for this study thanks to the generosity of Norman Herz [1]. Not all the data are relevant here, however. The most useful database is drawn only from relevant samples. Different regions have imported and carved specific marbles for many different reasons, including economics, war and other trade disruption, and changing aesthetic tastes. Art historical and social history sources can pinpoint the quarries that provide the best possible reference collection for the artist in question.

A number of quarries in the southern Mediterranean do produce marbles of the consistent color, softness, and quality preferred for sculpture. Although many of these Greek, Turkish, and North African marbles are typically larger-grained and cooler in color, they are commonly found in southern Mediterranean sculpture and architecture. Two regions, Mount Pentelikon near Athens and ancient Dokimeion (now Afyon; controlled by Turkey in the 17th century), do produce fine-grained white marbles. Petrographically, these marbles are certainly another possibility for any sculptor. The poor political climate between Turkey and the west restricted access to these areas at the time of Houdon’s work. An 1816 letter from Benjamin Latrobe to Senator Nathaniel Macon discusses available marble and eliminates these Turkish-controlled quarries: “The Parian and Penthelic Marbles of antiquity are not inferior to ours, but they are very superior to that of Italy. They are however inaccessible, being in the hands of the Turks…” (Fairman 1927, 32).

Some domestic white marble, quarried at St.-Béat in the Pyrénées, was used by French sculptors of the period. Other factors being equal, one might assume it would have been preferred as more easily accessible and politically expedient (Bresc-Bautier and du Mesnil 1986). This marble, however, has a larger grain size, more foliation and is harder and more brittle than Carrara marble. Not only is the stone more likely to split during carving, the large grains are also quite visible and the result can be a mottled effect (Fig 4). A portrait bust of Madame de Pompadour by Pigalle is one example of Pyrénéan marble used for sculpture (Fig 5).

Of all the marble available, the stone quarried in the Carrara region (which includes more than 40 quarries in three valleys) dominated the European market. The visual quality of Carrara marble was one reason for its broad use. The marble has a warm tint, producing a creamy ivory sculpture that appeals aesthetically. The carving properties of Carrara marble also made it desirable. Geologically formed by the metamorphic recrystallization of calcium or magnesium carbonate, marble is relatively soft, easy to cut, and takes a high polish. Carrara marble in particular has an extremely fine, even grain and very few impurities, making it prized by carvers. Peter Rockwell, in his *Art of Stoneworking*, describes Carrara statuary marble as “highly receptive to fine detail, as well as giving the impression of very high relative tensile strength. Extended arms and fingers… do not pose insurmountable problems… one of the two or three finest carving marbles known.” (Rockwell 1993, 27).
Figure 4. Calcite petrographic thin sections. Top: Carrara marble, unpolarized light, 100x. Bottom: Pyrenéen marble, polarized light, 100x.

Figure 5. Jean-Baptiste Pigalle, *Madame de Pompadour*, 1748-51, marble. Metropolitan Museum of Art.
Even at Carrara, marble of a quality suitable for sculpture is fairly rare. Although the Carrara region is large, the majority of marbles found there are of the gray-striped *calacata* type and other coarser grade marbles suitable for building (Fig. 6). White *ordinario*, found in fairly large quantity, is described by Rockwell as “off-white tending toward gray, frequently with lines or areas of darker gray... often seems slightly harder than the statuary marble... Its principal defect is the cold white to gray of its color, which makes it much less visually attractive than the statuary variety.” (Rockwell 1993, 27). Bedding planes and weak areas formed by streaks of soft impurities also make hand carving more difficult; such striped marble is more commonly used today with the advent of power tools for carving.

![Figure 6. Marble samples. Carrara Museum, Carrara, Italy.](image)

Only a few Carrara quarries consistently produced the fine-grained, white, statuary-grade marble so desired by the sculptors and patrons of the eighteenth century. Dolci has identified Ravaccione, Polvaccio, Betogli, Mandria, and Crestola in the Torano valley of Carrara, and Fantiscritti quarry in the Miseglia valley as producers of *statuario* (Dolci 1980). Others narrow the list still further. Klapisch-Zuber describes the marble of Betogli, Mandria, and Crestola as “semi-statuary,” and Mandria and Crestola marbles are yellowish in color, and marked by violet and yellow veins (Klapisch-Zuber 1973). Only small white blocks can be obtained from Mandria and Crestola, both of which bear numerous veins of pyrite and magnetite. Rockwell rates Betogli marble *ordinario*, rather than *statuario*, and it has been rejected by at least one discriminating French sculptor: in a 1774 letter to his friend and agent Vitale Finelli in Carrara, Clodion demands only the best marble, and specifically warns “not Betogli.” (Griseri 1961, 164).

Polvaccio was the quarry best known for its pure white *statuario* (Fig. 7). In 1741, Michel-Ange Slodz, Houdon’s teacher, described Polvaccio as the place “from which are extracted the most beautiful marbles” (Souchal 1966, 51). Even here, production was irregular, and primitive
excavation techniques a continual risk. A tourist describes the collapse of this quarry in the mid-18th century:

a little before I went to Serravezza, there occurred the collapse of the most famous and richest quarry of statuary marble called Polvaccio, so that for a great period of years, at least, one could not extract marble... and that of Pianello in said place, having marble not much good for statues, but only useable for working flat... (Klapisch-Zuber 1973, 89 note 6).

Figure 7. Polvaccio, 19th-century, engraving. Comune de Carrare, Italy.

The quarries at Seravezza (located approximately 20 km southeast of Carrara), exploited by Michelangelo and producing very fine white statuary marble, must be considered as another possible source for French sculpture. Seravezza is not mentioned as a source in documents preserved in the Archives Nationales and the Académie. Because the two regions are relatively close, however, the term “Carrara” occasionally refers to Seravezza as well.

Thus, although the Carrara region initially appears to be a broad source for sculpture marble, mineralogical variations within the region have been recognized for centuries by discriminating artists and patrons. When the finest and whitest marble was desired, the quarries which produced it consistently were limited to a very few: Polvaccio, Ravaccione, Fantiscritti, and Seravezza.
3.2 Marble availability and access

Documents in the Archives Nationales in Paris, and published correspondence from the Académie Française in Rome indicate that from 1750 to 1790, the marble available for sculpting was drawn from a very small pool indeed. Within France, the rigid structure of government made trade and imports difficult:

Nowhere was this system of State encouragement (direct subsidies, interest-free loans, concessions, exclusive privileges) carried so far as in late 17th- and 18th-century France, where manufactures royales and privileges secured loans and subsidies, honorific titles and practical monopolies (Miller et al. 1987, VI:430).

This statement especially applied to marble, which was an elite and rare material. Since 1700, the King had enforced a monopoly on all marble production, reserving the best for Royal projects and then selling the remainder at fixed prices through his Sûrintendent des Bâtiments. In 1725, absolute control was extended to all shipments entering France, and in 1765, French quarries were required to submit reports and samples to the King. Failure to comply was punishable by fines and confiscation. These strict controls and prices made domestic marble, from St-Béat, actually more expensive and unobtainable than that from Carrara (Bresc-Bautier and du Mesnil 1986).

Delays and restrictions in obtaining, transporting and distributing marble in Paris were considerable. French marble agents, including the King’s agent, purchased their marble blocks through marble workers and sculptors at Carrara, in the Ripagrande depot in Rome (Le Normand-Romain 1981), or at nearby ports such as Livorno, where Clodion picked up his marble blocks for Abbé Terray’s commission (Bailey 1993). In Carrara, the quarries were controlled by the local landowner, the Comte de Carrara. Marble was initially purchased from the Comte at a price that reflected costs of extracting and carting it to the nearby port at Massa (Montagu 1989).

When a particular project arose which required special attention, a French agent might be sent to select and purchase the marble personally. A 1741 letter from the Directeur of the Académie in Rome and the Directeur des Bâtiments, sums it up thus: “the work done by an intelligent man who is on the spot is very different than that of one who must work through the hands of the merchants” (de Montaiglon 1875-1892, IX: 444:4371). Slodz, sent to Carrara to find large blocks for Coustou’s horses (now on the Champs Elysées), took nine months to find marble suitable to the project, while Clodion, on a similar mission in 1774, wrote to the architecte du roy of the difficulties in procuring large blocks (Thirion 1885).

Although its primary purpose was to provide classical training for young artists, the Académie in Rome also provided French sculpture patrons with an important base from which to purchase marble. In their published correspondence, the Directeur des Bâtiments and the Directeur of the Académie in Rome discuss the quality of the marble, the availability of different types, and record details of many purchases (de Montaiglon 1875-1892). During their stay in Rome,
sculpture students were introduced to the quarries of Carrara and the mechanics of selecting and negotiating marble purchasing. These Rome-trained artists (including Slodz, Canova, Clodion, and Chinard) became the preferred purchasing agents for the Crown, arranging to visit Carrara and select high-quality blocks. Although in principle unpaid, such commissions were desirable as they allowed artists to stay in touch with the agents for the Crown, who were the source of all Royal commissions being made back in France. Chinard’s letter of 1806, offering such service, is a masterpiece of flattery: “I will find my recompense in the satisfaction of aiding the ‘immortels’ who direct the glory of the arts for the enlightened Ministry who protects them.” (Archives Nationales F21 476)

Once shipped to Marseilles, the marble imports were under the control of the Directeur des Bâtiments. Réau refers to the praticien Vincent Mazetti, shipping blocks from Italy for Houdon and other sculptors, and requesting storage space in a government warehouse (Réau 1964). After arriving in Paris, state-purchased marble was stored in one of the King’s warehouses at Chaillot, rue Louis-Grand, or (after 1772) La Muette (Bresc-Bautier and du Mesnil 1986).

Members of the Académie had strictly limited access to the royal marble stores. Only royal commissions entitled one to this marble, which had been selected and reserved for the King. Inventories of the dépôt des marbres at Chaillot show that larger blocks of marble were ordered with specific building or sculpture commissions in mind, and were tagged accordingly. Larger blocks were designated both an artist and a subject. Warehouse inventories also show that the vast majority of the marble came from Italy. There are very few mentions of blocks from Greece, and none of purchase or order of Greek statuary-grade marble (Archives Nationales O1 2065-2101; O2 315).

The delays and restrictions met with in acquiring marble seem to have led to a certain amount of sharing and lending of marble blocks and related services. Clodion, officially sent to Carrara to select marble for the King, was also expected to purchase additional blocks for commissions of his patron, Abbé Terray, at the same time. This marble was then shared out to the four artists commissioned by the Abbé (Poulet and Scherf 1992).

Expedience led Houdon to use his own marble for the production of his one Royal commission, the Maréchal de Tourville. In a hurry to see his work in marble, Houdon negotiated to provide his (previously purchased) block on condition that it be replaced by the Crown. On 7 October, 1780, D'Angiviller's agent, Cuvillier, agreed:

> Houdon will use his own block. We will replace it with one of the same size. The block will be chosen by Houdon from among those waiting at Carrara and Marseilles for the King and he will choose one of paste and grain approximately equal to the block that he delivers and that this same block given him in exchange, will be delivered free of postage and handling to his atelier in Roule (Réau 1922,370).

The Crown's reluctance to replace the block (Pierre later claimed conditions were "trop juste") protracted the negotiations, and by July 1782 Houdon is writing directly to d'Angiviller, and has still not received his replacement block (Réau 1922).
The international political situation also affected the availability of marble. War between France and Britain and depredations during the French and Indian War (or Seven Years War) slowed down shipping from 1756-1763. A period of relatively free trade followed the war, during which commercial enterprise flourished and Italian marble was used extensively for sculpture, and during which the bulk of Houdon's work was produced. This flood of trade lasted until the American Revolution placed France at war again in 1778. Royal and aristocratic expenditure on luxuries such as marble was being paid for by more and more forced, no-interest loans under Terré, Necker, and Calonne (Hirst 1910). The result was inevitable: in 1789 the Revolution effectively halted trade in luxury goods for the remainder of the century, due to domestic upheaval as well as difficulties in gaining access to Carrara (by 1793, France was at war with most of Europe). The Commision Temporaire des Arts was formed to deal with reports of looting at the Chaillot depot, and through the years of 1794-1795 steps were taken to provide surveillance and protection of the State supplies. In 1794, Clodion negotiated with the Commission Temporaire des Arts for the return of an unused block from a canceled commission (Tuetey 1917).

Although artists like Houdon continued to produce marble sculptures during the 1790's, they were probably using up old inventory. The marble trade did not revive until Napoleon’s conquests stabilized the French economy and opened new markets through the Treaty of Amiens in 1802. In an 1808 letter, M. Henraux, the commissioned agent for marbles for the French government, tells of boats full of marble, stranded on the Italian coast by the depredations of the English (Archives Nationales F21 573). Other officials note the excessive price of transport during the war and the fact that the Royal depot has not been replenished for a long time (Archives Nationales O2 315).

Thus the available historical documentation and contemporary examination of the marble and quarries indicate that Polvaccio and possibly Ravaccione were the primary source of large white blocks for French monumental sculpture in the late 18th- and early 19th-centuries. With the possible addition of Fantiscritti, it seems likely that these quarries were the source for most small marble blocks as well although clearly more variation is to be expected here. While other statuario quarries should be considered as well, these quarries must be well represented in the database.

4. Marble Analysis

4.1 Factors used to determine marble provenance

Historical research shows that French 18th-century sculptors were selective in their choice of marble. Can these marbles be distinguished analytically? Because a great deal of the isotopic data overlap, this technique cannot be used alone. To be useful, the isotopic data must be limited to as small and appropriate a group as possible. White marbles, the only color of interest here, are isolated first. Next, the marble is sorted by grain size. As mentioned earlier, Carrara marble is noted for its extremely fine grain. The maximum grain size seen at Carrara is only 1.5 to 2 mm (as compared to as high as 12 mm maximum grain size found in Greek, Turkish and North African quarries). The mineral composition of the marble is also important: some quarries
produce dolomitic marbles (i.e., with a magnesium carbonate content of more than 10%). Although this does not affect the visual appearance significantly, the mineralogy is easily detected by means of x-ray diffraction (Moens et al. 1988; van der Merwe et al. 1995).

4.2 Isotopic and petrographic techniques

Because of these distinctive features, marble samples should first be distinguished by measuring grain size and/or by x-ray diffraction. The mass of isotopic data can then be reduced to a few, distinguishable quarry fields. All stone samples (both geologic and sculptural) were initially examined using a 10x hand lens, for general color, mineral inclusions and distribution, and approximate grain size. Where samples were large enough, a portion was mounted and polished for petrographic examination. Examination of the polished section provides valuable information concerning grain size, texture, and grain size caused by metamorphic pressure in the stone, as well as very limited qualitative identification of accessory minerals. The mounted sample also remains available for further analyses. X-ray diffractometry was employed to establish whether the marble is calcitic or dolomitic, and the average grain size estimated by hand lens and/or through examination of a thin section. The results of these measurements were combined to identify the most probable quarry sources for the various samples.

All of the sculptures examined here were found to be calcitic and to be very fine-grained, with an average grain size of less than 1 mm in diameter (often much finer). These facts limit the possible quarry matches to only three Mediterranean regions: Mount Pentelikon, Dokimeion, and Carrara/Seravezza, eliminating white marble from St-Béat and most Greek and Turkish sources.

Of the instrumental analytical techniques explored for identifying marble, isotopic fingerprinting has emerged as one of the most useful. Carbon dioxide is extracted from the calcite mineral phase of the stone using phosphoric acid, and the isotope ratios of $^{18}\text{O}/^{16}\text{O}$ and $^{13}\text{C}/^{12}\text{C}$ measured in a mass spectrometer. Isotope ratios for each element are compared to the PDB standard, and the result expressed as $\delta$ or deviation from the standard, in parts per thousand (‰).

Studies have shown that several factors can influence the accuracy of isotopic analysis of marble. Weathering, contamination, natural variations in the rock, and the presence of inclusions or accessory minerals may cause shifts in isotope ratios. The analytical precision for the measurement of $\delta^{13}\text{C}$ is typically about 0.1‰; the new data reported here have precision of about 0.05‰. By contrast, isotope ratios within an outcrop or quarry have been estimated in earlier studies to vary up to 2.0‰, and variations have been found within a single, apparently homogenous slab of as much as 1.0‰. Weathering and contamination of the stone were also found to skew results considerably (Herz 1985; Herz and Dean 1986; van der Merwe et al. 1995).

The sculptures examined here produced far more consistent results than these earlier test cases. Aesthetic choices during this period ruled that blocks with only minimal inclusions or accessory minerals be used for sculpture, and that weathered and discolored outer surfaces of the quarried block be discarded. Consequently, data from the sculptures examined shows much less variation than the geologic samples tested in the publications cited above, by virtue of this pre-selection.
(and also since, having been kept continually indoors since cut from a fresh block, weathering is thereby omitted as a factor).

Statistical analysis of the sculpture data remains impractical; due to limitations of removing marble from valuable sculptures, it is often impossible to take more than a minute sample. Approximately 5 to 10 mg of marble were collected from each sculpture, typically from the back, underside, or bottom edge (if possible at the site of a previously existing chip or flaw) using a small chisel. Sculpture samples were analyzed using a VG PRISM mass spectrometer at the Peabody Museum, Harvard University, using a common bath autocabonate system and synthetic standards. Where duplicate runs were possible, the variation in $\delta^{13}C$ was 0.05‰ (Schrag 1997).

New geological samples (collected from quarries) were taken from fresh cuts at least six inches deep to avoid distortion from weathering. Each sample weighed approximately 1 kg. The geological samples were analyzed by Dr. Chris Hayward, geologist at the Natural History Museum in London (Hayward 1997).

4.3 Customizing the Carrara isotopic database.

Most Carrara data currently in use was obtained from a study of the Carrara quarries carried out in 1986 by Norman Herz and Nancy Dean (Herz and Dean 1986). Because the data were first collected for sourcing of ancient monuments and sculptures, the database has some gaps when used with later works. Isotopic data from the Torano quarries Polvaccio and Ravaccione, as well as the Miseglia quarry of Fantiscritti, should be included for best results. A map of the Carrara quarries sampled by Herz and Dean shows that these areas are not well represented (Fig. 8). Only one sample is identified as Polvaccio, for instance, which was a quarry of central importance in the period in question here. To redress this need, a trip to the Carrara quarries was made in 1997 (Fig. 9). There, additional samples were collected by Dr. Hayward and the author, focusing on the Torano valley quarries historically known to produce statuario. Figure 10 shows the Carrara map with the new sampling locations marked [2].

Twenty-three new samples from Polvaccio are plotted in Figure 11, along with the original Herz and Dean database of all fine-grained, calcitic white marbles. A detail of the Carrara fields is shown in Figure 12, with the new data points indicated as a darker color. Herz and Dean have already pointed out that two quarries, Seravezza and Mandria, can be isotopically distinguished from other Carrara quarries, and they are outlined (Herz and Dean 1986).
Figure 8. Map of Carrara quarries, reproduced from Herz and Dean 1986.

Figure 9. Collecting marble samples in Carrara, 1997.
Figure 10 Map of Carrara quarries, reproduced from Herz and Dean 1986, with new sampling locations added.
Figure 11. Graph: Isotopic analysis of fine-grained white marbles.

Figure 12. Graph: Isotopic analysis of Carrara quarries.
On examining Figure 12 it can be seen that, within the Carrara region, the Torano *statuario* quarries form a highly discrete group. Ninety percent of the data from Polvaccio clusters within 1‰ in oxygen isotope ratio, and 0.4 ‰ in carbon. The range is smaller than the previous "Carrara" field, which included architectural-grade marble, *calacata*, Betogli, and other geologically (but not art historically) significant quarries.

It is also apparent that data from the quarries producing lesser-quality stone such as Colonnata and Betogli are more dispersed. The most sought-after stone is located further up the Torano valley, and this is the source of the most tightly clustered discrete data. Crestola Basso, located on the extreme edge of the marble-producing region, taps a separate (and much smaller) marble layer in the earth and produces more random isotopic ratios. Because time and logistical constraints precluded collecting samples from the Miseglia valley, only two samples were available from the Fantiscritti quarry. Although it is accessed from the Miseglia valley, Fantiscritti exploits the same marble vein as the Torano quarries. It is located on the other side of the same mountain as the Polvaccio quarries, and today connects to the Torano valley by a tunnel. These data also plot at the center of the *statuario* data field. A relationship between the homogenous, unveined white marble that artists’ preferred visually, and an extremely narrow isotopic range is evident.

### 4.4 Isotope data for marble sculptures

It has become clear that from 1750 to the turn of the century, statuary marble shipped to France through the offices of the Crown was strictly limited in source as well as narrowly defined on an elemental level. Do the sculptures themselves corroborate this evidence? By comparing isotopic data from quarries with samples drawn from actual marble sculptures, patterns in sculpture production emerge.

Previous research in this area allows a larger picture of marble usage over time to emerge. During earlier research at the National Gallery of Art from 1994 to 1998, all the marbles in the collection were sampled and tested (Herz et al. 1995). Some of these data are reported here, sorted by date (Figs. 13 and 14). Figure 14 plots 19th-century sculptures and shows a broader spread of data points. It can be speculated that by this time, trade restrictions were loosened, international trade had expanded, and artists had more options for obtaining marble.

Figure 13, plotting French works dating from 1744-1790, shows a very tight grouping, clearly reflective of the historical and economic situation described above. The sculptures plot almost completely within the newly defined "Torano *statuario* group". Data for nine of the eleven works vary by only 0.6‰ in the oxygen isotope ratio, and less than 0.3‰ in the carbon.
The data for the National Gallery of Art collection show that only a tiny percentage of non-
ancient, western European works were produced from Greek or Turkish marbles, with the vast
majority identified as being from Carrara. For the period in question, samples plot well within
the isotopic field assigned to the Carrara region. The question of whether Seravezza marble was
used is also resolved. While the proximity of the two regions may have caused the quarries to be
referred to interchangeably, analytical evidence indicates that Seravezza was not used. Of all the
18\textsuperscript{th}-century French works sampled, only one data point might fall within the Seravezza quarry.
field. Until further evidence arises, it seems reasonable to conclude that Seravezza was not a common source for French sculptors. Mandria can be distinguished isotopically. Active use of Mandria quarry during the period with which we are concerned is not documented, and no National Gallery of Art sculptures analyzed matched Mandria, so there is no positive evidence that the French used these quarries.

5. Houdon

Can a single artist’s work be usefully assessed in the context of these new data? The National Gallery’s six sculptures by Jean-Antoine Houdon provided a starting point for addressing this question. An additional 25 works from nine other institutions, some well documented and others less so, were sampled and analyzed. Figures 15 shows the resulting data, plotted against the newly defined Torano statuario field.

![Figure 15. Graph: Isotopic analysis of Houdon sculptures.](image)

Houdon's sculptures can now be evaluated within the context of this newly defined group. Figure 16 shows the same data in closer detail. Numbered points refer to the itemized data table shown in Figure 17. The curatorial attributions of the different sculptures are not all equally firm, and the items sampled include some considered to be “after Houdon” as well as well-dated works and some unknowns. Comparing this curatorial information to the points plotted on Figure 16 reveals some encouraging correlations.
Of the five works thought to be “after Houdon” or only “possibly” Houdon, three plot outside the Torano *statuario* field. *Madame Clothilde* from Waddesdon Manor, which according to the curatorial documentation “may or may not be by Houdon” (Seeley 1997), is of Pentelic marble. As no other Pentelic marbles have been identified in Houdon’s oeuvre, the data reinforce the doubt expressed by the curator. The White House’s *George Washington*, considered “after Houdon”, also plots outside the Torano *statuario* field as does the similarly attributed *Benjamin Franklin*.

Of the seven works believed to be by Houdon, but dating after 1800, four lie outside the “Torano *statuario*” field. While such a small selection is hardly representative, it does suggest that the more varied marble use after the Revolution, seen on a larger scale in Figure 14, is consistent with this artist’s production.

Dating sculptures by identifying the stone from which it was carved involves inherent uncertainty. Because the marble blocks might be saved for years before being carved, a Torano *statuario* block could be used decades or centuries after it was quarried. Thus the isotope data for post-1800 works is less useful for interpretation purposes, even if a larger body of sampled sculpture were available. During the early nineteenth century, government commissions still used Torano *statuario*, since the Ravaccione quarry was exploited during the Napoleonic era. Of the four later works that fall inside the “Torano *statuario*” field, two, *Napoleon* and *Josephine*, are imperial commissions.
### Data Table: Sculptures attributed to Houdon

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<th>Title</th>
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<tr>
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<td>-1.7</td>
<td>2.0</td>
<td>1808</td>
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<tr>
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<td>1.7</td>
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<td>2.1</td>
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<td>-1.81</td>
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<td>1779</td>
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<td>2.4</td>
<td>not Houdon?</td>
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<td>George Washington</td>
<td>-3.32</td>
<td>2.4</td>
<td>after Houdon?</td>
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<td>Kimbell Art Museum, Fort Worth, TX</td>
<td>Benjamin Franklin</td>
<td>-1.43</td>
<td>2.37</td>
<td>after Caffieri or Houdon?</td>
</tr>
</tbody>
</table>

Bold-face type indicates well-documented works. Question marks following the date indicate doubtful authenticity. Curatorial information was provided from the curatorial files of participating museums, with additional information from Anne Poulet, of Anne Poulet Art Resources.

Figure 17. Data table: sculptures attributed to Houdon.
While the possibility of using old blocks of marble also holds true in the case of pre-
Revolutionary France, the historical evidence discussed previously suggest that rarity and high
demand allowed little sculptural marble to sit unused for long. The larger body of data also
makes interpretation slightly less speculative.

Of the 19 works thought to be by Houdon, and with a presumed 18th-century date, only three
sculptures plot outside the Torano *statuario* field. The National Gallery of Art’s *Alexander
Brongniart, 1777*, whose provenance is uncertain, is one outlier. This marble could be from
Seravezza, rather than Carrara. Two others, the National Gallery of Art's *Louise Brongniart,
1777*, and the Huntington Gallery’s *Sabine, 1791*, plot very close to the Torano *statuario* field,
but are also outside.

The very tightly clustered group, comprising three portraits of Voltaire from the National Gallery
of Art, the Victoria and Albert, and Versailles, forms another pattern worth noting. The very
large number of portraits of the famous scholar (estimated by Arnason at over 100) implies that
there might be less of the hand of the artist in these works. The overlapping data points could
suggest that the group was produced from the sections of the same marble block. This is also true
of *Napoleon* and *Josephine*, clearly carved as a pair.

6. Conclusions

By using historical material to focus the scientific analysis, then using scientific results to
confirm art historical observations, interesting and potentially useful comparisons may emerge.
This is especially so in a period such as 18th-century France, where political and historical
circumstances confine the data fields to very narrow ranges. Exploring these changes in the
French use of statuary marble, then developing an improved and expanded data base of both
Carrara quarry marble and marble sculptures in museum collections focusing on that use,
produces a deeper understanding of a specific period and its artists. Evaluated by this method,
Houdon’s sculptures show interesting groupings and anomalies that could be pursued, and may
relate to authenticity and date.

Dating sculptures by sourcing marble will always have inherent limitations. Although historical
research may be able to confirm still further the precise quarries exploited at any one time in the
historical era, the possibility always remains for idiosyncratic marble usage: blocks saved or
reused from different eras, etc. The isotopic data thus must always show likelihood rather than
limits. It can only highlight trends and groupings that merit further historical and stylistic
evaluation.

Likewise, the database of marble sculptures is still too small for statistical analysis. As more
museums analyze their collections, and as fingerprinting techniques continue to improve, the
information will become a highly useful authentication tool. Even with this small body of works,
the results are promising enough to suggest the method should be pursued.
Endnotes

1. The database for stable isotope analysis of white marbles, made available by Dr. Norman Herz of the University of Georgia, contains data from numerous sources, both published and unpublished, including: Craig and Craig 1976; Herz and Dean 1986; Moens et al., 1988; and Jongste et al. 1995.

2. Hayward and Holbrow research was supported by the Samuel H. Kress Foundation and by the Andrew W. Mellon Foundation, 1997.

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FROM FAKE TO FABULOUS: REDEEMING FAKES AT THE WALTERS ART MUSEUM

Terry Drayman-Weisser

Abstract

Many objects in American museums have no documented provenance or have incomplete, discontinuous or unverifiable histories. In the past, museums depended on experienced curators and art historians to evaluate the authenticity of such objects. Today, many museums have added the conservator and conservation scientist to their professional teams. Often this has led to the re-evaluation of earlier conclusions regarding the authenticity of objects and to the “redemption” of some objects previously declared spurious. This paper presents several case studies of objects in the Walters Art Museum whose authenticity had been questioned, including a Renaissance terracotta sculpture, a Gothic ivory, a medieval Limoges enameled plaque, and two Renaissance enameled pendant jewels. Conclusions and the methods used to re-evaluate the objects are discussed.

Introduction

As most art historians and conservators know, when the authenticity of an object has been questioned, the object can lose its place in history and its status in a collection. There are consequences which can range from labeling the object dubious, to taking the object off view, to the most extreme action of deaccessioning the object. In addition, questioned objects sometimes are handled or stored using a lower standard of care.

There can be many reasons for questioning the authenticity of an object. Most commonly there are issues of style or iconography, or inconsistencies in materials or methods of manufacture. There are many ways, from simple to complex, of evaluating authenticity and arriving at conclusions with confidence, although absolute certainty may be an impossible goal. For this reason, labeling an object a forgery or fake should not be taken lightly. Once questioned, it is extremely difficult to bring respectability back to a piece, since there will always be those who will continue to doubt later evidence supporting authenticity. On the other hand, efforts made to evaluate an object can be of great benefit, since in the end, both the object and its original context are better understood.

The following are some examples of objects questioned and redeemed at the Walters. Each object has its own story to tell.

Joseph

In 1987 the Walters put on an exhibition called “Artful Deception: The Craft of the Forger.” One of the objects the curator selected for the show was a painted terracotta figure of Joseph, a
seated, two-thirds life size sculpture that seventeen years earlier had been declared a fake (Fig. 1). This piece has an interesting history. It was originally thought to be by the late 15th century Tuscan sculptor Matteo Civitale, but it was condemned as an early 20th century fake by a noted curator from the National Gallery of Art in Washington, D.C. (Lewis 1970). The basis for the condemnation was that the Walters’ Joseph had appeared in a photograph published in 1914 in *Art in America* while in the home of collector, Thomas Fortune Ryan. In the photograph, Joseph formed part of a nativity group along with two other terracotta sculptures, a kneeling Madonna and a Christ Child, propped on a cloth pillow (Fig. 2). At some time after the 1914 photograph, the Madonna and Child were united on contiguous bases and the cloth pillow under the Child was replaced by one of terracotta. It was in this new configuration in 1943 that the sculptural group titled, *Madonna Adoring the Child*, entered the National Gallery’s collection. The Walters acquired Joseph in 1949. In 1970 the National Gallery’s curator determined that both the Madonna and Child were fakes (Spicer 1990).

Figure 1 (left). *Joseph* (WAM 27.531). This Renaissance terracotta was declared a fake in 1970.

Figure 2 (right). Photograph of Walters’ *Joseph* as part of a nativity group while in the home of Thomas Fortune Ryan. Published in *Art in America*, 1914. Madonna and Child figures later purchased by the National Gallery of Art, Washington, D.C.

The National Gallery had arranged for thermoluminescence (TL) dating to be carried out on their sculptures from this group. The results gave a last firing date around 1900. (Lewis 1970; Spicer
Although the Walters’ Joseph had not been tested, the fact that it had been documented in 1914 in the company of the now condemned pieces was enough to condemn it as well. Joseph was taken off view and relegated to storage, where it remained until it was selected for inclusion in the “Artful Deception” exhibition.

It was Joseph’s new prominence, although in the negative context of an exhibition on fakes, that stimulated renewed interest in him. Since Joseph had not been tested, there was a possibility, even though thought to be remote, that Joseph could be the one genuine piece in the nativity group. Rather than officially labeling the terracotta figure a fake, the author approached the curator of the exhibition about carrying out TL dating. The curator was concerned that the results would not be available until after the exhibition opened, but in the end he was persuaded that there would be public interest in the results during the exhibition and that information on the testing method could be incorporated into the text panel. Visitors would be encouraged to return to discover the results. Two samples for TL dating were taken from Joseph, one from the top half and one from the bottom, and sent to the Research Laboratory for Archaeology and the History of Art at Oxford for testing.

Joseph was installed in the exhibition along with a copy of the 1914 photograph showing Joseph with the National Gallery’s Madonna and Child sculptures. The wall label heading was “Guilt by Association” and the text stated why Joseph was almost certainly a twentieth century fake. The results came back in the middle of the exhibition period. The TL testing yielded a firing date range of 1407 to 1607, placing Joseph’s manufacture date firmly in the Renaissance. The curator draped a banner across the wall label proclaiming the verdict: “Not Guilty!” Today Joseph commands a prominent place in our newly reinstalled Palazzo galleries.

But that is not the end of the story. As reported by Michael Belman, then a Mellon Fellow in objects conservation at the National Gallery, Madonna Adoring the Child was requested for loan in 2004 and the Gallery’s curators requested that the TL dating be repeated. One of the original TL samples taken in 1970 was from the base of the Madonna. The other was from the pillow beneath the Child, apparently taken as a reference, since it was known that the pillow was a modern addition. More recently, upon further examination, it was determined that the base of the Madonna, obscured in the 1914 photograph, was also possibly a recent addition. New samples were taken from the Madonna, avoiding the base, and also from the Child. The TL results show that the Madonna is indeed twentieth century, while the results for the Child place it in the seventeenth century (Belman 2005; Belman 2007). So it seems that Joseph is Renaissance, the Child may be somewhat later, but the Madonna was made shortly before it was sent to the collector Thomas Fortune Ryan, likely to create a more enticing and complete nativity group for sale.

**Vierge Ouvrante**

The Walters’ ivory Vierge Ouvrante (or opening Virgin) is 43.5 centimeters tall and has wings that open in the middle to reveal interior carvings of scenes of the life of Christ (Figs 3 and 4). This impressive object was photographed by A. Aubrey Bodine and published on January 25, 1931 in the Baltimore Sun, where it was referred to as a fourteenth century treasure in Henry
Walters’ collection. In 1995, it was requested for loan for an exhibition of Gothic ivories to be held at the Detroit Institute of Arts that would subsequently come to the Walters. Consequently, the object was examined by Donna Strahan, at that time an objects conservator in the Walters conservation laboratory, to determine whether it could travel safely. Due to insecurities around the hinges and extreme cracking, the object was not recommended for loan.

Figure 3 (left). *Vierge Ouvrante* (WAM 71.152). The ivory sculpture in its closed position.

Figure 4 (right). *Vierge Ouvrante* (WAM 71.152). The ivory sculpture in its open position.

To the surprise of the Walters, the organizers of the exhibition challenged the decision by saying that our concerns were mitigated by the fact that the object was a fake. In fact, the intention was to exhibit it in a room of questioned pieces, and it would be labeled “dubious” in the exhibition catalogue. This view was supported by a previous director of the Walters, Richard Randall, an expert on Gothic ivory, who was so convinced of the object’s spurious status that he left it out of
his 1985 comprehensive catalogue of the Walters’ ivory collection. The reasons for questioning
the authenticity of the object were inconsistencies in iconography and style, and the fact that
there were only a few other pieces known of this size, type, and style made in ivory, all known to
be fakes made in the early 19th century in Europe (Randall 1995).

After discussions with Richard Randall concerning his doubts about the authenticity of the
_Vierge Ouvrante_, the author agreed to carry out a technical study. Since ivory contains the
organic component collagen, the possibility of Carbon14 (C14) dating was investigated.
Permission was granted to sample the object for testing. It must be emphasized that taking a
sample for any type of analysis can be damaging to an object; but taking a large enough sample
for C14 dating is especially intrusive. The decision to proceed with sampling was based both on
the knowledge that without testing, the object would be labeled a fake and relegated to storage or
possibly be deaccessioned, and that the object was large enough to accommodate sampling from
a hidden area.

It was found that the amount of sample required for C14 dating varied according to which
laboratory was doing the testing. Dan Kurtz, an intern in the objects conservation department at
that time, was assigned to survey C14 laboratories to ask about sample size, sampling
techniques, turn-around time, and cost. Based on the information and feedback he received, we
chose the Oxford Research lab for Archaeology and the History of Art. Dan removed a 500 mg
sample from the bottom of the central section of the ivory figure (Figs. 5 and 6). When the
results came back, everyone was stunned. The ivory could be dated to between 1020 and 1220
with a 95.4 percent degree of confidence. This was exactly the right time frame for this object.

Figure 5 (left). Bottom of middle section of _Vierge Ouvrante_ before sampling for C14 testing.

Figure 6 (right). Bottom of middle section of _Vierge Ouvrante_ after sampling for C14 testing.

Of course, this is the date the elephant died and does not prove that the ivory was carved at that
time. So, alternative scenarios at least had to be considered. Could the _Vierge Ouvrante_ have
been carved from an earlier damaged object? Considering the large size of the object and the way the shape of the object follows the form of the outer part of the tusk, it does not appear to be recarved from an earlier damaged object. Could a forger have carved the *Vierge Ouvrante* from a previously uncarved old tusk? The interior surfaces of the statuette are patinated with age to the same degree as the exterior surfaces. If an older tusk had been recently carved, the interior would show less aging than the exterior. The only parts that show evidence of artificial aging are some ivory repairs done before the object entered the Walters collection in 1903. These repairs have incised, tinted artificial cracks on their surfaces. Another strong argument against a recently carved older tusk is that it would be highly unlikely that a forger would have come across a 600 year old specimen of such a large size. And, if for the sake of argument, he did, how would he have known to carve it in the style of the exact date of the tusk? Certainly no one at that time ever dreamt that in the future dating of ivory would be possible. It seems too fantastic that a forger should have unerringly chosen to copy the correct style for the date of the ivory.

Based on the C14 date, scholars began to re-evaluate the *Vierge Ouvrante*. An article was written by art historian, Kelly Holbert, supporting its new C14 date, tracing the object’s unusual and circuitous history and describing how its parts had been separated and later reunited. It is even possible that the 19th c. fake *Vierge Ouvrante* figures currently in European collections were inspired by the Walters’ *Vierge Ouvrante*, since the fakes may have appeared on the market around the same time the Walters object was sent to Paris for restoration (Holbert 1997/98).

Since the results of the C14 dating have been known, the Walters’ *Vierge Ouvrante* has taken on even greater prominence and is now a highlight in the Gothic art galleries. Its uniqueness, that once condemned it, now is the very attribute that makes it again one of the great treasures of the Walters.

**A Medieval Limoges Enamel Plaque**

In 2005 a striking Limoges enameled plaque with an appliqué of a female figure caught the attention of the Walters’ current director (Fig. 7). The plaque, catalogued as 12th to 13th century, is in the shape of a terminus of the proper right arm of a cross and is made of gilded copper decorated with incised lines and blue opaque enamel in the champlevé technique. Holes at the borders of the plaque indicate where nails were used to secure it to a wooden cross. The appliqué figure also is made of gilded copper and has incised lines and glass inset eyes and collar decorations. The director, a medieval specialist, had begun to question the object’s authenticity for several reasons. At 26.4 centimeters in height, the object is substantially larger than other known similar pieces. In addition, he had questions about the iconography relating to the applied female figure. And, finally, the object’s condition is unusually good for its supposed age (Vikan 2005). The director brought the object to the conservation laboratory for examination and asked the author to see if there was any evidence to condemn or support the object’s authenticity.

The first task was to determine how an object of this type would have been made, and what the compositions of the materials would have been. Fortunately, a very detailed technical study of medieval Limoges champlevé enamels had been carried out by Isabelle Biron, Pete Dandridge, and Mark T. Wypyski. The study was published by the Metropolitan Museum in a catalogue in
1996 at the time of a major exhibition of this material. The technology and material compositions published in this catalogue served as a reference during the examination of our object as described in the following section of this paper (Biron et al. 1996).

Copper plates for plaques from this period were not cast directly. They were made by hammering from a previously cast ingot. Indentations, folds and delaminations in the metal, visible on the reverse of the Walters piece, indicate that the copper surface expanded and deformed due to repeated hammering to thin it into a sheet (Figs. 8 and 9). An X-radiograph confirmed that the object was formed by hammering as it revealed that the metal is uneven in thickness with some thinner areas taking a rounded shape from hammer blows.

Figure 7. Medieval Limoges enamel plaque with appliqué (WAM 44.22).
Figure 8. Uneven surface, folds and delaminations on the reverse of the Walters medieval Limoges enamel plaque as evidence of forming by hammering.

Figure 9. Uneven surface, folds and delaminations on the reverse of the halo attached to the appliquéd on the Walters medieval Limoges enamel plaque as evidence of forming by hammering.
In the champlevé enameling technique, cells for the enamel are recessed below the metal surface either by casting them in or gouging them out. The cells are then filled with enamel to a level even with the original metal surface. The method of preparation of the cells for the enamel on the Walters plaque is consistent with that described in the Metropolitan catalogue. On works of this period each cell was cut away around the edges first to create a trough. Then the center of each cell was scraped away with a sharp tool such as a scorper or graver, but to a shallower depth than the trough at the perimeter of the cell. The cells were filled with colored glass frit and fired to melt the glass. The resulting enamel was polished smooth and level with the original metal surface. A damaged corner of the Walters object where enamel is missing reveals the scorper marks from scraping away the center of the cell and a deeper trough around the perimeter of the cell (Fig. 10). The X-radiograph was examined to determine whether the preparation of the cells overall was consistent with this technique. Darker lines surrounding each cell were visible in the X-radiograph, confirming that the metal at the perimeter of each cell is thinner than at the centers of the cells (Fig. 11).

Figure 10. An area where the enamel on the Walters medieval Limoges plaque is missing, revealing a deep trough at the perimeter of the cell and scorper marks from removing metal from the center of the cell.

Figure 11. Detail from an X-radiograph of the Walters medieval Limoges plaque revealing dark lines at the perimeters of the cells confirming that the metal is thinner in those areas.
It has not been determined definitively whether incised surface details were created before or after the enamel was fired in the medieval period. What is known is that the lines were created with a graver. The surface details on the Walters plaque appear to have been created with such a tool. According to the Metropolitan catalogue, after engraving, burrs and high spots were removed from flat areas and from appliqués by pulling a curved-edge or straight-edge tool with rounded corners across the surface. Such tools created a rippled effect, especially visible on the broad surfaces of appliqués. By using raking light on the Walters object, it was possible to see the undulating, rippled appearance and parallel markings left by such a technique (Fig. 12).

During this period, separate parts such as plaques and appliqués were joined mechanically with copper rivets. The rivet heads either were incorporated into the surface decoration or made to stand proud of the surface. On the Walters piece, the female figure appliqué was joined to the plaque with two rivets, although only one original survives. The halo on the figure was also separately made and attached with a rivet. Decorative materials such as glass cabochons and semi-precious stones were sometimes added to medieval objects of this time period. These additions were often held in place by creating a punched socket, applying the decoration, then burnishing the socket edges around the decoration to secure it. The attachment of glass cabochon eyes and collar decorations on the Walters object is consistent with this technique (Fig. 13).
Figure 13. Glass cabochon eyes and collar decorations are set into punched sockets with burnished bezels on the appliqué on the Walters medieval Limoges plaque.

According to the Metropolitan catalogue, after finishing and smoothing, exposed metal surfaces of enameled plaques and appliqués were brushed with an amalgam of gold and mercury. They were heated to drive off the mercury, and the gold was then burnished to a smooth, reflective surface. Gold in the incised lines could not be burnished and remained mat. Since the gold did not adhere well to the enamel, it could be brushed off easily from these surfaces. Finally, stippling with a pointed punch was done over the gilding on the undecorated surfaces of the plaques. Indications of these techniques are present on the Walters object (Fig. 14).

Figure 14. Detail of gilded and stippled area on the Walters medieval Limoges plaque.
It was concluded that the Limoges enamel plaque and appliqué in the Walters is consistent with medieval methods of manufacture when compared to the technical observations in the Metropolitan catalogue. But another issue had to be addressed: were our plaque and appliqué originally made to go together or were they put together at a later date from parts of two different objects? Medieval practices again would help answer this question. The layout for a medieval plaque was planned in advance. If an area was to be covered by an appliqué, that area was not enamelled or decorated, likely due to the unnecessary expense and labor involved in decorating an area that would not be visible in the end. Also, since gilding was carried out after the appliqué was attached, the area beneath the appliqué should be bare copper, and the area left in reserve should mimic the shape of the appliqué. Fortunately, one of the rivets on our piece had been replaced with a screw held in place on the reverse with a nut. We removed the screw and this allowed us to carefully rotate the appliqué figure to view the surface of the plaque beneath. We discovered that the surface had been left in reserve in the exact shape of the appliqué. We concluded from this that the two parts were made to go together (Fig. 15).

Figure 15. The area of the Walters plaque left in reserve beneath the appliqué is visible after rotating the appliqué on one of its rivets. The reserve area mimics the shape of the appliqué, confirming that the two parts were made to go together.

The technical examination indicated that our piece was likely of medieval manufacture. However, we could not confirm its date through visual examination alone. We know that the compositions of enamels have changed over time, and that the level of impurities in copper metal decreased with improvements in refining techniques after the industrial revolution. Therefore we felt that analysis of the copper plate and the enamel might confirm whether our object was truly medieval and might even help pinpoint a timeframe within the medieval period.
Mark Wypyski, research scientist in the Department of Scientific Research at the Metropolitan Museum, agreed to analyze samples from the Walters’ object and to compare the results to known compositions from the medieval period through the 19th century. Samples of blue enamel were taken from fragments that previously had broken away but were lodged in crevices on the surface. Samples were also taken from two inconspicuous spots of raised copper on the reverse. The samples were quantitatively analyzed using a combination of energy dispersive and wavelength dispersive spectrometry in the scanning electron microscope.

Wypyski reported that the analysis of the scrapings from the metal substrate was consistent with medieval copper (Wypyski 2005). The blue enamel was found to be a soda-lime-silica glass with low magnesium and potassium. The sodium source was natron and the opacifier was calcium antimonite. These results showed that it was a Roman glass composition produced through the end of the 4th c. AD. According to Wypyski, technical studies of medieval Limoges enamels indicate that glass tesserae from Roman period mosaics were re-used in the medieval period up until the early 13th century. In the 13th and 14th centuries a locally made soda-lime glass that was higher in magnesium and potassium using plant ash as the sodium source and tin oxide as the opacifier was more typical. 19th and 20th century forgeries of medieval enamels generally are lead alkali glasses that are high in potassium, but with no magnesium, and are opacified with lead arsenate. Therefore, we were able to conclude that the enamel is no later than the early 13th century.

While perusing the curatorial file relating to this plaque, the author came across a photograph of another plaque with appliqués in the Victoria and Albert Museum collection. A likely association already had been proposed between the Walters’ plaque and theirs due to the presence on both of pseudo-Kufic inscriptions and the similarities in the background color and decoration. Both plaques are large for their type and would have been attached originally to a wooden cross, ours at the end of the proper right arm and the V & A’s at the foot of the cross.

If indeed the two plaques came from the same large cross, which seems very likely, Dr. Audrey Scanlon-Teller, Kress Post-doctoral Fellow at the Walters, has identified the patronage under which these enameled objects were made. Based on an inscription along the bottom edge of the V & A’s plaque, Scanlon-Teller has been able to associate the plaque with Saint Stephen of Muret, the founder of the Abbey and Order of Grandmont, and with other similar objects made for the high altar of the Abbey church there in the 1200 style (Scanlon-Teller 2007).

So, although the Walters medieval Limoges enamel was once questioned, it is now back on display labeled without reservation. By combining the technical observations with the results of the analysis of the metal and the enamel, as well as research on an inscription, we have been able to show not only that the Walters’ object is medieval, but also that it was produced in the 12th or early 13th century likely in association with the Abbey of Grandmont.
Renaissance Jewels

Discoveries related to the authenticity of Renaissance jewelry have brought new scrutiny to many collections, including that at the Walters. Of particular concern was the re-discovery in 1978 of over 1000 drawings at the Victoria and Albert Museum attributed to the 19th c. German goldsmith Reinhold Vasters (Truman 1979). The drawings were thought to be Vasters’ renderings of magnificent Renaissance objects, including many pieces of jewelry; however, notations on the drawings specified what colors to use when enameling the objects.

These drawings, it was suddenly realized, were in fact production drawings for objects in the Renaissance style. This in itself would not have raised great alarm, except that a number of the drawings corresponded to supposedly Renaissance objects in a number of well-known collections (Hackenbroch 1986). At this point every object for which there was a corresponding Vasters drawing was suspect. Even Renaissance objects for which there were no drawings were being carefully scrutinized, since the drawings at the V & A might not represent the entirety of Vasters’ work. There also was the realization that there were likely other goldsmiths producing Renaissance-style works in the 19th and early 20th centuries. In fact, to further complicate matters, it was revealed in 1993 that Alfred André, the highly regarded 19th c. Parisian restorer, also had been making Renaissance-style objects, including jewelry (Distelberger 1993). Distelberger reported that André’s family still retains many of the models and casts he had created, some related to purportedly Renaissance objects in collections around the world.

It was in this climate that Hugh Tait, a scholar from the British Museum was invited to review the Walters’ extensive Renaissance jewelry collection. He questioned a number of the pieces and stated they were in fact works of the 19th century. The suspicions he raised were to impact a project being planned for the reinstallation of the Walters Palazzo building. The curator of Renaissance and Baroque art, Dr. Joaneath Spicer, decided that no questionable objects were to be installed. This compelled us to do a focused study on the Renaissance jewelry. The study, generously funded by the Richard C. von Hess Foundation, involved a technical examination of materials and techniques and an analysis of the enamels to see if they were consistent with the Renaissance. Mark Wypyski, research scientist at the Metropolitan Museum of Art, agreed to do quantitative analysis using a combination of energy dispersive and wavelength dispersive spectrometry in the scanning electron microscope.

Two of the objects from that study are presented here. One is a hat badge depicting Adam and Eve in the Garden (Fig. 16). Tait had stated that although this piece was not included in any 19th c. drawings or models that had come to light, it was clearly 19th century. For the Walters’ study, the hat badge first was reviewed from the point of view of its method of manufacture. It is made of gold, partially enameled, with attached diamonds and rubies. The central medallion is made from two layers of sheet gold that together form the image seen from the front. The upper layer is decorated with a scene of Adam and Eve created either by using the repoussé technique from the reverse or by working the gold sheet over a relief model from the front, followed by chasing. The negative spaces around the image elements in the upper layer were cut away to reveal the lower layer of gold. Finally, the lower layer of gold visible from the front was worked using a punch to create a matte texture around the figures. The medallion is encircled by a decorative, partially enameled gold frame.
Figure 16. Renaissance hat badge (WAM 44.266) thought to be a 19th c. fake.

Figure 17. Reverse side of Renaissance hat badge showing construction details.

From the reverse one can see the punched areas that correspond to the negative spaces of the medallion’s top layer (Fig. 17). This demonstrates that the punch work was done after the two layers were joined. The two layers of gold are joined with strips of gold from the back of the upper layer inserted through slits in the lower layer. The ends of the strips are splayed out like butterfly wings on the reverse of the lower layer. The final steps were enameling, and attaching the gems. This system of construction is typical of Netherlandish Renaissance goldsmiths work (Hackenbroch 1979).
The results of the analysis of all colors of enamel on the medallion were consistent with Renaissance date, as opposed to the results of analysis for the frame, where all the enamels were consistent with 19th century compositions. Especially significant was the analysis of the green enamel on the frame. The colorant was identified as chromium, which was not used until the 19th century. Copper and iron oxides were identified as the colorants in the green enamel on the medallion, which is consistent with Renaissance period enamel (Drayman-Weisser and Wypyski 2007).

Based on the method of manufacture and the analysis of the enamels on the medallion, and the analysis and lack of any evidence of re-enameling on the frame, it was concluded that the medallion is indeed Renaissance, but in the 19th century the frame was added or replaced. Calling the object a fake would be like saying that a 16th century painting is no longer 16th century if it is in a 19th century frame. The object is now accepted as a 16th c. object and it has now been put on display in our newly installed Palazzo.

The second object from the Walters’ jewelry study to be discussed here is the Personification of Fortitude pendant, made of gold that is partially enameled and set with pearls and a large diamond (Fig. 18). This object was immediately labeled a fake when a Vasters drawing of it came to light (Fig. 19). There are some differences between the actual jewel and the image in the

![Personification of Fortitude pendant](image1)
![Reinhold Vasters, drawing for Fortitude pendant](image2)

Figure 18 (left). Renaissance Personification of Fortitude pendant (WAM 44.622) thought to be a 19\(^{th}\) c. fake.

Figure 19 (right). Reinhold Vasters, drawing for Fortitude pendant, Victoria and Albert Museum. E.2801-1919. © V&A Images Victoria and Albert Museum, London
drawing, e.g. the chain and decorative element at the top, the shape of the pearl at the bottom, and the angle of the stag on which Fortitude rides all differ, but there is little doubt it is the same object. Again, the approach was to study the method of manufacture and to analyze the enamel to determine whether it was consistent with 16th century composition. The first surprise came when the reverse side of the pendant was examined (Fig. 20). It was clear that the pendant had been damaged, repaired, and some new parts possibly had been added at a later time (Fig. 21).

Figure 20. Reverse side of Personification of Fortitude pendant.

Figure 21. Detail of reverse side of Personification of Fortitude pendant showing damage, repairs and additions.
The colorant in red enamel used during the Renaissance was copper. In the late 18th century there was a change to antimony oxide. Thus analysis of red enamel can help distinguish Renaissance from later works. In addition to analysis, one visual clue we began to look for as a sign that an object was Renaissance was fairly reliable, but subtle. If there was copper-based red enamel on an object, a white halo could be seen under magnification where the red enamel touched the gold (Fig. 22). If antimony was the colorant, there was no halo (Drayman-Weisser and Wypyski 2007). It is possible that the halo is caused by the copper diffusing into the gold wherever it is in contact during firing, leaving behind a copper depleted fringe in the enamel.

Figure 22 (left). Red enamel with white halo at the edges indicating that the enamel is copper-based and consistent with the Renaissance (WAM 44.464).

Figure 23 (right). Detail of red enamel with white halo on Fortitude’s garment indicating copper-based enamel consistent with the Renaissance.

When examining the Fortitude pendant, a white halo at the edges of red enamel was found in many places, including at the edges of Fortitude’s red garment (see Fig. 23). Therefore, we began to suspect that at least parts of the object were made in the Renaissance. However, one must be cautious since it is possible that some enamellers continued to use older glass recipes into more recent times. In some areas the red enamel did not exhibit a white halo, e.g. on the chain, the floral embellishments associated with the chain attachment points, and four small projections behind the bezel-set diamond. The analysis of the rest of the enamels confirmed that only the enamels in the areas with no halos have compositions consistent with the 19th century. Samples from all other areas were consistent with 16th century enamel.

Based on the repairs evident on the reverse and the differences in the enamel compositions in different parts, it seems likely that the object was manufactured during the Renaissance, but was damaged, repaired and embellished in the 19th century. The changed angle of the stag appears to have occurred when the pendant was damaged, as what appears to be a metal fatigue crack in the gold can be seen in one of the stag’s legs near its hoof.
These findings may shed new light on the nature of Vasters’ drawings. Many scholars had assumed that the drawing of the Personification of Fortitude pendant was a design for production. But this study shows that it represented an embellished Renaissance pendant. It is not certain whether the jewel was repaired before or after the drawing was made. For some the question still remains: Is this a Renaissance object? a fake? a repaired jewel? For the Walters the issue was clarified, and the pendant can now be displayed with a label that clearly distinguishes those parts that are Renaissance from its 19th century embellishments.

Conclusion

All of the objects presented here had been considered dubious or outright fakes at one time. In each case this led to intensive study and analysis by conservators and conservation scientists. Although it may not always happen this way, each of the objects studied here has been redeemed. Because they now have been so thoroughly studied, these objects have become the examples against which others can be compared, and they are more highly valued than before they were questioned. For those who have been involved in these studies, these objects have been transformed from fake to fabulous.

Acknowledgments

I would like to thank Dr. Gary Vikan, Director of the Walters Art Museum, for his support during these studies. It is invigorating to work in an environment where studies such as those presented here are encouraged, no matter where they may lead. Dr. Joaneath Spicer, Curator of Renaissance and Baroque Art, deserves special thanks for her consistent enthusiasm and support during the study of the Renaissance jewelry. I also would like to thank Mark Wypyski for sharing his extensive knowledge of enamel composition and working so closely with me on the medieval enamel Limoges plaque and on the Renaissance jewels. Those projects could not have been successful without his generous input. I would like to thank Jennifer Giaccai for her invaluable assistance in interpreting data for the medieval Limoges plaque. And last, but certainly not least, I must acknowledge Michael Belman for so willingly sharing information on the National Gallery’s Renaissance terracottas and for always responding so quickly to my last-minute questions.

References


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ALTERED STATES: HENRI MATISSE’S SCULPTURE AURORA

Ann Boulton

Abstract

As part of a larger technical study of the sculpture of Henri Matisse, in preparation for the exhibition Matisse Painter as Sculptor (jointly organized by the Dallas Museum of Art, The Nasher Sculpture Center and The Baltimore Museum of Art), six versions of the Reclining Nude I (Aurora) were examined. Comparisons were made through measurements, base tracing, photographs and 3-D computer models from laser scans of all six casts. This paper will discuss variations amongst different casting techniques, different media and between early and late casts. Two bronzes deemed unauthorized casts by the authors of the catalog raisonné will be included in the discussion. Matisse’s overall bronze production in France in the years 1906-1954 will be considered as background information.

Introduction

This paper is taken from a larger technical study of the bronze sculpture of Henri Matisse. The study, which included examinations of more than 120 bronze casts was initiated in preparation for the exhibition, Matisse Painter as Sculptor, jointly organized by the Dallas Museum of Art, The Nasher Sculpture Center and The Baltimore Museum of Art (BMA).

Much of the technical study was supported by a Samuel H. Kress Paired Fellowship at the Center for Advanced Study in the Visual Arts at the National Gallery of Art in Washington, D.C. Oliver Shell, Associate Curator of European Painting and Sculpture at The Baltimore Museum of Art was a partner in the study that is published in the exhibition catalog (Boulton 2007).

This paper will focus on one sculpture, Reclining Nude I (Aurora), first modeled in clay by the artist in 1907. Six casts of that sculpture will be discussed here that show some curious variations; four of the six are of questionable authenticity.

Background

Henri Matisse (1869-1954) modeled his first sculpture, a jaguar (Fig. 1), in 1899 at age 30 and cast his first bronze in 1906. He continued making sculpture until nearly the end of his life-his last work, Katia, modeled in 1950-51 at age 81(Fig.2). Unlike Degas, another painter who made sculpture, Matisse exhibited and sold his sculpture early and often.
Figure 1. Photograph of Matisse with plaster model of *Jaguar Devouring a Hare*, copy after Barye 1899-1901. Photograph by Alvin Langdon Coburn, George Eastman House, Rochester, N.Y. Gift of the photographer.

Figure 2. Photograph of Matisse working on Standing Nude (Katia), Dmitri Kessel for *Life Magazine*. © Getty Images.
More than 80 different sculptures are known today, almost all of which were cast as limited editions in bronze during his lifetime. After his death in 1954, his family continued to produce bronzes until all editions were complete, the most common number in each edition being 10. All in all an estimated 744 bronzes have been produced (Duthuit 1997).

Prior to 1925 all Matisse’s bronzes were sand cast at one of two foundries, Bingen and Costenoble (later Costenoble) that unfailingly applied a foundry mark (Fig. 3); and Florentin Godard. All Godard casts examined lacked foundry marks. The foundry identification comes from records at the Matisse Archives, Paris, as reported in the catalogue raisonné (Duthuit 1997), with further clarification by Lebon (Lebon 2003). (A third foundry, Cullen, probably made two sand-cast medallions; these were not part of the study). After 1925 all further bronzes made during the life of the artist were cast in lost wax by the Valsuani foundry that ultimately produced more than 400 casts. All casts examined had foundry marks (Fig. 4) except two very small works. After Matisse’s death Valsuani continued to produce casts for his heirs. Susse, Rudier and Thinot foundries also made casts posthumously. The family destroyed almost all original plasters when the bronze editions were finally complete in the 1990s (de Guébriant 1994).

Figure 3. Henri Matisse, *The Serf*, cast 1908, detail, foundry mark of Bingen and Costenoble. The Baltimore Museum of Art, The Cone Collection, formed by Dr. Claribel Cone and Miss Etta Cone of Baltimore, Maryland.

Figure 4. Henri Matisse, *Reclining Nude I (Aurora)*, cast 1930, detail, foundry mark of Valsuani. The Baltimore Museum of Art, The Cone Collection, formed by Dr. Claribel Cone and Miss Etta Cone of Baltimore, Maryland.
Because Matisse cast his bronzes as needed for a show or sale, editions were produced incrementally over decades; therefore it is common to find that early casts within an edition are sand casts while later casts of the same sculpture in the same edition are lost-wax casts. This makes it possible to compare the same sculpture as a sand cast and a lost wax cast (Figs. 5, 6).


Methodology

The study included examinations of casts in normal light of the exteriors of all casts and the interiors when possible. Sometimes low magnification was used if needed. Many of Matisse’s sculptures are open on the bottom and interiors are sometimes easily viewed. Interesting surface features, especially mold lines were documented with photography. A form (see Appendix 1) was used for each work, noting features such as the casting technique, core pins, armatures, casting flaws, surface articulation, foundry marks, patination colors, surface finishing cold work, sprue stubs, etc. Magnets were used to check for iron armatures inside closed forms, tape measures and calipers were used to do basic measurements as much as possible. As the study progressed laptops loaded with photographs of sculptures previously examined were used for comparison.

When possible base tracings (Fig. 7) were made to help compare the size of similar casts. Since bronze shrinks when it cools size measurements and base tracings can help clarify relationships among similar casts. Bronzes cast directly from the foundry plaster model would all be about 1%-2% smaller than the plaster model (Beale 1975). Bronzes smaller than these casts would likely be surmoulages, a word that means a cast made from a cast. Base tracings were an especially useful tool for Matisse’s sculpture because the majority of his works have the base modeled as an integral part of the work. Even for sand-cast sculptures that are sometimes cast in more than one piece and joined after casting, the base, if present, is cast integrally with a portion of the subject. Base tracings helped to flag sculptures for more detailed size measurements via laser scanning in order to make 3-D computer models for comparison [1]. Eleven works in several collections were laser scanned including the six Aurora casts that are the subject of this paper.

Figure 7. Henri Matisse, *Head with Necklace*, cast 1930, with base tracing. The Baltimore Museum of Art, The Cone Collection, formed by Dr. Claribel Cone and Miss Etta Cone of Baltimore, Maryland.
Radiography, and x-ray fluorescence analysis were also part of the project. Radiography was performed on some works in the collections of the BMA, the Metropolitan Museum and the Hirshhorn. X-ray fluorescence analysis of the metal alloy was performed on all works in the BMA collection and on one from the Hirshhorn Museum. Results of these investigations did not inform our *Aurora* study and so will not be considered further here.

**Aurora**

Six casts of *Reclining Nude I (Aurora)*, were examined as part of the study. These included bronze casts at the Baltimore Museum of Art (Fig. 8), the Museum of Modern Art (MOMA) (Fig. 9), Albright-Knox Art Gallery (Fig. 10), Raymond and Patsy Nasher Collection (Fig.11), and in a private collection. A sixth cast made of terracotta was examined at the Hirshhorn Museum (Fig.12). A summary of observations comparing the six sculptures is included here (Fig. 13). Additional information was collected on several other casts that were not available for examination.

Figure 8. Henri Matisse, *Reclining Nude I (Aurora)*, cast 1930, The Baltimore Museum of Art, The Cone Collection, formed by Dr. Claribel Cone and Miss Etta Cone of Baltimore, Maryland.

Figure 9. Henri Matisse, *Reclining Nude I (Aurora)*, unauthorized sand cast, date unknown, Museum of Modern Art, New York.
Figure 10. Henri Matisse, *Reclining Nude I (Aurora)*, sand cast 1912, Albright-Knox Art Gallery, Buffalo, N.Y. Room of Contemporary Art Fund.

Figure 11. Henri Matisse, *Reclining Nude I (Aurora)*, lost wax cast 1951, Raymond and Patsy Nasher Collection, Dallas.

<table>
<thead>
<tr>
<th>DATE</th>
<th>CAST</th>
<th>SIZE</th>
<th>FOUNDRY</th>
<th>MOLD LINES</th>
<th>JOINS</th>
<th>PROVENANCE</th>
</tr>
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<tr>
<td>Albright Knox</td>
<td>1912</td>
<td>Sand</td>
<td>A</td>
<td>F.Costenoble</td>
<td>Yes</td>
<td>Mechanical</td>
</tr>
<tr>
<td>BMA</td>
<td>1930</td>
<td>Lost wax</td>
<td>A</td>
<td>Valsuani</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Hirshhorn</td>
<td>Before 1919?</td>
<td>Terracotta</td>
<td>B</td>
<td>N/A</td>
<td>No</td>
<td>None visible</td>
</tr>
<tr>
<td>Nasser</td>
<td>1951</td>
<td>Lost wax</td>
<td>B</td>
<td>Valsuani</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>MoMA</td>
<td>1930’s?</td>
<td>Sand</td>
<td>A</td>
<td>Unknown</td>
<td>No</td>
<td>Brazed</td>
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<tr>
<td>Private collection</td>
<td>1930’s?</td>
<td>Sand</td>
<td>A</td>
<td>Unknown</td>
<td>No</td>
<td>Brazed</td>
</tr>
<tr>
<td>Plaster model  (known only from a photograph)</td>
<td>c.1907</td>
<td>Plaster</td>
<td>Presumably larger than A</td>
<td>N/A</td>
<td>Yes</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Size B is 4% smaller than size A

Figure 13. Summary of data comparing the six sculptures.
Of these six the Baltimore cast has the best provenance. It was bought in 1931 from the artist by Etta Cone, a Baltimore collector, and came to the BMA in 1950. It was cast in 1930 in lost wax in one piece by the Valsuani Foundry. It can be considered the standard for comparison. The earliest cast in this group, that at the Albright Knox, is a sand cast made in 1912 according to the catalogue raisonné (Duthuit 1997), and marked F. Costenoble. While the provenance for this work is not entirely known, it compares very favorably with other more secure works made by this foundry and with the BMA cast. Typical for work from this foundry, it is a very high quality cast with nice finishing done after casting including very carefully fitted joins (it is cast in three pieces) that are mechanically fastened. This was considered to be the standard for comparing sand casts.

Unauthorized sand casts

Two casts, that at the Museum of Modern Art and one from the private collection, have long been considered unauthorized casts by the author of the catalog raisonné (Duthuit 1997). MOMA staff has been in agreement with this assessment of their cast for many years. Our examination of these two casts revealed that both were sand casts without foundry marks and shared a number of other similarities; they were cast in three pieces, joins were brazed, cold work done to finish the casts was clumsy and underneath the bases a white paint-like substance had been partially applied to the metal surface (Fig. 14). This last feature is believed to have been an attempt to mimic lost wax casts made at the Valsuani foundry that always retain white investment remnants under the base.
Similarities were such that it seemed reasonable to conclude that both unauthorized casts had been made at the same foundry about the same time. Of great interest was the fact that mold lines had been removed on both casts as part of the final finishing operation, normal foundry practice, but not Matisse’s (Boulton 2007) (Fig.15). This is in marked contrast to both the BMA (Fig. 16) and Albright Knox casts that retain prominent mold lines. Matisse’s intentional preservation of certain mold lines will be discussed in a later section.

Figure 15. Henri Matisse, *Reclining Nude I (Aurora)*, unauthorized sand cast-date unknown, detail showing lack of mold line on arm. Museum of Modern Art, New York.

Figure 16. Henri Matisse, *Reclining Nude I (Aurora)*, lost-wax cast 1931, detail showing mold line on arm. The Baltimore Museum of Art, The Cone Collection, formed by Dr. Claribel Cone and Miss Etta Cone of Baltimore, Maryland.
Finally and most curiously, base tracings and subsequent laser scanning (Fig. 17) revealed these to be the same size as the BMA and Albright Knox casts; the assumption had been that these would be surmoulages, casts made from another bronze cast. The fact that they are the same size as the BMA cast indicates that they had been made from a larger plaster model. This would seem to cast doubt on the legend that these two casts, along with a third in a European museum collection for which examination was not possible but for which a base tracing was obtained, were illicitly cast in Germany in the 1930’s from a bronze sent there for exhibition. The brazing of the joins is an indication that they were made post-World War I, as torches do not seem to have been in common use in art bronze foundries until after the war (Boulton 2007). Even today in France, the most traditional art bronze foundries use mechanical means to fasten joins in sand-cast works (Rama 1988).

Figure 17. Overlapped laser-scanned computer models of three casts of Henri Matisse, *Reclining Nude I (Aurora)*, one from The Baltimore Museum of Art, the Museum of Modern Art and the Albright-Knox Art Gallery. The BMA’s cast (green in both pairs) is the same size as the Museum of Modern Art’s (blue) and the Albright-Knox’s cast (yellow).
Two smaller casts, bronze and terracotta

The last two casts of the six being considered here are more difficult to characterize. Both are considered by the catalogue raisonné to be authorized casts. The Nasher bronze, listed as having been cast at the Valsuani foundry in 1951 in the catalogue raisonné, has a very good provenance, having come through the Pierre Matisse Gallery (Matisse’s son, Pierre, became an important art dealer in New York City and handled his father’s later work). There is little doubt that this sculpture was cast at the Valsuani foundry; it compares favorably in almost every way to dozens of other works by that foundry that were examined in the course of the study including the BMA Aurora. It is a lost-wax cast made in one piece. The foundry mark is good, the interior of the base retains typical white investment material and has the usual sprue and riser stubs. Especially notable is the patina, rich, dense, deep, nearly black like that on other Valsuani works examined. This appears to be their signature patina, noir Valsuani (Valsuani black; Lebon 2003) for which they were justly famous.

It therefore came as a great surprise to discover that this cast is not the same size as the BMA Aurora, but is 4% smaller as demonstrated by overlapping computer models of both works (Fig. 18). A 4% difference would indicate a cast thrice removed from the original plaster, a cast of a cast of a cast. Other differences include a lack of mold lines (Fig. 19), and other important surface details perhaps removed by overzealous surface finishing, or lost through excessive shrinkage of the bronze, and the addition of lumpy areas on the base, perhaps sloppy repairs.

Figure 18. Overlapped laser-scanned computer models of two casts of Henri Matisse, Reclining Nude I (Aurora), one from The Baltimore Museum of Art, the other from the Raymond and Patsy Nasher Collection, Dallas. These superimposed computer models are colored to
distinguish the Nasher’s cast (red) from the BMA’s cast (green). The Nasher cast is about 4% smaller, the size difference is most obvious here in the feet and indicates that these two bronze casts were not made from the same model.

Could Matisse have chosen a different model for this cast? A precedent exists for that in another work, Head of a Child (Pierre Matisse). Two securely-provenanced casts of this work, one cast in 1912 (Weatherspoon Art Museum) and the other in 1922 (BMA), and bought by collectors Etta Cone and her sister Claribel, show about a 1.5% size difference. It seems that the original plaster must have been destroyed in the war, so that Matisse chose a bronze cast to use as a model to complete the edition later. Could this have happened to the Aurora plaster in World War II? Photographs of the no-longer-extant original plaster (with mold lines much in evidence as on the BMA cast) taken in Matisse’s studio between 1949-51 (Fig. 20) would seem to invalidate that theory. In addition, photographs in the catalogue raisonné (Duthuit 1997) of another bronze Aurora made at Valsuani the same year, 1951, 0/10, and still owned by the Matisse family, shows the prominent mold lines and other surface details present on the BMA cast, but missing from the Nasher cast. It seems unlikely that the Nasher bronze was known by the artist.

Figure 19. Henri Matisse, Reclining Nude I (Aurora), lost wax cast 1951, detail showing lack of mold line on arm and missing bump on side under arm. Raymond and Patsy Nasher collection, Dallas.
The last cast to be considered here and most puzzling is the Hirshhorn terracotta cast of *Aurora*. Considered authentic by the author of the catalogue raisonné (Duthuit 1997), it is described there as one of two extant terracottas from an original series of five, three of which were destroyed by Matisse in 1919. According to a letter written by Marguerite Duthuit (Matisse’s daughter) to her brother Pierre, the dealer, “(Matisse) destroyed the edition because it shrank too much.” (Duthuit, M. 1959). Both of the surviving terracottas have provenance imperfections [2].

Base tracings and 3-D computer models show that the cast is identical in size to the Nasher bronze (Fig. 21). Terracotta would be expected to shrink substantially on drying and subsequent firing (as much as 10%) but the fact that this is the same size as a bronze cast seems remarkably coincidental. Further similarities are evident in the lack of surface details; all mold lines and important surface articulation such as the large lump on the side under the raised arm are missing (Fig. 22). Both have fingers articulated on the lower hand unlike the mitten-shaped hand present on the BMA and Albright-Knox bronzes.
Figure 21. Overlapped laser-scanned computer models of two casts of Henri Matisse, *Reclining Nude I (Aurora)*, a terracotta from the Hirshhorn Museum and Sculpture Garden, Smithsonian Institution, Washington, D.C. (green), and a bronze from the Raymond and Patsy Nasher Collection, Dallas (yellow). These superimposed colored computer models show both casts to be the same size.

Figure 22. Henri Matisse, *Reclining Nude I (Aurora)*, terracotta cast before 1919, detail showing lack of mold line on arm and missing bump on side under arm. Hirshhorn Museum and Sculpture Garden, Smithsonian Institution, Washington, D.C. Gift of Joseph Hirshhorn, 1966.
Matisse’s mold making is discussed in great detail in the larger technical study (Boulton 2007). Relevant to the discussion here is the fact that the artist’s love of line, so evident in his painting, drawing and cut outs, is equally prominent in many of his most important sculptures including *Aurora*. The transformation of a clay sculpture first to plaster, then often to wax, and finally to bronze offered as many as five separate opportunities to create mold lines on the surface of the finished work. Lines made at the foundry were carefully removed; only certain lines created by the artist himself or his mold maker were retained. These few lines, the result of the artist’s carefully considered and discriminating vision, were selectively retained to emphasize important contours or create surface decoration. They are not accidental artifacts of production and are integral to the overall composition of the sculpture.

A logical explanation for the similarity in size of the terracotta and the Nasher bronze would seem to be that the terracotta is actually a plaster cast made to look like terracotta [3] and was made in a mold taken from the Nasher bronze or another of similar size. Because plaster does not shrink it will form a cast the same size as whatever was used as a model, in this theory, a bronze. The reverse could not be true (that the bronze might have been made using the terracotta as a model) because bronze would shrink on cooling and be smaller in the end than the terracotta. Further evidence that the Hirshhorn work might not be clay is that although the sculpture is apparently hollow as one would expect of a cast, the bottom is sealed up and there are no visible holes for air to have escaped during the firing of the clay. This should have resulted in destruction of the clay during firing but would not present a problem for plaster. However, a surface scraping of the terracotta was subjected to analysis by FTIR by Susan Lake at the Hirshhorn and showed that the material is, in fact, terracotta. More invasive sampling is advisable.

A further complication is recent information obtained about the other extant terracotta cast of this work that is in the collection of the Royal Art Museum in Copenhagen. This work was not examined in the study, but detailed photographs and a base tracing were obtained. Photographs make clear that the mold lines and other important surface articulation similar to the BMA cast are present on this work (Fig. 23) unlike the Hirshhorn work, but the base tracing shows that it is the same size as the Hirshhorn cast. How can this be explained?

One can imagine that perhaps Matisse authorized this edition of five terracottas prior to 1919 when art bronze casting had been precluded by the war effort for some years (Lebon 2003). At the end of the war when it seemed possible that art bronze might be cast again some day soon he chose to destroy the remaining terracottas, but perhaps two had already been sold. If indeed he destroyed the remaining three, “because they shrank too much” (Duthuit 1959) perhaps the Hirshhorn cast is indicative of their appearance. That could explain the lack of surface detail—perhaps a casualty of excessive shrinkage. This would not explain, however, how shrinkage affected the surface detail of the Hirshhorn cast, but allowed it to attain the same size as the Copenhagen terracotta cast for which the surface detail appears to be unaffected. Surface detail can also be intentionally removed from terracotta in a leather-hard state prior to firing by abrasion with sandpaper. It seems very unlikely that Matisse would have done this given his hard-won selective surface articulation, but it is not impossible. This could explain both the similarity in size of the bases of the Copenhagen and Hirshhorn work, and the difference in surface articulation.
Figure 23. Henri Matisse, *Reclining Nude I (Aurora)*, terracotta cast before 1919, detail showing mold line on arm and bump on side under arm. Royal Art Museum, Copenhagen, Denmark.

**Conclusion**

The staff at the Matisse Archive in Paris diligently pursues and when possible destroys unauthorized works of art. *Aurora* has been an especially vexing problem through the years. There is a known group of unauthorized plasters as least some of which are thought to have been made from the bronze now at the Musée national d’Art moderne, Centre Georges-Pompidou (de Guébriant 2007). Another series of bronzes with the Bingen and Costenoble foundry mark cast through and cold worked after casting to read Fondeux (rather than Fondeurs) are known; one was destroyed by the Susse foundry at the behest of the Archives staff in 1979. Perhaps one of these bronzes served as a model for the Nasher bronze; this could account for the 4% shrinkage. The Hirshhorn terracotta remains an unsolved mystery.
Acknowledgments

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Endnotes

1. Five works were scanned by the firm Direct Dimensions, Owings Mills, MD and one was scanned by the Van Duzen Archives, Dallas, TX.

2. The timeline of the provenance of the Hirshhorn work as stated in the catalog raisonné seems a little confused. It is listed as (1) family of the artist, (2) Mr. And Mrs. Otto Spaeth, New York, (3) Lee A Ault, New York. (4) Theodore Schempp, New York, (5) Joseph H. Hirshhorn, New York April 8, 1959-May 17, 1966, (6) Given to the museum in 1966. According to preliminary research conducted on the Web, Lee Ault was an art dealer in NY from 1970-78, Otto Spaeth was a vice president of the Whitney Museum who collected art made between the wars and who died in 1954, and Theodore Schempp was an American art dealer working in Paris from 1937-50. Thus it would seem that Theodore Schempp must have been the go-between for the family of the artist and Spaeth that could put the sculpture in France as late as 1950. Ault must have been the go-between for Spaeth to Hirshhorn, and perhaps he was working informally prior to 1970. The Copenhagen work has a sad history. It was confiscated by the Nazis from the Folkwang Museum in Essen in 1929, sold at a Nazi sale at the Fischer Galerie in Lucerne, June 30, 1939 (#95), bought there or later owned by Theodor Woelfers, Malmo (Sweden) then Aage Fersing (an art dealer with this name was involved in a fake Rodin bronze scandal in the 1990’s). It has been at the Copenhagen museum since 1956.

3. Plaster is easily amended while wet with additions of pigment, sand, ground brick or terracotta or myriad other substances to substantially change its appearance. It is not uncommon for pink plaster objects to be misidentified as terracotta in museum collections.
Appendix 1

MATISSE SCULPTURE EXAMINATION FORM

TITLE: NUMBER/OWNER
CORRESPONDING BMA NUMBER:

MATERIAL: bronze plaster terracotta DATE OF CAST:

FOUNDER/FOUNDRY MARK
Impressed/stamped/other
SERIES NUMBER:
Inscribed in wax?
SIGNATURE:
Inscribed in wax?

OTHER MARKS/LABELS

CASTING INFORMATION: lost wax/sand interior visible? Sand or investment
Interior description

Cast in sections?

Base? How attached

Core pins?

Describe mold lines on surface: shallow/deep/location/offset

Surface quality: lumpy, dry, smooth, articulated

Bubbles/pits

PATINANTION: brown, light brown, dark brown, reddish brown, greenish brown, black, translucent/opaque other:

FINISHING: smooth, evidence of file marks, lack of finishing, investment traces

OTHER TECHNICAL OBSERVATIONS:

COMPARISON TO BMA EXAMPLE:
PHOTOS TAKEN, OTHER DOCUMENTATION:
EXAMINED WHERE AND BY WHOM?

References


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“DISCOVERING” A MEDIEVAL CANDLESTICK IN THE COLLECTION OF THE WALTERS ART MUSEUM

Julie A. Lauffenburger

Abstract

In 1935 a seminal work on medieval metalwork was published in Germany illustrating a variety of fantastic yet functional objects from Northern Europe that included candlesticks, small decorative sculpture and plaques and a subset of functional art known as aquamanilia. Aquamanilia, Latin for ‘water’ and ‘hands’, are hollow vessels used in both secular and religious settings for the ritual washing of hands. Though there are hundreds in existence, still aquamanilia are a little known object existing in only a handful of American museums with sizeable medieval collections. But to turn of the century collectors like William and Henry Walters, they were an irresistible find.

Recent scholarship has confirmed several fakes or later reproductions among this small subset of bronzes, and it is in this context that the Walters collection will be examined. This paper will introduce the Walters’ collection of six aquamanilia and two prickets that come from both the European and Islamic Medieval period. It will then focus on a discussion of two prickets that take the form of Samson and the Lion and how in light of new technical research one that has always been relegated to storage as a fake, received some renewed attention.

Introduction

While examining the medieval collection in the Walters’ storage facility, a metal candlestick in the shape of Samson and the Lion (54.429, which will be referred to as “the questioned Samson”) (Fig.1) was noted as having striking similarities to a candlestick of the same subject matter then on view in the galleries (54.784, referred to as “the 13th c. Samson”) (Fig.2). In fact, the candlestick on view had recently been included in the exhibition and corresponding publication Lions, Dragons and other Beasts: Aquamanilia of the Middle Ages, Vessels for Church and Table (July 12- October 15, 2006). A review of the Walters’ records regarding the Samson and Lion candlestick in storage (54.429) indicated that its authenticity was in question and it had been therefore left in storage. In light of the newly published technical information included in Lions, Dragons and Beasts, and discussions regarding medieval metalwork of this type, the candlestick was taken from storage and a study begun to try and determine with more precision the date of its manufacture.
The Walters’ Samson and Lion candlesticks are contemporary with medieval aquamanilia and were produced in essentially the same way and likely in the same workshops, therefore a review of the technical literature on aquamanilia was essential in interpreting both candlesticks. In addition, the direct comparison of the 13th c Samson, 54.784, (recognized as a fine example of Mosan metalwork, produced in a region the Meuse river valley in present day Belgium, France and the Netherlands), to the questioned Samson, 54.429, provides useful information.

Aquamanilia are hollow vessels for the holding and pouring of water into the hands, used in both religious and secular settings. They are especially noteworthy for their use of anthropomorphic and fantastic animals as subject matter. In form they are distinguished by a hole at the top for filling, a handle and a spout for pouring. Many of the late 19th century museums in Europe and the United States have as part of their collections one or more aquamanilia and stylistically
related candlesticks. Early scholarship on aquamanilia includes Otto von Falk and Erich Meyer’s *Bronze-Gerate Des Mittelalters* (1935), which remains today an essential illustrated list of all known aquamanilia and related metalwork of the early 20th c. Interestingly, even at this early date, the book already includes references to fakes and forgeries. Ursula Mende continued the German scholarly contributions with her important work on the metal alloys (Mende 1981). Early publications in this country out of Cleveland and Boston included technical studies of pieces in their collections (Christman 1974 and Netzer 1991). Most recently, in a comprehensive catalogue and accompanying exhibition at the Bard Graduate Center for Studies in the Decorative Arts, NYC, Peter Barnet and Pete Dandridge from the Metropolitan Museum of Art (2006) have included a wealth of technical information on the methods of producing and casting aquamanilia.

**The Walters Art Museum collection**

Father and son collectors William and Henry Walters, active in the late 19th and early 20th centuries, amassed the majority of the 28,000 objects in the Walters Art Museum’s comprehensive collection. Among those collections were many pieces of medieval metalwork, including noteworthy examples of early enamels and reliquaries. A specific subset of this group is the little known genre of cast vessels known as *aquamanilia* and related candlesticks.

The Walters’ collection, primarily acquired before the death of Henry Walters in 1931, is in part a reflection of the tastes of a post-industrialist merchant class filtered through the tastes of important dealers of the time. The Walters has in its collection six aquamanilia and two related candlesticks, all but one of which was acquired prior to 1931. Of the eight pieces, two of the aquamanilia are recognized fakes and one candlestick, the questioned Samson, 54.429, was cast under suspicion early after its entry into the collection. Why in this case were the odds not in favor of the collector, especially one with a fairly discriminating eye? This can be explained in part by an increase in demand for medieval material that was a result of the simultaneous explosion in archaeological excavations and a rise in disposable wealth represented by the new merchant class. These developments made the late 19th century fertile ground for the production and sale of forgeries. It is known that as early as the 1850s German museums were selling plaster casts of aquamanilia for educational purposes (Barnet and Dandridge 2006). By the 1870’s cast metal copies were being produced by several German foundries including: C. Haegemann in Hanover, C.W. Fleischmann in Munich and Nuremberg, J.H. Schmidt in Iserlohn, Beumers in Duesseldorf (Barnet and Dandridge 2006). Sales catalogues of the German companies offered their copies correctly identified in the catalogue as new castings, and they served as teaching devices, replacements for damaged originals in historic churches, or as decorative pieces. Not surprisingly, however, some of these copies eventually made their way to the art trade as legitimate art of the middle ages. From here they easily moved into private and public institutions whose collections were being formed at the time. One aquamanile in particular, a lion with flame tails from the Nuremberg German National Museum, has approximately 20 castings known in at least three sizes (Mende 1990). The existence of three different sizes implies that casts several generations removed from the original were available as each successive molding and casting process results in an approximately 4% shrinkage factor. So it is evident that at the
time Henry Walters was acquiring his medieval collection the art market was already infused with 19th century replicas and forgeries.

The Romanesque and medieval originals were all unique lost wax casts, but the copies were manufactured in the then modern technique of sand casting, allowing them to be easily produced as multiples. The recent study by Barnett and Dandridge (2006) clearly documents and reproduces by way of a recreation by a living artist, the step by step production of an aquamanile using the lost-wax method.

As previously mentioned, both of the Walters’ Samson and Lion candlesticks were purchased and brought into the collection prior to 1931. Therefore it is clear that the candlestick in question, 54.429, was made prior to the comprehensive von Falke and Meyer publication of 1935. This is significant because early museum records indicate that 54.429 was described as a “forgery copied from 219a and 221 in Falke and Meyer” (Walters Art Museum, undated). The Walters’ Samson candlestick most closely resembles #221 but it is clearly not cast from this piece as the position of the legs and head differ. Moreover, the acquisition history of the Walters candlestick makes a forgery based upon the Falke and Meyer publication, an impossibility. This does not preclude that the examples included in Falke and Mayer could have been known to a potential forger from other publications. In fact, #221 was illustrated in publications as early as 1875 and was in the collection of the Victoria and Albert Museum, and could have been accessible for study or copying.

The museum record for the Samson candlestick in question, 54.429, goes on to say: “Eyes are glass and modern…the socket of the candlestick is upside down…Ellsworth claims it is old” (Walters Art Museum, undated) [1]. A closer examination of the technical details typical of medieval metalwork is now necessary.

**Hallmarks of a medieval Aquamanile**

A centaur aquamanile from Nuremburg, ca 1400, is currently on display in the Walters galleries (54.62) (Fig.3). This piece is particularly interesting as it is an example of a vessel with a dual function. At the terminus of the centaur’s extended hands are two open rings for holding candles while at the same time the spigot in the chest makes its use as a water vessel evident. The centaur has a radiating tail described in the literature as the “flametail” type (Mende 1990), indicative of the Nuremberg school itself. An examination of this piece will serve to illustrate some of the common and defining technical features of these sculptural forms during this period.

An x-radiograph shows the centaur is hollow-cast in one piece except for the spigot (Fig.4). The interior wall conforms closely to the exterior cast, which indicates the use of a very detailed and meticulously formed core. As is typical, the core extends only slightly into both the front and back legs, leaving the majority of the leg solid cast. In general, the desire for a closely formed core was a matter of economy, the less metal used, the less costly the cast. Additionally, the choice of solid or hollow leg may reflect the vessel’s function. For instance a solid-cast leg may have been preferable for the aquamanile as it would impart greater strength for a vessel designed...
to be moved about a table and secondly it would prevent water from sitting in the deep voids and corroding the metal as well as becoming contaminated.

Figure 3. Aquamanile in the shape of a centaur. The Walters Art Museum, 54.62.

Figure 4. X-Radiograph of aquamanile from Fig. 4. The Walters Art Museum, 54.62.
In this late German example the core pins, used to secure the core within the investment prior to casting, have been replaced with circular metal plugs of an alloy similar in color to the cast. In earlier aquamanilia it is more typical to find small tapered core pins of either iron or copper alloy, still in place (Barnet and Dandridge 2006).

Because they are closed figures, except for very small openings for filling and pouring of water, the removal of core to create the receptacle for water was often achieved by the creation of a clear-out at the chest or underbelly of the animal. In this case, a rectangular clear-out, used for easy removal of the core material, doubled as a fixture point for the separately cast spigot on the centaur.

One final detail that is a hallmark of the early medieval aquamanilia is the evidence of cold working after casting (Fig. 5). This takes the form of engraving and also includes a repertoire of punch work.

Figure 5. Detail of engraved lines of hair from Fig. 3. The Walters Art Museum, 54.62.

The trappings of the 19th century forger

By way of contrast, the discussion now turns to the Walters’ aquamanile in the shape of a horse, 54.425 (Fig.6). This horse was purchased in 1927 as German manufacture of the 14th century. When examining the horse, several technical details do not correspond with what is expected of the metalwork of the period. It is evident both with visual inspection and looking at the x-radiograph that the horse is very unevenly cast and therefore lacks the feature of a carefully
formed core (Fig. 7). In fact, it is so thin in places that there are now large punctures in the side walls. In addition, there is no clear-out for the removal of the core, which has resulted in the incomplete removal of core in the horse’s head. The complete removal of core material would have been important given the function as a water vessel: even though the water was not intended for drinking, sediment from the core would have been undesirable.
An additional feature that casts doubt upon the authenticity of this figure is the lack of engraving or cold working after casting. A detail of the horse’s head shows the as-cast detail of the horse’s mane (Fig. 8). It clearly lacks any of the engraving found on the lion’s mane in the Nuremberg example. In fact this horse belongs to a group of fakes, which were taken directly or indirectly from a medieval original in the Bayrisches National Museum inventory number 2495. Several of these forged pieces are illustrated in the last section of von Falke and Meyer’s 1935 work (1935, 225-228).

The ‘Samson and Lion’ type

Representations of the Samson and lion story can be broken down into two main types. Type 1 has the lion facing forward, and Type 2 has the lion’s head twisted back and facing Samson (von Falke and Meyer 1935). Of the two Walters’ examples the 13th Samson, 54.784, falls into the first category and the questioned Samson, 54.429, falls into the second category.

The questioned Samson, 54.429, represents a category of material that is difficult to define. It unlike either the clear-cut example of the forged horse aquamanile, or the striking examples of medieval workmanship seen in both the Walters’ centaur and the 13th c. Samson candlestick. This candlestick is not cast directly from any known published source and it appears to be a unique cast done in the lost-wax method.
It is useful at this point to review its relationship with the Samson candlestick #221 in von Falke and Meyer (1935, 93), in the collection of the Victoria and Albert Museum (V&A) in London. The V&A does not currently display this piece as it is also uncertain of its date of manufacture (Campbell 2007; [2]). The pose and expression of both lions appears almost identical from the photographs. The figures of Samson, though very close to each other, differ in significant ways. The positions of the left and right legs on the figure are reversed, something that could not have happened if the Walters’ Samson was directly cast from the V&A example. Also, the cloaks on the two figures are different; the Walters’ example incorporates a tuft at the waist, something not seen in the V&A example. Furthermore the height of the V&A candlestick is recorded as 22.3 cm and the height of the Walters piece as 34.5 cm, again making a direct casting impossible.

In 1935 there was one known “precise copy” (von Falke and Meyer 1935, 106) of the V&A candlestick that exactly replicated patterns of wear and corrosion seen on the V&A example. The copy was in the Henkell collection in Weisbaden at the time of the von Falke and Meyer publication, confirming that it was not the Samson and Lion candlestick now in the Walters’ collection as the Walters’ Samson entered the collection prior to 1931 (von Falke and Meyer 1935). What is in question is the relationship between these two European examples. If they are as identical as indicated, then perhaps one is a later copy of the other original or perhaps they are both 19th century casts taken from the same original model, whose whereabouts is yet unknown. Whatever the relationship between the other two candlesticks, the Walters example is not a direct copy of either example, and still stands as a unique cast.

Stylistically the questioned candlestick raised no red flags during recent discussions with the curators at the Walters, though it is clear that it is of less sophisticated workmanship than other examples of medieval date. This is evident primarily in the difference in sculptural qualities of volumes such as the hair and lion’s tail and the extent and quality of the punch work and engraving after casting. It remains possible that this could be a result of differences in workshop practice or skill of an individual artisan.

The x-radiograph

Each of the candlesticks is cast around a single complex core that includes both Samson and the lion (Fig. 9). The closely modeled core of the questioned Samson, 54.429, parallels the final cast surface, though the casting itself appears to be a bit thicker than the 13th c. Samson. The core extends only minimally into the legs of the questioned Samson, a feature in common with aquamanilia, leaving the legs solid cast. Exceptionally, the 13th c. candlestick has completely hollow legs, perhaps as a result of economy and function. It makes sense for vessels holding water to have primarily solid legs so that the water does not get trapped and stale in the hollows, but this does not hold true for the candlestick. It would therefore be possible to use less metal in the candlestick.
Lauffenburger

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Figure 9. Left: X-radiograph of the questioned Samson and Lion candlestick, 54.429. Right: X-radiograph of the 13th c. Samson and Lion candlestick, 54.784.

A pair of small circular core pins is evident on both x-radiographs and is a hallmark of lost-wax casting. On the 13th century Samson they appear as small circular points of a less dense material in Samson’s upper thigh area. However, on the Samson from storage they appear as small circular points of a more dense material near Samson’s left foot, perhaps indicating they are still in place as tapered metal pins.

Both candlesticks also contain a rectangular shaped clear-out for the removal of the core material. In the case of a candlestick, core removal is primarily to address the issue of weight rather than the issue of water quality as with the aquamanile. The clear-out of the questioned Samson is at the front of the chest and the clear-out on the 13th c. Samson is located directly beneath the belly (Fig. 10).
Figure 10. Top: Detail of clear out on the questioned Samson, 54.429. Bottom: Detail of clear out on the 13th c. Samson, 54.784.
While the cores both closely parallel the exterior form of the cast metal, in both cases additional applications of wax were used to create the tufts of hair on the mane and the face of Samson on both candlesticks.

The Walters card catalogue file contains an undated quote that indicates that the drip pan on the questioned Samson, 54.429, was “upside down”. This claim was refuted by closer examination. In fact the drip pan was simply deformed and had originally, as in the 13th c. Samson, 54.784, been part of the cast stem but was now, as a result of damage, in the incorrect orientation. X-radiography of the candlesticks show that like the 13th c. Samson, 54.784, the questioned Samson is constructed of rolled and soldered sheet metal with a vertical seam extending its length (Fig.11).

![Image 1](image1.png) ![Image 2](image2.png)

Figure 11. Left: Detail of drip pan and pricket, questioned Samson, 54.429, Right: 13th c. Samson, 54.784.

**The metal alloy**

The composition of both Walters’ Samson and Lion candlesticks was examined using XRF [3]. Bulk composition was analyzed qualitatively from clear areas of metal on the underside of the lion’s feet on both prickets. In both candlesticks the composition appears to be a quaternary alloy of copper, zinc, tin and lead, an alloy combination that was in common use in the middle ages
and is referred to as latten (Netzer 1991). The alloy is consistent with the compositions of the alloys reported by Dandridge in his analyses of aquamanilia.

Analysis of the prickets on both candlesticks shows a composition of primarily copper. Traces of lead may result from the soldering process and traces of mercury may be from surrounding areas of mercury gilding.

**Cold working and finishing**

Both Samson and Lion examples at the Walters have been extensively worked after casting; the primary difference between the two again appears to be in workmanship. Areas of 54.429, the candlestick from storage, that are embellished with engraving or punch work include the lion’s mane, face, legs, hind quarters and tail, and the tunic, hair and face of Samson. A V-shaped graver and circular punch appear to have produced the majority of details on the candlestick. In addition to circular punches and V-shaped gravers the other Walters’ Samson also incorporates a true beading tool that leaves a half round stamp and results in a hollow circle. A comparison of several details shows the range of tools used and effects obtained on the surface of the brasses (Fig. 12 and 13).

![Image 1](image1.png) ![Image 2](image2.png)

Figure 12. Left: Detail of engraving, questioned Samson, 54.429, Right: 13th c. Samson, 54.784
As part of their surface embellishment, both candlesticks were mercury gilded (the presence of mercury detected with XRF). The gilding on the Samson from storage is worn and remains in recesses and engraved lines reflecting a pattern of wear from use.

The transparent red glass eyes of the Samson from storage were examined and in one case showed signs of glass deterioration, perhaps indicating it has weathered over a period of time (Fig.14). There are several documented examples of glass inlaid eyes, although they are generally of an opaque glass more typical of the early medieval period. It remains possible that
the glass inserts could have been added at a later date and therefore does not have immediate impact on the authenticity of the piece as a whole.

Figure 14. Detail of glass eye, questioned Samson, 54.429.

There are a few areas of what appears to be cuprite and malachite on the questioned Samson, 54.429, from storage. In those areas the cuprite appears beneath the malachite and it is hidden in recesses and areas difficult to clean. The overall texture of this Samson is somewhat odd and has a pebbly appearance, and though this is unlike the well polished surfaces of the many published examples, it is not unlike other documented examples from the Mosan region, for example a small lion aquamanile from the National Gallery of Art in Washington, D.C. (1942.9.281).

**Conclusion**

The author welcomes further discussion of the Walters Samson and Lion candlestick, 54.429. The current study has shown that it incorporates many of the characteristics of aquamanilia of the Middle Ages and compares favorably with known alloys of the genre. Its relationship with a candlestick in the Victoria and Albert Museum in London remains a puzzle and will be pursued further. Yet overall, in execution it is very closely related to other known examples from the Mosan region and may represent a slight variant on a popular secular subject, Samson and the Lion.

**Acknowledgments**

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Endnotes

1. Ellsworth was the chemist at the Walters from 1934-1937.

2. The V&A find its overall manufacture and its bright green corrosion troubling but the piece has never been analyzed nor has it been published since von Falke and Meyer. While it was not possible for this publication, the author is pursuing a more detailed study of the V&A example.

3. XRF was performed by Walters Art Museum Conservation Scientist, Jennifer Giaccai, using a Bruker AXS ARTAX system with a rhodium tube and polycapillary lens.

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FAKING PRE-COLUMBIAN ARTIFACTS

Catherine Sease

Abstract

Faking artifacts in the Americas does not have as long a history as in other parts of the world. Most scholars believe that it started in the early 19th century in Mexico. Once started, however, it has developed, grown and flourished. This paper briefly discusses the history of faking Pre-Columbian artifacts. Specific examples from Central and South America illustrate the particular issues associated with faked artifacts that contributed to their manufacture or the difficulty in identifying them.

Introduction

Faking is the production of copies of antiquities for the purposes of deception. In the Americas, faking is believed by most scholars to have begun in Mexico in the early 19th century (Walsh 2005). Prior to that, the cultures of the Americas were little known and not of particular interest to collectors.

Many collections of antiquities in Europe, and later in the United States, were started by scholars, aristocrats and the wealthy, who went on the Grand Tour and brought back oddities and curios from their travels. The romance of the past was rediscovered on a large scale following the uncovering of classical archaeological sites in Europe, most notably Pompeii and Herculaneum, in the 18th century. This renewed interest in the past gave rise to serious collecting on the part of aristocrats and scholars (Howard 1990). It was at this time that many important Greek and Roman sculptures and other antiquities found their way into aristocratic homes and collections throughout Europe. (Vaughn 1990).

After the industrial revolution, as wealth spread down through society, the collecting phenomenon also filtered down (Vaughn 1990). Eventually, anyone with education and taste who wanted to demonstrate these sensibilities found collecting antiquities ideally suited to this purpose. Not surprisingly, this created a demand for artifacts. Antiquities became scarcer and harder and more expensive to acquire. This forced many collectors to branch out to find new areas of antiquities. In the classical world, they turned to prehistoric artifacts, turning them into works of art. They also looked to other parts of the world, including Asia and the Americas. (Ekholm 1964; Bray et al 1975).

As interest grew, an imbalance was created between supply and demand. Demand rapidly surpassed supply and the stage was set for enterprising individuals to create fake antiquities to meet this demand. As new acquisitions were displayed in private collections or nascent museums, they piqued the interest of collectors. Avid collectors soon learned to follow the discoveries of the fledgling field of archaeology and they wanted what was being excavated and making headline news. The intense interest that developed led to a rapid rise in the commercial value of antiquities, and the emergence of the faking industry was a natural outgrowth of this.
interest. The supply of genuine artifacts has never been large enough to fill demand and over the
decades and centuries, the art of forgery has flourished and developed to a high level of
production, sophistication and refinement. (Ekholm 1964).

Mexico

Mexico, with its rich history, was the ideal place for faking to start in the pre-Columbian world. The ancient indigenous cultures of Mexico were numerous and produced diverse artifacts in a wide variety of styles and materials. (Ekholm 1964). Many of these materials, such as jade, turquoise and gold, were considered luxury materials in Europe and the United States, increasing the value of the artifacts even further in the eyes of collectors. Added to this was Mexico’s ideal situation next to the United States, a wealthy country full of collectors. (Ekholm 1964). These factors made Mexico a fertile area for forgers.

Most scholars believe the history of faking antiquities in Mexico dates back to the first decades of the 1800s (Walsh 2005). This was the period when Mexico gained its independence and the country was opened to foreigners. The opening of Mexico was greatly facilitated by the creation of the railway at this time. Once established, the railways expanded rapidly, opening up vast areas to the public that had been hitherto inaccessible, including the American west, southwest and Mexico. The exploration industry that quickly developed was soon followed by a tourist industry and visitors were anxious to bring home souvenirs of their trips to Mexico (Ekholm 1964).

This was also a time of tremendous growth in American and European museums. Particularly in the United States, fledgling institutions were attempting to amass large, synoptic and encyclopedic collections that covered as much of the world as possible. (Walsh 2005). Of particular interest were objects from the mysterious, unknown areas of the world. Exhibitions of exotic artifacts and antiquities were guaranteed to bring in large crowds of curious visitors in London and other large cities (Bray, et al. 1975).

These factors rapidly created a demand for antiquities that far outstripped supply. (Ekholm 1964). Artifacts were being freshly made and passed off as authentic as fast as they could be produced, such as some small stone figurines that came into the Yale Peabody Museum’s collections in the late 19th century (Fig.1).

In the 1880s, William Henry Holmes, an early student of Mexican archaeology associated with the Smithsonian, reported on some spurious black pottery vessels from Mexico similar to those in Figs. 2 and 3. He stated that it would be very easy for “a native artisan to imitate any of the older forms of ware [ceramics]; and there is no doubt that in many cases he has done so for the purpose of deceiving” (Holmes 1886).
Figure 1. Stone figurines from Mexico. The one on the left is possibly real. The one on the right is a fake. Courtesy of Peabody Museum of Natural History, Yale University.

Figure 2. Fake Aztec blackware vessel.Courtesy of the University of Pennsylvania Museum of Archaeology and Anthropology. Not accessioned.
About the same time, the French explorer Desiré Charnay made several collecting trips to Mexico. Like Holmes, he was aware of the faking industry and stated that it was centered in Tlatelolco, a suburb of Mexico City, and had begun around 1820 (Walsh 2005). At the rate that fakes were being manufactured and disseminated throughout the world, Charnay felt that all private collections were ‘infested’ with them (Charnay 1887). Certainly by the turn of the 20th century, there is good evidence that a trade in false antiquities flourished and by the 1920 and 1930s forged material was consistently filtered through the United States to Europe.

Faking was able to flourish in part because virtually nothing was known about the prehistory of Mexico at this time (Ekholm 1964; Walsh 2005). Collectors in the 19th and early 20th century were acquiring artifacts without any certain cultural or historical knowledge of what they were buying. The iconography, carving styles, methods of manufacture or materials were unknown to them; not only to them, but to the experts as well (Ekholm 1964). Because little or no archaeological work or serious study had taken place, there was no knowledge base with which to compare the fakes being produced. The experts did not know what normal was and therefore did not know what artifacts should look like. As a result, fakers had complete license to make whatever they thought they could pass off as an antiquity (Fig. 4). Eugene Boban, another early French explorer and dealer in Mexico, said that the majority of these early fakes were not

Figure 3. Fake Aztec blackware vessel. Courtesy of the University of Pennsylvania Museum of Archaeology and Anthropology. Not accessioned.
molded or copies but were “pure fantasy, and are a type of bizarre caricature whose inspiration escapes us but whose principal purpose is to trick the public” (Walsh 2005).

Ironically, many of these “fantasy” pieces have been in respected museums throughout the world for decades, if not a century or more, and are now considered to be masterpieces because of their individuality (Walsh 2005). The fact that they are unique and anomalous without any counterparts did not seem to have overly concerned these institutions. One ironic twist of their status in museums was that the critical eye of many archaeologists and art historians was trained on these fakes, probably further hindering the identification of fakes. This is not to say that all fantastical artifacts are fakes.

As serious archaeological exploration began to focus on the Americas, experts were more concerned with developing chronologies (Ekholm 1964), a necessary first step in studying an ancient culture. Even by the mid-20th century, the archaeologist Gordon Eckholm admitted that scholars “haven’t gotten around to the full and proper study of the extraordinary varieties of art objects that are found” (Ekholm 1964). Although he was talking of Mexico, this was true as well of scholarship throughout the Americas. As a result, the experts themselves did not understand well the range of variation within the different categories of artifacts, for example, Aztec sculpture or Olmec ceramics. They also neglected to study and document the materials and technology used by ancient American craftsmen which would have helped later in the effort to identify fakes.
Central and South America

Faking does not seem to have as long a history in the rest of Central and South America as it does in Mexico. This is probably due to these areas being located farther away from the United States and Europe and the fact that they were opened up to tourists and collectors later than Mexico. Even so, they have not escaped. The same pattern as we have seen in Mexico occurred in the rest of the Americas. Collectors moved in in the wake of missionaries, colonists and explorers and created a demand initially for archaeological objects, in particular, for Andean artifacts, but later for ethnographic objects as well. Ceramic, gold, shell and wooden artifacts from the Andes have been extensively faked in the 20th century (Ekholm 1964). (Fig. 5)

Towards the end of the century, gold objects from Costa Rica and Panama became of particular interest to collectors and hence to fakers (Ekholm 1964).

Types of fakes

Over the years, the most sought after material, and therefore the most faked, came from Mexico, including Olmec, Maya and Aztec artifacts, and from Peru, including material from the Chavin and Moche cultures. Pottery is by far the most commonly faked material and forgeries today are very sophisticated. Zapotec vessels (Fig. 6) are often forgeries so well executed that they require thermoluminescence and neutron activation dating to reveal their modern manufacture. (Bowman 1990). Moche vessels, in particular, are in great demand today and portrait vessels, due to their strong appeal, were known to be faked early on in 19th century (Jones 1990).
Obsidian, readily available in Mexico, was commonly used by indigenous peoples to make tools and ornaments of various kinds. It is not surprising, therefore, that artifacts in obsidian have been commonly and extensively faked (Fig. 7). In fact, according to Ekholm, it is almost axiomatic that all large objects of obsidian should be viewed with suspicion (Ekholm 1964). This is also true of objects made of rock crystal. Most of the obsidian forgeries appear to date to the early 20th century as do those made of rock crystal.

Stone masks, especially those in the Teotihuacan style, are numerous and commonly faked (Fig. 8). Their relative simplicity makes them easy marks for fakers. In particular, the lack of iconographic detail makes them less likely to be questioned and until fairly recently there was no body of indisputable examples that could be used for comparison. As late as 1964, none had been excavated and therefore did not have a solid provenance (Ekholm 1964).
Mummy masks are probably the most sought after antiquities from Peru and they too were faked as early as the 19th century. To make them seem more authentic, the fakes were decorated with genuinely old feathers and bits of textile.
Although ceramics and stone are the most common materials faked, artifacts of bone, shell and various metals including copper, silver and gold, are also forgeries.

Examples

When one looks at artifacts from Mexico, it is easy to see how some are easier to fake than others. Chupicuaro figurine heads from Western Mexico (Fig. 9) are incredibly plastic in style, freely and individually fashioned out of clay. It would be relatively easy, even by someone not overly gifted artistically, to make a figurine in the style of these heads that could be passed off as an authentic one.

![Figure 9. Genuine Chupicuaro figurine heads from Central Mexico. Courtesy of the Peabody Museum of Natural History, Yale University.](image)

Similarly, portrait vessels from the Mochica culture (Fig. 10) might be slightly easier to fake than other more stylized pottery vessels because of their very nature. As portraits, they depict individual characteristics and facial traits, as can be seen in these examples, making it more difficult to distinguish authentic from fake.

It would be much harder to fake a more stylized figurine, for example, a Teotihuacan warrior figure (Fig. 11) or an Aztec deity (Fig. 12). The details of the warrior’s headdress, clothing and accouterments must agree with the known iconography of the appropriate culture and time period. Similarly, deities had their special attributes and proscribed methods of presentation. Faking such figurines requires considerable knowledge on the part of the faker and provides more grounds on which to slip up. On the other hand, these details, or lack of them, can make it easier for an educated eye to detect fakes.
Figure 10. Genuine Mochica portrait vessel from the North Coast of Peru. Courtesy of the Peabody Museum of Natural History, Yale University.

Figure 11. Genuine Teotihuacan figurine fragment wearing a warrior’s headdress. Courtesy of the Peabody Museum of Natural History, Yale University.
As with anything, the issue of fakes is not black and white. There are degrees of faking that blur the picture. With pre-Columbian antiquities, what you see is not necessarily what you get. This is especially true with South American artifacts where heavy restoration makes it difficult to identify fakes. Many genuine artifacts are found in such a poor state of preservation that they have little or no market value. A fresh coat of paint and possibly the addition of some missing elements, however, can bring old pieces back to life and enable them to command decent prices. This is a form of partial faking.

In some instances, the pieces are genuine but broken when found. The handiwork of a gifted restorer can make clay figurines or vessels, for example, appear intact with the breaks skillfully hidden under layers of added plaster, paint and dirt. In other instances, ceramic vessels are found intact, but the painted surfaces are badly damaged or missing altogether, perhaps due to the action of water-soluble salts (Fig. 13). Skilled repainting of the design, perhaps followed by some distressing of the paint layer, can make the vessel appear as though it were straight out of the ground.
Both of these techniques are what we in archaeological conservation call faking, but what is really being faked is the fact that the piece is not in as good condition as it might at first seem.

Pastiches are also common and they represent a higher degree of faking. Two or more incomplete vessels can be cobbled together using bits and pieces from each to create a whole vessel. Since all the sherds used are genuinely old, scientific dating techniques are less likely to identify the piece as a fake.

Yet another category is the complete replication of an artifact. A wide variety of techniques have been utilized to make modern artifacts look old, including adding dirt and all manner of accretions to make the surface look worn and old. The frog vessel in Fig.14 is a modern creation covered with thick, unsightly accretions to make it look genuinely old. Another technique is to attach genuinely old bits and pieces to pots or mummy masks. For example, fragments of old textiles and feathers were adhered to pots or metal artifacts to make them appear old. Ceramic vessels have long been considered the most important artifacts from these areas. Textiles, especially fragments, when found at sites, generally were tossed aside and left exposed to the elements. Not infrequently, they were used as packing material for the more valuable ceramics. As a result, bits and pieces of genuine textile fragments were readily available.
Another problem in identifying fakes involves the use of molds. Many cultural groups throughout the Americas used molds to mass produce ceramic vessels (Fig. 15) and figurines. For example, many Peruvian stirrup spouted jars and portrait vessels were molded (Donnen 1992). These molds were frequently placed in graves in antiquity where they were found centuries later when the graves were looted. In the 19th century, enterprising forgers realized that by using old molds they could produce vessels that were perfect in style. All that was needed was to age the clay surfaces by distressing them in various ways, adding accretions or pieces of textiles to make them look convincingly old. Often artifacts were buried long enough to become stained or develop rootlet marks on their surfaces to make them look ancient.
Conclusion

Clearly the issue of fakes in pre-Columbian archaeology is a large topic and this paper can only skim the surface. In the last decades of the 20th century, experts began to systematically look at old and large collections of pre-Columbian antiquities in the United States and Europe to determine which pieces are fakes. Over the years, these fakes have confused and distorted our understanding of pre-Columbian art and culture and it will take a considerable effort, as well as a great deal of time, to unravel the genuine from the forgeries. This will undoubtedly involve a collaboration of archaeologists, art historians, conservators and conservation scientists, each bringing their own particular expertise to bear on the problem. It should be an interesting time for those of us who work in institutions with large collections of pre-Columbian material.

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FABRICATING THE BODY: THE ANATOMICAL MACHINES OF THE PRINCE OF SANSEVERO

Lucia Dacome and Renata Peters

Abstract

The so-called anatomical machines of the Prince of Sansevero, on display at the Museo Capella Sansevero in Naples, are two anatomical models, of a man and a woman, which depict the system of blood vessels in the human body. They were made by the anatomist Giuseppe Salerno in the mid-18th century and presented as the result of anatomical preparations based on a technique known as “anatomical injection” (injection of embalming substances in cadavers).

Sansevero’s anatomical machines have gradually become the subject of a legend, according to which the models were the outcome of an operation of human vivisection in which a woman and a man were killed through the injection of embalming substances in their blood vessels. Due to lack of written documentation on the early history of the anatomical machines, controversy continues about how they were actually made. This project tried to address this controversy by combining examination and instrumental analysis of their raw materials and manufacturing techniques with historic research. The conclusions of this study contradict the content of the well-known legend and raise questions about the nature of these objects as products of anatomical injection. More importantly, they also allow the re-telling of the story of the anatomical machines and offer an insight into the world where the legends surrounding Sansevero and the models were originated.

1. Introduction

The so-called anatomical machines of Raimondo di Sangro, Prince of Sansevero (1710-1771), are two anatomical models, of a man and a woman, which represent the system of blood vessels of the human body (Figs. 1, 2 and 3). Still surviving today, they were manufactured by the anatomist Giuseppe Salerno in the mid-18th century and were originally displayed as part of the cabinet of curiosities of Raimondo di Sangro, an eighteenth-century Neapolitan nobleman, military man, savant, and writer, who contrived curious objects and mechanical devices, and displayed them in his Palace. As a natural inquirer, di Sangro engaged in correspondence with savants in other parts of Europe; in a series of letters published in the 1750s he claimed, for example, to have found a source of eternal light on the basis of his experimental pursuits (di Sangro 1753a, di Sangro 1753b, de Sangro 1991). Di Sangro also claimed to have contrived special materials such as waterproof fabric, vegetable silk, vegetable wax and artificial blood, and to have used some of these materials in the creation of objects for his cabinet and in the decoration of the Sansevero Chapel (Cioffi 1994). Di Sangro’s cabinet and chapel (Fig. 4) became Grand Tour attractions and were regularly visited by travellers. In 1766, they were described in the booklet “Breve nota di quel che si vede in casa di Raimondo di Sangro, Principe di Sansevero” (Anon. 2001), a text believed to have been authored by di Sangro himself, which introduced visitors to the curiosities one could see in the Sansevero Palace. The two anatomical
machines are the only objects of the cabinet known to still exist today.

Fig. 1. The female anatomical model.
(All photos by R. Peters except as noted).

Fig. 2. The male anatomical model.
Fig. 3. The male and female models on display at the lower level of the Sansevero Chapel and Museum (Renata Peters in the middle). Photo by L. Dacome.

Fig. 4. The Chapel of Sansevero, also known as Santa Maria della Pietà.
Historical documentation on the manufacture of the anatomical machines is scarce. In the few 18th century sources that have survived to this day, the anatomical machines are presented as anatomical preparations based on “injection”, an embalming technique (believed to be based on injecting cadavers with a mixture of waxes, solvents and other materials) that allowed visualizing inner bodily parts. Perfected in the late 17th century by Dutch anatomists such as Reinier de Graaf, Frederik Ruysch, and Jan Swammerdam, the technique of anatomical injection was regarded as a particularly promising means for investigating the inner body and an invaluable source of medical knowledge based on visualization (Cole 1921, Cook 2007).

The history of the manufacture and early viewing of the anatomical machines may easily be placed in this context. Created by an anatomist and displayed in the cabinet of curiosities of a savant, these anatomical objects testify to the intersection between 18th century anatomical pursuits, experimental cultures, and practices of collecting and displaying. Yet this is only one aspect of these objects’ peculiar histories. By the end of the 19th century, the origin of the anatomical machines became the subject of a legend in which they were taken to be the result of the injection of embalming substances into two of di Sangro’s servants while they were still alive (Croce 1923). In 1894, the essayist Fabio Colonna di Stigliano reported about the legend in a prestigious periodical on Neapolitan monuments and arts, “Napoli nobilissima”, where he wrote that he had gathered the story in the streets and alleys of Naples (di Stigliano 1894, Croce 1923).

Lack of documentation on the raw materials and manufacturing techniques of the anatomical machines has made it difficult to appraise how the models were actually made. This shortage has, in turn, created a fertile ground for the spreading of the legend, which survives to this day.

This paper discusses some aspects of the manufacturing techniques and raw materials of these two anatomical models and the impact that lack of historical memory of these processes may have made on the history of the models as well as on the biography of the Prince of Sansevero himself. Investigation into the raw materials and manufacturing techniques of the anatomical machines took place in tandem with historic research on the activities of the Prince of Sansevero. The social-historic aspects of the research informed the examination and instrumental analysis of the pieces, and vice-versa. The integration of these two approaches posed new questions, and opened up the way to a more informed understanding of the material fabric of the models and the context in which they were created.

As it will be shown below, the conclusions drawn from this study contradict a well-known legend and raise questions about the “authenticity” of these objects as products of anatomical injection. More importantly perhaps, these conclusions provide new insights into the history of these anatomical models.

2. Viewing the inner body

The history of anatomical models dates back well before the 18th century. A long-standing tradition of votive objects invoking or acknowledging divine intervention in the cure of serious diseases and injuries found expression in the offering of anatomical models of the affected bodily parts. Since the Renaissance, anatomical models also started to appear in artistic ateliers and in the cabinets of physicians and surgeons as tools that helped both artists and medical practitioners
to study the proportions of the human body. In the course of the 18\(^{th}\) century the practice of anatomical modeling reached a high point of production and dissemination thanks also to the patronage of a number of European sovereigns, including Peter the Great of Russia, pope Benedict XIV, the Grand Duke of Tuscany Peter Leopold and his brother the Holy Emperor Joseph II, who sponsored the creation and displays of anatomical collections. By the end of the 18\(^{th}\) century, anatomical models could be found in a variety of venues, including museums, natural history and medical cabinets, workshops, academies, universities and medical and midwifery schools. They were used in the training of medical students, midwives and artists, and came to be regarded as an effective method of anatomical teaching that could spare students the problems associated with the dissection of cadavers (e.g. deterioration, smell or risk of contamination). In addition, models revealed the wondrous complexity of the human body, and enticed the curiosity of increasingly larger audiences of lay viewers. Along with anatomical models made out of different materials, such as wax, wood, clay and plaster, 18\(^{th}\) century anatomical collections often also included anatomical preparations of embalmed bodily parts (Haviland and Parish 1970, Lemire 1990, Düring et al 1999).

By the time the anatomical machines appeared in the cabinet of curiosities of the Prince of Sansevero, anatomical preparations based on injection had come to be regarded as a particularly effective means for investigating the inner body and revealing otherwise invisible bodily parts. As such they had raised the expectation that it was possible to visualize the circulatory system and chart the human body in an unprecedented way. In 1784, the British anatomist William Hunter emphasized this expectation by saying that “filling the vascular system with a bright colored wax, enables us to trace the large vessels with great ease, renders the smaller much more conspicuous, and makes thousands of the very minute ones visible, which from their delicacy, and the transparency of their natural contents, are otherwise imperceptible” (Hunter 1784, 56).

3. The impact of the Machines

By displaying a complex web of blood vessels, di Sangro’s anatomical machines substantiated a remarkable instance of this process of unveiling the “invisible”. In 1766, “Breve nota di quel che si vede in casa di Raimondo di Sangro, Principe di Sansevero” presented them as unique objects because they displayed whole bodies and were crafted with special diligence. However, almost a century and a half later, Colonna di Stigliano described them as a “macabre and dreadful sight” characterized by a “dreadful entanglement of veins and arteries that stimulated in the viewer the greatest marvel” (di Stigliano 1894, 121 and 154).

Speculations on the origin of the anatomical machines have proliferated since the publication of Colonna di Stigliano’s article. The anatomical machines have been interpreted, re-interpreted and situated in ever new contexts. Over the years, they have accordingly appeared in a variety of publications ranging from newspaper articles to comic books, from surrealist periodicals to esoteric publications and horror websites.

In 1964, the female anatomical machine appeared on the cover of an issue of the French periodical “La Brèche, Action Surréaliste”, an irreverent surrealist periodical edited by André Breton among others. In a celebratory article by Paule Thévenin, which questions the reliability
of the legend, di Sangro is portrayed as a man of insatiable curiosity and free thinking, a “savant impenitent” (an unrepentant savant) and “intrepid discoverer”. The anatomical machines, on the other hand, are described as the outcome of “injection”, and an expression of Sansevero’s inventive genius (Thévenin 1964, 15).

Some twenty years later, the anatomical machines made their entry in the world of comic books, when they became the main characters of an issue of the Italian publication Martin Mystère, titled “Il Principe delle Tenebre” (Castelli and Alessandrini 1985). The comic series describes the adventures of Martin Mystère, also known as “Detective of the Impossible”. In “Il Principe delle Tenebre” the anatomical machines are unearthed during the excavations of Sansevero’s old laboratory. They are then resuscitated, their DNA is cloned and they are replicated and turned into villains whom Martin Mystère, a very resourceful hero, has to confront.

The legend has continued to circulate across the media and on 18 October 1996, for instance, the journalist Rino di Stefano published an article on the Prince of Sansevero titled “Il principe maledetto”, in which the legend was presented for readers of the Italian newspaper “Il Giornale” (di Stefano 1996).

“La leyenda del Príncipe Alquimista”, a book written by Pierdomenico Baccalario (2002), presents a different angle. When in disagreement with the headmaster of their school, the main characters, Darío y Fiammetta, are told the story of Raimondo di Sangro’s struggles and pursuits. Di Sangro is portrayed in a redeeming light and described as a misunderstood man who was ahead of his time.

The advent of the internet has opened up new venues for the dissemination of the legend. A search on “Raimondo di Sangro” on the popular Google search engine (Google 2007) returned 79,000 entries. The content of the first 30 entries ranges mainly from esoteric to horror-related topics where the legend of the anatomical machines is often narrated with macabre overtones. Di Stefano’s own article is available on the web both in Italian and in English under the title “Raimondo di Sangro, the ‘Sorcerer’ Prince” (di Stefano 1996).

The above is only a sample of the attention the anatomical machines have attracted over time and the different reactions they have provoked. Perhaps also due to this conspicuous presence in the media, the anatomical machines have become again a regular sightseeing for tourists visiting Naples today.

4. Manufacturing techniques and raw materials

The heirs of Sansevero and current owners of the Sansevero Chapel hold all rights relating to the anatomical machines. Authorization for examination and sampling was kindly granted after detailed negotiations and the submission of a comprehensive work plan. Unfortunately, the amount of time for examination and the extent of sampling granted were quite limited, and thus the results of this study are only partial. Nonetheless, it suffices to determine the nature of the materials of the anatomical machines and their manufacturing techniques.
The models show a complex and delicate network of arteries, veins and capillaries of different thicknesses, colors and lengths. They are about 160 cm tall, the female is slightly taller. The male figure is mounted directly onto the wall. There are two lead alloy braces above each knee (Fig. 5), hooks drilled into each tibia and a large screw placed into the occipital bone of the cranium (Fig. 6). The female is mounted onto a plinth, attached to it from the feet (Fig. 7).

Fig. 5. Lead alloy braces help hold the male model onto the wall.

Fig. 6. There is a large screw placed into the occipital bone of the cranium of the male model.
Fig. 7. The female is mounted onto a plinth, attached to it from the feet.

The bones of the models are held together with metal pins, nails and wires (Figs. 8 and 9). Most of the bones are present in both figures but many of them seem either very or slightly out of place, suggesting that they may have been moved in the past. Some of the vital organs are

Fig. 8. The bones are held together with metal pins, nails and wires (see metal pin placed into the head of the humerus).
present but also seem misplaced. Although the organs were not sampled, visual examination suggests they may have been made with a core of wood which was coated with wax (Fig. 10). The enlarged aspect of the area where the uterus would have been suggests that the woman may have died either while or after giving birth (Fig. 11). No pubic symphysis (cartilaginous joint) could be seen between the pubic bones (Fig. 12).

Fig. 9. Wires and cables hold the bones in place.

Fig. 10. Visual examination of the organs suggests they may have been made with a core of wood which was coated with pigmented wax.
The crania were sawn open and copper alloy hinges were placed on either side (Fig. 13) so that the complex network of blood vessels present in the cranial cavity could be inspected. The crania were opened and copper alloy hinges were placed on either side (Fig. 13) so that the complex network of blood vessels present in the cranial cavity could be inspected. The

Fig. 11. The enlarged appearance of the area where the uterus would have been suggests that the woman may have died either while or after giving birth.

Fig. 12. No pubic symphysis (cartilaginous joint) could be seen between the pubic bones.
possibility of handling, opening and disassembling anatomical models was a frequent feature of their function as educational objects. The male has only 16 teeth, some with longitudinal cracks (Fig. 14). They seem to have been cut, sawed or sanded. It is not known when or whether the missing teeth were pulled out. The outer surface of the male’s cranium is clean, the female’s cranium, on the other hand, is covered with blood vessels (Fig. 15) and she has most of her teeth present.

Fig. 13. The crania were sawn open so that the complex network of blood vessels present in the cranial cavity could be inspected.

Fig. 14. The male has only 16 teeth; some have longitudinal cracks.
The feet of the male figure are missing (Fig. 16), so is one of his testicles and the fetus that used to lie by the female’s feet. The female’s structure is much sounder than the male model’s and her general appearance is more organized. However, they seem to have been made following the same techniques and using the same materials.

Fig. 15. The outer surface of the female’s cranium is covered with blood vessels.

Fig. 16. The feet of the male figure are missing.
Vessels from the two models were sampled in different areas. Altogether, 12 samples (from 3 mm to 30 mm long) were taken, 4 of them were already disassociated from the models. No material was collected from the organs or arteries due to their large dimensions and conspicuous locations. All samples were examined using transmitted and polarized light microscopy, scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). The results of these analyses show that the studied vessels have a core made out of a metal wire twisted with fibres, and coated with a mixture of pigmented waxes (Figs. 17 and 18).

Fig. 17. Some of the 12 studied samples. The results show that the studied vessels have a core made out of a metal wire twisted with fibers, and coated with a mixture of pigmented waxes.

Fig. 18. Core of some of the studied samples, after having the wax layer scraped off.
SEM analysis revealed that the metal wire is made out of an iron alloy. Transmitted and polarized light microscopy identified the fibers (twisted with the iron wire), as silk. FTIR analysis was used to study the wax. The resulting spectra showed it to be consistent with characteristics of bees wax. Interestingly but unsurprisingly, historic research showed that these materials were commonly used by modelers of the 17th and 18th centuries (Archivio di Stato di Bologna 1732, Archivio di Stato di Bologna 1742, Haviland and Parish 1970, Lemire 1990).

This study did not uncover any evidence to indicate that the anatomical machines were made following the techniques of injection. No evidence was found to indicate that the vessels of the cadavers used to make the so-called anatomical machines were injected with embalming substances.

On the contrary, all the evidence uncovered indicates that the circulatory system depicted on the anatomical machines was artificially fabricated with waxes, an iron wire and silk fibers, probably following techniques commonly used by anatomists of that time (Archivio di Stato di Bologna 1732, Archivio di Stato di Bologna 1742).

5. Conclusions

Di Sangro’s anatomical machines seem to have an undeniable capacity to evoke a codified imagery of dread and death. Arguably, their ghastly looks may have contributed to raise the curiosity and imagination of viewers. At the same time, lack of knowledge about their origins and manufacturing techniques has seemingly created a propitious ground for the development of a legend that situates them in the contexts of the narratives about human vivisection and the controversial handling of cadavers that has accompanied the history of anatomical practice. The anatomical machines provide a particularly interesting case study for exploring both the history of anatomical objects and the complex web of relations that are inscribed in historical artifacts. Having taken on different meanings at different times, and having been appropriated and reinterpreted in a variety of different arenas (as medical specimens, horror creations, mythical objects, curiosities, educational tools, etc), these anatomical objects offer a unique point of entry into the study and historical reconstruction of the ‘life of things’. The idea that things have a life of their own and as such may become subjects of biographical writing is not new. As Igor Kopytoff has put it (1986, 66), we may ask objects similar questions to those one asks in relation to people’s biographies. In order to understand ‘the life of things’, we need to consider their origins, originators, status, uses and careers in different times, cultural markers, changes caused by age and end of usefulness. Similarly, we need to understand the various phases of their existence, the impact the environment and social factors had on their lives, and their changing relationships with people.

By investigating the manufacturing techniques of the anatomical machines, this research has aimed at contributing to their biography. In the absence of appropriate documentary evidence, examination and instrumental analysis informed the understanding of material fabric of the models and allowed us to step back from the legend that has developed around di Sangro’s anatomical machines.
Furthermore, this study may also inform the conservation of similar anatomical models. Likewise, it may be useful in the discussions on the notions of authenticity and fabrications, and how those are affected by people’s perceptions and beliefs. All the controversy that has surrounded the Turin Shroud illustrates how hard it is to predict how collective imagery evolves (Hedges 1997). The different studies that have been carried out to assert the exact date of the origin of the shroud have done little to affect the faith some people have in it. In some ways, these studies have even been incorporated into the way the shroud is perceived. Similarly, the recent revelation that some of the material believed to be the relics of Joan of Arc may in fact have been made from the remains of an Egyptian mummy (Buttler 2007) also has the potential to cause further debate about the relationship between notions of authenticity and the perception of historically charged objects.

Although the conclusions drawn from this study are at variance with the content of the legend developed around the anatomical machines, our aim has not been to set it aside. Rather, the process of investigation has made it possible to revisit the legend in light of the variety of interpretations and re-appropriations that have characterized the life of these anatomical models. By drawing attention to the complex historical interplay between texts, oral traditions and artifacts, this study enriches our understanding of the history of anatomical models, their place in the material culture of medicine and their role as sources of knowledge.

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3D SCANNING OF DEER STONES ON THE MONGOLIAN STEPPE

Harriet F. (Rae) Beaubien and Basiliki Vicky Karas

Abstract

The Smithsonian’s Museum Conservation Institute has been exploring the use of 3D imaging technology in conservation, including field applications. As part of a collaborative Mongolian-Smithsonian archaeological project in northern Mongolia, MCI conservators tested this technology in the documentation of Bronze Age carved stone monuments during the 2005 and 2006 field seasons. This paper discusses our experience with two different types of portable 3D scanners (laser and structured-light), and the conservation uses of the data.

1. Introduction

Deer stones have been a significant focus of research for the Joint Mongolian-Smithsonian Deer Stone Project (DSP), a multi-disciplinary collaboration working in northern Mongolia since 2001 [1]. Hundreds of these carved stone monuments, dating to approximately 3,000 years BP, are distributed across Mongolia’s vast steppe (Figs.1, 2).

Figure 1. Ulaan Tolgoi site, showing deer stones and associated burial features (Photo by P.T. DePriest 2004).
They are considered to be among the most important archaeological treasures of Central Asia, yet very little is understood about their age, stylistic development, function and meaning within the cultural contexts that produced them. This is due in part to their geographic isolation, which has hampered systematic documentation and archaeological investigation. They are additionally endangered by unprotected exposure to harsh environmental conditions, with on-going deterioration from weathering, biological effects and, increasingly, human impact. These factors give high priority to research and documentation efforts, which the DSP has incorporated into its program of investigations in the northernmost province of Hovsgol aimag.

Documentation activities, carried out by conservators from the Smithsonian’s Museum Conservation Institute (MCI) since 2005, include the use of 3D scanning technology [2]. The technology provides an effective, rapid, accurate and non-contact means of capturing accurate and detailed topographic information in digital format. This paper presents an overview of 3D scanning during the 2005 and 2006 field seasons of the Deer Stone Project, using two different portable scanning methods, and the anticipated conservation uses of the data.

2. Deer stone documentation

Deer stones – often surrounded with ritually buried deposits of horse crania, cervical vertebrae and hooves, and associated with larger stone burial complexes called khirigsuur – are thought to be commemorative monuments of leaders of nomadic peoples who inhabited the steppe during the Bronze Age-Early Iron Age. They are typically ornamented in low-relief carving with a zone of ornately antlered creatures, framed by ring elements and belt-like bands hung with various
tools.

Of the estimated 700 found in the steppe regions of Central Asia, over 550 are in Mongolia alone. No comprehensive inventory of these monuments currently exists, although a publication by Volkov (2002), a Russian researcher working Mongolia in the decades prior to its independence in 1992, provides a useful foundation and is one of the few accessible resources. He catalogued approximately 400 deer stones from 82 sites, and illustrated a small percentage of these with sketch drawings. In general, documentation of all but a few of Mongolia’s deer stones is incomplete, and generally limited to selected photographic views and non-technical drawings.

An early attempt to document a deer stone in three dimensions was carried out by the DSP in 2002 using a conventional mold-making process, with a stone famous for its unique incorporation of a human face in its iconography (Ushkiin Uver DS #14). It was robust enough to withstand applications of liquid soap, silicone rubber and polyurethane foam mold layers, in a process that took several days, carried out by skilled model-makers and with imported materials. The mold was brought back to the Smithsonian, and several casts were made at the Office of Exhibits Central, one of which was later returned to the National Museum of Mongolian History in Ulaanbaatar for display (Fitzhugh 2002, Fitzhugh 2003a:31). The limitations of this molding and casting approach for documenting deer stones, many of which have weathered and deteriorating surfaces, encouraged MCI to propose the use of 3D scanning technology as part of the documentation effort, which would also include systematic photography, descriptive information and condition records.

3. Laser scanning - 2005 Field Season

The 2005 field season of the Deer Stone Project was our first opportunity to test the feasibility of using 3D scanning as a field documentation tool, based on preliminary work carried out by Karas (then-MCI conservation fellow) (Karas 2006). The scan team consisted of the authors, as well as Carolyn P. Thome (model-maker, Smithsonian’s Office of Exhibits Central), who was involved in the molding and casting of Ushkiin Uver DS #14 three years earlier. During a three-week period in the field (June-July), the team conducted tests on twelve deer stones at six sites in Hovsgol aimag, as described in the following sections.

3.1. Scanning equipment

A handheld Polhemus FastSCAN Cobra laser scanning system was used by the MCI scan team in 2005. Its key components are the wand (range finder), the transmitter, the reference receiver (optional) and the processing unit, all safely transported in a customized Pelican 1610 case (Fig.3).
The Polhemus system software was run on a Hewlett-Packard Pentium IV laptop computer. The computer and scanner were powered in the field by a portable Honda EU1000i generator developed specifically for use with precision equipment.

3.2. Scanning process (general)

A 3D data file for the object is constructed from a series of “sweeps” of the wand, which is moved in a controlled motion approximately 10-15 cm above an object’s surface (Fig.4).

The wand projects laser light in a thin line (<10 cm in length), at a wavelength of 670 nm, through a centrally-mounted laser line generator. The wand operates at a scanning rate of 50 lines per second and with a resolution of 0.5 mm (Polhemus 2001; Polhemus 2004). A profile of the object’s surface, consisting of thousands of 3D coordinate points, is created at every intersection of the laser line with the surface. The miniature camera in the wand simultaneously records the changes in surface shape, based on varying angles of reflectance of each profile, and each point is individually located in 3D space through triangulation (Fig.5).
The triangulation process relies on the fixed position of both laser-line generator and camera, and the transmitter which generates magnetic fields in three directions. The amplitude of these fields locates the position and orientation of a receiver mounted in the wand. One component must maintain a fixed (unchanging) relationship with the scan subject, and two options can be followed. The first uses the transmitter as the fixed datum, which means both it and the object must remain immobile during scanning. In this case, the computer locates each profile relative to the transmitter. The second option (used in the Mongolia project) uses a small reference receiver, which is attached to the object surface to serve as the fixed datum. In this configuration, the computer locates each profile relative to the reference receiver rather than the transmitter, which can be moved or carried during scanning; the object with its attached receiver can also be moved as needed. During scanning, the area of the attached reference receiver is avoided until the end, when a final procedure is carried out: the transmitter is anchored and temporarily established as the fixed datum, the reference receiver is removed, and the final missing area is scanned.

With either configuration, scanning must be carried out in a single episode. During scanning, the digitized 3D information conveyed by all these components is calculated by the processing unit and the computer, and is simultaneously mapped by the system software in graphic form; this is displayed on the computer screen, and serves to guide the progress of scanning. The “raw data” can be displayed in point-cloud, wire-frame, or solid graphic formats. Note that color information is not collected by this system.

3.3. Field procedures

The portability and compactness of the laser scanning system were ideal for use in the field, but several features posed challenges in creating a suitable scanning environment for each deer stone: sensitivity to direct sunlight, which interferes with the data capture; poor performance in cold environments; and inability to be used in the vicinity of metal objects, given the system’s use of magnetic field triangulation and resulting distortion in spatial data. To create adequate conditions for scanning during the day, temporary tent-like shelters were built over the deer stones using wooden poles (including 5-meter lengths borrowed from nearby animal corrals) which were draped with medium-weight canvas (40 m, sewn into a 10 m x 6 m panel),
supplemented inside with light-weight black fabric (Fig.6).

![Figure 6. Shelter set-up used for laser scanning, shown with Ulaan Tolgoi DS #5 (Photo by H.F. Beaubien, 3 July 2005).]

The scanning configuration included use of the reference receiver, attached to the deer stones using lightly applied adhesive tape. One person scanned with the wand, another provided guidance based on the computer display, and another adjusted localized shading.

In 2005, a total of 12 deer stones were scanned, 9 of which resulted in complete data files [3]. One of the 3 incomplete data files was that of Ulaan Tolgoi DS #2, the tallest known deer stone at 3.8 m (visible in Fig.1). Its great height exposed a shortcoming of the Polhemus system. The reliance on a fixed datum point and functional range limits between the system components meant that objects over a certain size could not be scanned as a single unit; in this case, files for upper and lower halves were generated. The data quality was also inferior, because of the difficulty of shading the stone during scanning. For the successfully scanned deer stones, an average of 2 to 3 hours each was required for setting up the shade shelter and scanning; two could be completed in a day’s time.

3.4. Data processing

The raw data files collected for each scanned stone ranged in size between 23 and 96 MB, and were easily stored on the laptop computer. It is typical that scan data files are flawed by noise (areas of light interference, overlapping data) as well as areas missed in scanning (Fig.7).

These are cleaned up in a series of post-processing steps that require considerable time. The Polhemus data in particular contain noise derived from an inherent weakness in the working properties of the hand-held laser scanner and system software.
Raw data from each of the deer stones were processed by Karas in two steps, which required a total of approximately 12 hours per deer stone data file. The first step used the Polhemus system software, in which the sweeps were aligned (or registered) and merged to produce a “basic surface.” The system software could be used to cut out data from adjacent materials (grass, ground surface) as well as extraneous noise resulting from light leakage, but most of this work was impractical to do in the field. Any further editing also required more sophisticated software, so was done later at MCI. Using the system software, the basic surface files were saved as stereo tessellation language files (STL), a commonly used format for non-color data, and imported into other 3D graphic software for the second step of editing.

The 3D graphic software principally used for editing was Rapidform XOS (INUS Technologies Inc.); PolyWorks (InnovMetric Software Inc.) was also used in processing one of the files. The most problematic noise was imperfect surface data that appeared as numerous irregular spikes in the polygonal mesh. These were extremely difficult to remove without losing good data in the surrounding mesh. As a result, the spikes were mechanically reduced as much as possible but not completely removed, in order to minimize data loss, and thus are still visible when viewing STL files from all laser scanned deer stones.

Filling voids in the data was also carried out in this software, which allows the operator to select the particular holes to fill and creates a fill by extrapolating curvature from the data mesh surrounding the hole. This program displays the fills as a uniform mesh (in mesh view), or as smooth patches for larger fills (in solid view), so that fills are always detectable. The fully processed data files are saved as new STL format files, for archival purposes and use in other applications (Fig.8).
4. Structured light scanning – 2006 Field Season

The promising results from scanning in 2005 encouraged MCI to acquire a different type of scanning system that was specifically developed for cultural heritage applications, and to test its use in the field. The 2006 scan team consisted of the authors and Leslie G. Weber (then-MCI conservation fellow), along with an archaeological assistant, Songuulkhuu Namjil. During a three-week period in the field (June), the team scanned 15 deer stones and three fragments at two sites, as described below.

4.1 Scanning equipment

A Breuckmann triTos (GmbH) structured light system was used for scanning in 2006. Its components include the tripod-mounted sensor bar (in this case 30 cm long) with projector and camera, and the controller, safely transported within a custom-made hard case (Fig.9).

The structured light projection is calibrated using optical calibration plates, housed separately. The camera lenses are interchangeable to give varying fields of view; in this case, 675 mm lenses were used, which allowed a field of view for each “patch” of 67 cm on the diagonal and a working distance of 1.085 m. The triTos system software was run on a Hewlett-Packard Pentium IV laptop computer. The computer and scanner were powered in the field by the Honda generator used in 2005 and stored in the interim in Ulaanbaatar.
4.2 Scanning process (general)

A 3D file for the object is constructed from “patches” of data that are stitched together during the scanning process. For each patch, the proper working distance is established by aligning two laser dots on the object’s surface, and then a series of organized patterns of structured light is projected in quick succession (Fig.10).

The patterns are simultaneously photographed using a digital camera that is aligned with the projector. The photographic images capture the edge distortion of the projected light pattern as it strikes the object, as well as color information. The system software processes the distortion and color information to generate 3D point cloud data. Because the point cloud’s (XYZ) range and (RGB) color values are recorded together, the color information is registered exactly with its corresponding 3D point. After the light sequence is completed, the patch of new data is displayed graphically on the computer screen; it can be added to the previously acquired data by aligning several overlapping surface feature details. The data file can be temporarily closed and re-opened, which allows the scanning process to be carried out in more than one phase if necessary.

The triTos system has a triangulation angle of 20 degrees, which allows for fewer scans and
better data capture on objects with complex geometry, e.g., areas of high relief, although the tripod mounting can also inhibit access to some surfaces. Even with the lowest resolution lens, the resolution is 15-20 microns.

4.3. Field procedures

The structured light scanning system is somewhat sensitive to light conditions, which can affect contrast in the light patterns projected onto the object. As in 2005, day-time scanning required that temporary shade shelters be built over the deer stones, but these also needed to accommodate the 1.085 m working distance between the tripod-mounted camera and surfaces to be scanned. We modified our earlier shelter design by using traditional ger (yurt) walls to form a spacious rigid enclosure, in conjunction with a superstructure of wooden poles and canvas to create a relatively light-tight tent-like structure (Fig.11).

The Breuckmann scanner did not have the Polhemus’ temperature sensitivity, so we were also able to scan at night, making a shelter unnecessary (Fig.12).
During scanning, one person operated the computer, another handled the tripod, and another assisted with shading and the tripod.

In 2006, 15 deer stones (one in three parts) and three additional fragments were successfully scanned, including Ulaan Tolgoi DS #2, which had posed problems in 2005 [4]. Night scanning proved to be the most effective arrangement, unrestricted by the shelter and providing ideal light-contrast conditions to produce excellent data. Because of its more cumbersome tripod mounting, however, scanning with the Breuckmann required more time than with the Polhemus, averaging at least 5 hours per stone.

### 4.4. Data processing

The raw data files from structured light scanning are very large, but can be stored on the laptop computer. For example, the largest deer stone (Ulaan Tolgoi DS #2) produced a 4.34 GB file, and after processing a 366 MB STL file. The data files are generally of excellent quality and relatively unflawed. The minimal noise arises from overlaps and alignment during scanning, and is easily filtered out during processing. Given logistical constraints in the field and computer memory requirements, however, this phase took place at MCI. The files were processed by Karas in two steps, requiring a total of approximately 6 hours per deer stone data file.

In the first step, the triTos system software (Optocat 2006) was used to convert the raw data files into STL and PLY files. The PLY format, in particular, is designed to store 3D data with a variety of properties, such as color information, surface normals and texture coordinates; these features allow the front and back side of the surface data’s polygonal mesh to have different properties. These were exported to Rapidform (XOS or 2006) 3D graphic software, used in the second step for all further processing. This included alignment, merging and filling holes (the latter as described in the Laser Scanning section above). The fully processed data files were saved as new STL and PLY format files, for archival purposes and use in other applications (Figs. 13, 14).

![Figure 13. Ushkiin Uver DS #2: computer screen view of the 3D digital file processed from structured light scanning, shown in STL format during editing in Rapidform (Photo by B.V. Karas, 2007).](image)
While color capture is considered a desirable feature of this scanning system, in practice accurate color information (acquired by the digital camera) requires stringently consistent lighting conditions. These are not possible to achieve in a field situation, and as a result our PLY files have a distracting patchwork appearance from subtle variations in lighting as each data patch was acquired. Note that the topographic information, determined by edge distortion of the projected light patterns, is not affected by these variations, as seen in the STL files.

5. 3D Results and data applications

Field scanning in 2005 and 2006 produced complete 3D digital files for 24 deer stones and 3 additional fragments from the Hovsgol aimag sites of Evdt Valley 1, Ulaan Tolgoi, Erkhel East 1, Erkhel North 1 and Ushkiin Uver [2, 3]. The processed STL files, which are viewed using downloadable Free Viewer versions of the 3D graphic software, provide an often clearer view of decorative and technical features than photographs, and can serve as the basis for accurate drawings and other graphic products, as the example for Ushkiin Uver DS#14 produced at MCI by Melvin J. Wachowiak (2007), seen in Fig.15.
Figure 15. Ushkiin Uver DS #14: computer screen views of the four sides, taken from the 3D digital file (STL format) processed from structured light scanning. The roll-out illustration with vector overlays of images was created using Adobe Photoshop and Illustrator (Photo by M.J. Wachowiak/B.V. Karas, 2007).

Metrological tools, which allow precise measurements to be taken between any set of points in the data file, are providing accurate dimensional information (Fig.16).

Figure 16. Ulaan Tolgoi DS #5: computer screen view of the 3D digital file (STL format), with height calculations in Rapidform (Photo by B.V. Karas, 2007).

Contour lines allow data slices to be made for cross-sectional measurements, and to define baseline planes for use with color mapping or digital elevation tools. These tools could potentially be
used to monitor surface changes, such as erosion (Fig. 17).

Thus far, MCI has tested several techniques of 3D model production using the STL files, with the assistance of the Smithsonian’s Office of Exhibits Central (OEC) and other commercial providers. These include computer numerical controlled (CNC) milling, where the data are used to guide the cutting tools, and rapid prototyping (also called 3D printing), where thin layers of casting resin are selectively cured in areas corresponding to data slices in the STL file (Figs. 18, 19).
Models (positives) can be manufactured at any scale and in a range of media; molds (negatives) can also be made from the STL file for conventional production of casts.

6. Conclusion

In summary, scanning offers a rapid, accurate and non-contact method of capturing 3-dimensional information with many applications in conservation, including in the field. The scan files can be graphically displayed in a number of ways to provide detailed iconographic, metrological and technical information for scholarly study. They can be used to record and monitor condition on a fine scale, and to carry out virtual reconstruction and compensation of loss. Models or replicas produced from the scan files offer greater accessibility for museums and research endeavors, and can potentially be used as in situ surrogates for severely threatened originals that can be removed to a suitable, protective and secure environment.

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Endnotes

1. The team, under the direction of Dr. William W. Fitzhugh (Arctic Studies Center, National Museum of Natural History), includes Smithsonian specialists from the Anthropology, Botany and Exhibits departments of the National Museum of Natural History, the Office of Exhibits Central (OEC), and the Museum Conservation Institute (MCI). Mongolian counterparts are from the National Museum of Mongolian History and the Mongolian Academy of Sciences, including the Institutes of Archaeology and of History, with the support also of the American Center for Mongolian Studies in Ulaanbaatar. For an overview of the DSP and archaeological site reports for each season, see Bayarsaikhan et al. 2005; Fitzhugh 2002; Fitzhugh 2003a; Fitzhugh 2003b; Fitzhugh 2004a; Fitzhugh 2004b; Fitzhugh 2004c; Fitzhugh 2005a; Fitzhugh 2005b; Fitzhugh et al. 2005; Fitzhugh 2006; Fitzhugh 2007; Neighbors 2005; Ochirkhuiag and Baiarsaikhan 2004. For regional survey reports, see Frohlich et al. 2004; Frohlich et al. 2005; Frohlich and Bazarsad 2006; Frohlich and Tsend 2007; Wallace and Frohlich 2005.

2. MCI’s field documentation activities in 2005 and 2006 are reported in Beaubien 2006; Beaubien and Karas 2006a; Beaubien and Karas 2006b; Beaubien et al. 2007a; Beaubien et al. 2007b; Karas and Beaubien 2007; Karas et al. forthcoming

3. Complete 3D data files were produced for the following: Ulaan Tolgoi (Erkhel Lake) DS #s 1, 3, 4 and 5 (MCI 6085, see Karas 2007d); Erkhel East 1 DS #s 1 and 2 (MCI 6086, see Karas 2007b); Erkhel North 1 DS #s 1 and 2 (MCI 6087, see Karas 2007c); Evdt Valley 1 DS #1 (MCI 6088, see Karas 2007a). Incomplete 3D data files were produced for the following: Ushkiin Uver DS #1, Tsatstain Khoshun DS #1; Ulaan Tolgoi DS #2. Data files are archived at MCI, under project #s, as noted.

4. Complete 3D data files were produced for the following: Ushkiin Uver DS #1-#14 plus 3 fragments (MCI 6084 on-going, and MCI 6089, see Wachowiak 2007); Ulaan Tolgoi DS #2 (MCI 6085, see Karas 2007d). Data files are archived at MCI, under project #s as noted.

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A NEW METHOD FOR CLEANING MARBLE

Kory Berrett, Virginia Naude and Richard Wolbers

Abstract

This paper describes a recent treatment project that succeeds in providing deep cleaning of stained marble where traditional methods had failed. The treatment methodology builds on poulticing techniques using an aqueous cleaning system delivered with a gel-paste poultice mixture. Two materials new to conservation are introduced: a gelling agent, Vanzan NF-C, that is especially effective for aqueous media and can tolerate an unusually wide pH and ionic strength range while maintaining high viscosities; and nitrilotriacetic acid (NTA) a chelator for calcium ions able to disrupt relatively insoluble calcium salts, and staining agents formed by residues of prior treatments (detergents, soaps, coatings, etc.), without affecting the calcium carbonate itself. This new approach promises to be useful for similarly stained marble sculpture.

Background

A new method for cleaning marble was developed under the sponsorship of the Union League of Philadelphia. Located at Broad and Sansom Streets, a few blocks from Philadelphia City Hall, the Union League occupies an 1865 brownstone French Renaissance style building and a conjoined 1910 Beaux Arts building. The architectural complex houses an extensive collection of painting and sculpture as well as an important archive and library of Civil War history.

The Union League was among the first private institutions in Philadelphia to work with conservation professionals in caring for their collections. Following the establishment of programs to address the needs of the archives and the paintings collections, the sculpture collection was surveyed in the mid 1980s and treatment projects were designed to go forward annually.

This paper describes the treatment of two marble figures: the first, “America Mourning Her Fallen Brave” is a life-sized allegorical figure carved in 1867 as a response to the American Civil War by Philadelphia sculptor James Henry Haseltine. The work includes elements that symbolize both the Union and Confederate causes.

The second, “Esmeralda” is by an unknown artist. The image represents the Gypsy girl Esmeralda and her goat Dalji, characters from French novelist Victor Hugo’s famous work “The Hunchback of Notre Dame”, published in 1831.
These figures were cleaned in 1988 as part of a program to improve the appearance of the five major marble sculptures in the entrance spaces. No records of past treatment were available. It seemed likely that housekeeping staff had included the objects in their routine maintenance and possible that outside advice had been solicited for occasional treatment. Virginia Naudé and a team from Norton Art Conservation Inc. removed an opaque, buff, water-soluble wash that may have been applied to disguise staining in the stone. Underneath the wash they encountered grime, passages of wax and occasionally areas of paint. The 1988 treatment consisted of an overall cleaning using deionized water and Stoddard solvent emulsion (mixed 1:1 with a Synthrapol-N non-ionic detergent serving as an emulsifier) followed by localized use of organic solvent and commercial stripers where necessary. After cleaning, a wax-resin varnish was applied consisting of 3 parts Cosmolloid 80 H microcrystalline wax and 1 part Laropal K-80 resin in Stoddard solvent. This formula was developed at the Victoria and Albert Museum (Hempel and Moncrieff...
1972). The resin was added to harden the surface and make it easier to routinely water clean in galleries that have constant particulate dirt problems. It was used here to protect the marble surfaces from food and beverage spills in the Club’s busy reception spaces and to enable staff to water wash any incidental markings or spatters.

Although after cleaning the marble surfaces were acceptable and the sculptures’ presentation was markedly improved, there was a distinct discoloration that had failed to yield to any combination of solvents or poultices tested during treatment. It appeared that some material was lodged subsurface that did not yield to available methods and materials. Although the color was not dissimilar to the lighter orange areas in iron staining patterns on marble, the uniformity and consistency of the overall color was familiar from past experience with the effect of a treatment or coating application.

Naudé returned to address this dilemma as other sculpture conservation projects went forward at the Union League, testing the discolored surfaces with non-polar solvent gels, buffered ammonium citrate solutions and proprietary paint strippers as these systems were developed and came into use by sculpture conservators. The turning point occurred during a major architectural renovation in 2004 when improving the visual appearance of the marble sculpture became a high priority. The conservator and the staff of the Union League responsible for the art collection agreed that identification of the subsurface material, and the design of a treatment targeted specifically at its removal, was the appropriate next step. The client understood that it would probably be necessary to remove a small stone sample. More importantly, they knew that the research and testing program they were asked to fund was not guaranteed to succeed. Hence, the Union League’s commitment to the collection was essential to the development of this method.
Analysis

Berrett removed a small fragment (approximately 1 cm³) of the stone from a curl on the underside of the goat’s tail, an unobtrusive area on the reverse of the “Esmeralda” group, using a Dremel tool. Wolbers mounted the sample in Extec polyester resin and cross-sectioned it using a disc-type sander (Sears) and an array of graded bound-abrasive cloths (Micromesh). In cross section, the staining material was yellowish in normal light, lightly auto-fluorescent under UV-blue light illumination conditions, and clearly penetrated the porous stone surface up to an average depth of 50 µm (0.05mm).

Figure 4 (left). Normal light view, Magnification 125 X Nikon Excite 120 Xenon lamp; cross-polarized. Photograph by Wolbers.

Figure 5 (right). Violet excitation, Nikon BV-2A cube; EX 400-440, BA 470nm. Photograph by Wolbers.

The staining material was a heterogeneous mixture of oily or lipid materials ranging from normal surface soil deposition material to residuals from both applied paints, and paint removal agents (positive staining with lipid soluble fluorescent dyes). As expected, the surface also appeared to contain a continuous non-fluorescent clear coating, and a second distinctly turbid non–fluorescent material applied over it, consistent with the conservation records noting that both a wax (Cosmoloid 80H) and a synthetic resin (Laropol K) had previously been applied to the surface.
The cross-sectioned sample was stained with reactive fluorescent dyes, and yielded positive results for both lipid (+Rhodamine B) and fatty acid moieties (Bromomethylmethoxycoumarin) on staining.

Figure 6 (left). Green excitation stained with RHOB, (.02% Rhodamine B in ethanol). Photograph by Wolbers.

Figure 7 (right). Violet light stained with BMMC (6,7 Bromomethylmethoxycoumarin .25% in acetone). Photograph by Wolbers.

This suggested that both lipid moieties were present in the sample and that in all likelihood calcium salts of these fatty materials would be present as well, given the CaCO$_3$ matrix of the stone. The presence of even weakly acidic materials like long chain fatty acids might initiate the breakdown of CaCO$_3$, and yield calcium salts of these fatty acids which are highly insoluble materials normally (Pohle 1944). It also suggested that a combination of surfactant and chelating cleaning systems might be the most effective approach to removing the soiling materials.

Testing

Reaching the deeper soiling and staining materials within the stone surface first required reducing the overall surface burden of wax-resin material (the protective coating applied in 1988). A xylene gel was chosen for this, because pure solvents that would solvate the wax and resin materials would risk driving more material into the porous stone surface at the moment of their dissolution. Solvent gels like the one used are essentially surfactant and polymer complexes carried in solvent systems (Wolbers 2000). The surfactant in this case was Ethomeen C-12 (Akzo Chemie, available through Talas, NYC) an ethoxylated cocamine derivative. As a ‘basic’ material, the Ethomeen could be bound ionically to a polyacidic material like Carbopol 954 (a
polyacrylic acid material produced by B.F. Goodrich, available through Talas. NYC) to form a stable polymer/surfactant complex. The Ethomeen still retains much of its surfactant-like character, even ‘bound’ to the polymer. The advantage is two-fold in this arrangement: the viscosity of the gels produced from low concentrations (1-2% w/w) in solvents of surfactant-polymer complex are quite high (40-60K centipoise), limiting diffusion of materials into the stone surface. An added benefit is the relative ease in clearing these materials from even porous surfaces; the polymer-surfactant complex is so high in molecular weight that they are physically restricted from penetration and more likely to be retained at the surface.

The composition of the xylene gel used was:

100ml xylene  
20ml Ethomeen C-12  
2 g Carbopol 954  
1ml de-ionized water

The gel was applied to the stone surface in areas 10 cm square, allowed to dwell for one minute, stirred with a soft brush, and wiped from the surface along with solubilized materials. The area thus treated was then rinsed and cleared with mineral spirits to remove the last remnants of gel.

After surface cleaning and coating removal, discoloration of the stone remained. As a second stage of cleaning, a poultice approach was chosen to allow for extended contact time, provide an absorbent matrix for retention of solubilized materials, and to effectively bring the required surface chemistry to bear on the residual staining or soiling material present both at the surface and deep within the stone.

The aqueous phase in the poultice featured a chelating material, nitrilotriacetic acid. The log dissociation constant for NTA with Ca$^{+2}$ (7.60) favors the formation of Ca$^{+2}$ NTA complexes in the presence of various other calcium salts, but not the dissociation of the stone substrate itself (log $pK_{sp}$ CaCO$_3$ is 8.54). Under essentially CO$_2$ free conditions (e.g. under a gel or poultice) where air is restricted severely at the substrate surface or is completely unavailable, the most stable pH for a carbonate like marble is about 10.3 (Livingston 1992). At pH values this high however NTA would be of little use since, like most of the common anionic chelators, NTA works best above its highest $pK_a$ (5.5) and below pH 9. By way of compromise, the pH of the cleaning system was elevated to about 9 using a sodium borate ($pK_a$ 9.3) buffering system. A non-ionic surfactant (Triton XL-80N) was also included because of its general compatibility with the other ionic materials in the mixture (Triton X:-80N is an alkylxypolyethyleneoxy-polypropyleneoxy ethanol type surfactant produced commercially by Union Carbide. As a neutral or non-ionic structure, it can be mixed with other ionic solutes without precipitating them from solution.) The HLB for Triton XL-80N is 12.5, and is just sufficient for detergency and solubilization of likely residual soiling, coating, and staining materials (‘HLB’ is an acronym for ‘Hydrophilic Lipophile Balance’ number, which defines a surfactant’s functionality and strength. See Wolbers for more detailed discussion of surfactants and HLB number in aqueous cleaning systems).

To summarize, the poultice contained the following aqueous solution:
100ml de-ionized water
0.5g sodium borate
0.5g NTA
6 drops Triton XL-80N

A small volume (approximately 2ml) of a dilute sodium hydroxide solution (1M NaOH, Sigma Aldrich) was added to induce rapid dissolution of the NTA and then the pH of the mixture was re-adjusted between 8.5 and 9 with a dilute HCl solution (1M HCl, Sigma Aldrich) using a calibrated standard glass electrode pH meter (Oakton, model WD-35624-22 pH Tester). Next the Triton X-L80N was added to the solution. The solution was then gelled using a xanthan gum, Vanzan-NFC (1% w/v, Vanderbilt Chemical Co). This gelling agent is especially effective for aqueous media and can tolerate an unusually wide pH and ionic strength range and still maintain high viscosities. The gel was then further modified into a gel-paste by adding an equal volume of Whatman CF-11 cellulose fiber to create both a viscous and absorbent matrix for the poulticing effect. The texture of the gel-paste poultice can vary depending on the ratio of cellulose fiber added to the mix, from a light ‘meringue’(5:5) to a consistency more like bread dough (5:7). Spot tests revealed that changes in texture affected the handling characteristics of the material without altering is effectiveness. During the treatment phase we found the dough consistency was easier to apply and to remove. Examination of the stone surface after treatment using 5X and 10X magnification revealed that the surface polish of the sculptures were undisturbed.

This two-step cleaning process was spot tested in situ over two days. In all, more than three dozen small cleaning tests were performed, with adjustments to working variables including changes to pH within the range of 8.0 to 10.0; and changes to dwell time between two and 20 hours, using a layer of thin polyethylene wrap to prevent evaporation. At the conclusion of the testing phase a contact time of 6 hours was established as the minimum needed for optimum performance. The final test areas were prominently located to help convince the decision makers the treatment method showed promise.

Treatment

The proposal for treatment included seven steps: 1) vacuum to remove loose dust and soil; 2) remove the old wax-resin coating and embedded soil using xylene gel; 3) clear the gel with mineral spirits using pre-cut absorbent cotton pads (Webril, Handi-Pads, available from Talas, NY) and cotton swabs; 4) apply the NTA gel paste poultice and cover with polyethylene film; allowing the mixture a minimum of 6 hours to work; 5) clear the gel paste using paper towels, Webril pads and swabs; 6) clear all residues with thorough water washing; and finally, 7) apply a protective coat of Renaissance microcrystalline wax. The wax-resin mixture previously applied has been reported to be more difficult to remove than wax alone. Since the new installation location did not require frequent washing the less complex coating was selected.

The sculpture “America Mourning Her Fallen Brave” was treated in the fall of 2005. Scaling up the method to a level appropriate to accomplish these treatments required an estimate of surface
area for each sculpture, acquisition and preparation of materials, and relocation of the sculpture to a well-ventilated work site. The firm of George Young Company, Philadelphia, was contracted to move the sculpture and its two base elements to a work space in their warehouse. The sculpture and its base support were disassembled and moved in sections. This work space featured large doors on either side, allowing cross ventilation and diffuse ambient light from daylight. At the work area short piers of timber were erected to hold each of the elements above the floor at a reasonable working height.

The first treatment step after photographic documentation was vacuuming all surfaces to remove loose soil. Next the old coating of wax and grime was cleared using xylene gel, working from bottom to top. The xylene gel proved to be very efficient and could be cleared almost immediately using mineral spirits and cotton pads. This step required personal protective gear including respirators with organic vapor cartridges and disposable gloves rated for xylene exposure.

Once several broad passages were cleared of the old coating the gel-paste poultice was applied. The extended dwell time dictated a rhythm to the treatment’s execution, with gel-paste poultice applied as the last step in the afternoon, followed by clearing of the gel-paste poultice the following morning, some 16 to 18 hours later. This working interval was a matter of convenience since no significant variation in results between the 6 hour minimum and longer exposures was noted during testing (Fig. 8).

After clearing and rinsing the previous day’s poultice, the next adjacent section was cleared of wax and subsequently treated with gel paste poultice. No tide lines or visible boundary lines were observed as newly treated areas overlapped previous work (Fig. 9).

Figure 8. “America Mourning Her Fallen Brave”. Detail; poultice has been applied over half of the face, covered in plastic wrap, and left overnight. Photograph by Berrett.
During work it was useful to reserve an area that demonstrated this difference for a variety of visitors to the work site. Throughout the treatment process clearing the stone of both previous and current working materials was of critical concern. As work proceeded, each area was cleared of bulk material, then rinsed repeatedly with water and wiped dry (Figs. 10, 11).

Some of the deeper recesses required additional applications. In a few crevices the final cleaning was accomplished using a steam machine (Robby Steam machine VS 3000, 45-65 psi.).

When the sculptures were disassembled for movement to the work site, the base under each was found to include an internal metal armature that also required treatment. At the top of the hollowed base element there is set into the stone an iron ring with three spokes and a raised pin at its central hub. This fixed installation receives a wheel with five-spokes. Each spoke terminates with a steel roller (Fig. 12).
Figure 10 (left). “Esmeralda”. Poultice applied over left arm, shoulder, and right forearm sections. Photograph by Naudé.

Figure 11 (right). “Esmeralda”. After removal of poultice and clearing of working materials. Photograph by Naudé.

Figure 12. “America Mourning Her Fallen Brave”. Iron armature in upper section of base, rotating arm piece turns on central pin, after treatment. Photograph by Berrett.
The rollers move between the iron ring set in the base and a corresponding ring set into the lid, allowing the sculpture to be turned manually (Fig. 13).

It was not uncommon in the Victorian period to provide decorative handles to allow the viewer to rotate the sculpture on its base and consider the work in a different light. On both of these base units it was possible to thread decorative brass handles into steel bushings set into the stone allowing a change in orientation with very little effort. The iron elements were vacuumed and then cleaned of superficial rust using synthetic abrasive pads (3M Scotch-Brite) to loosen soils and oxidation without scratching the metal, and mineral spirits on cotton to clear surfaces. The cleaned metal was rinsed and dried with ethanol followed by acetone and then coated with microcrystalline wax applied with heat.

Small compensations to both sculptures were made using the mixture of polyvinyl acetate AYAC, ethylene acrylic acid copolymers A-C 540 and 580, and Irganox 1076 (Gänsicke and Hirx 1997). The fills were colored prior to application by adding Golden PVA paints into the melt chosen because the commercially prepared paints disperse more readily into the resin mixture than pure pigments (see Figs. 14, 15).

“Esmeralda” was treated in late January and early February of 2007 using the same materials and techniques. This project was carried out in a secure and well-ventilated area in the basement of the Union League building. The heavier soiling and deeper staining of this work resulted in even greater contrast between its ‘before’ and ‘after’ treatment, appearance (Figs. 16, 17).
Figure 14. “America Mourning Her Fallen Brave”. Overall view, before treatment. Photograph by Berrett.

Figure 15. “America Mourning Her Fallen Brave”. Overall view, after treatment. Photograph by Berrett.
Conclusion

In many ways this treatment is typical of the solubility problems that conservators confront routinely on these kinds of surfaces. The accumulation of coating materials, waxes, polishes, and residues from prior treatments (detergents, soaps, salts of acid and bases from cleaning, etc.) tend not only to occlude these surfaces, but present special challenges to the conservator in terms of the wide variety of materials likely to be encountered and in need of removal. One unifying feature in these cases is the inevitable presence of calcium itself from the substrate material, and concomitantly, the formation of relatively insoluble calcium salts with weakly acidic materials in these mixtures that make them so seemingly intractable. NTA as a chelator for calcium ions in particular will be a useful tool for conservators working on marble cleaning problems. NTA’s ability to bind calcium is as high as practically possible without surpassing the stability of calcium carbonate itself, making it’s inclusion in aqueous preparations for cleaning these types of surfaces an important new tool. The use of chelates in aqueous preparations for cleaning artifacts is not new, of course; both citrate and EDTA have found use as general chelating materials on a wide variety of artifact surfaces. But predictably, citrate would have a much weaker effect on
marble cleaning problems than NTA (weaker binding to calcium, and therefore a weaker ability to dissociate other calcium salts present), and EDTA would be far too aggressive, surpassing the stability of calcium carbonate itself.

Acknowledgments

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Suppliers

Carbopol 954: Distributed by Talas, 20 W. 20th Street, 5th Floor, New York, NY 10011 www.talasonline.com

Ethomeen C-12: Distributed by Talas, New York, NY

Micromesh Abrasive Cloths: Obtained as a kit from Peachtree Woodworking Supply, 3250 Oakcliffe Ind. St., Atlanta GA (770 458 5539).

Nitrilotriacetic Acid ‘NTA’: Sigma cat no. N 9877, Sigma-Aldrich, 3050 Spruce St., St. Louis, MO 63103 www.sigma-aldrich.com

Vanzan NF-C: Product number 70506 XP, R.T. Vanderbilt Company, Inc. P.O. Box 8500-1361, Philadelphia, PA 19178-1361 www.rtvanderbilt.com

Whatman CF-11: Cellulose powder distributed by Bodman Industries, P.O. Box 2421, Aston, PA 19014

References


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TREATMENT OF A WPA ERA TOPOGRAPHICAL MAP OF THE STATE OF LOUISIANA

Shelley Reisman Paine, James Bernstein, Richard Wolbers and Mary Zimmerman

Abstract

The conservation of a WPA era painted plaster topographical map was a very successful collaboration between the Louisiana State Exhibit Museum, conservators and student interns. The Museum was built in 1938 to showcase the products and industries of the State of Louisiana. The map was created c. 1939 by Duncan Ferguson, sculptor and Conrad Albrizio, painter. It is 14.3 meters (14 feet) in diameter and located in a 1.22 meters (4') deep floor well in the atrium of the museum. It depicts Louisiana with each parish, parish seat, river, neighboring state and the Gulf of Mexico. Microscopic cross-sectional analysis revealed the surface was repainted approximately eight times covering the original muted surface with layers of glossy bright colors. Each successive repainting, colors, roads and icons representing Louisiana's commerce were altered or relocated to update information. This fabricated surface turned the artwork from an artistic expression into educational tool.

The treatment project was organized as an advanced work-study project spanning two nine-week summer seasons. This approach permitted the conservators to research the artwork, train and supervise conservation graduate and pre-program students to master techniques to complete the treatment. Working as a team, each conservator and student worked “in one hand”, treating the map in such a way that it appeared as if only one person performed the treatment. This required intense training and collaboration. Further, the site precluded using a scaffold. This required the team to work directly on the map, and to develop specialized treatment materials and techniques to accommodate the site. The treatment removed multiple layers of garish overpaint, using solvent gels, followed by filing and inpainting to reveal the beautiful muted colors of the original presentation.

Introduction

The topographical map of the State of Louisiana is a New Deal era artwork created by Duncan Ferguson and painted by Conrad Albrizio in 1939 for the opening of the Louisiana State Exhibit Museum. The Museum was built in 1938 to showcase the products and industries of the State of Louisiana. It is 4.6 meters (15’) in diameter and located in a 1.22 meter (4’) deep floor well, surrounded by a railing, in the middle of the central atrium (Fig. 1). Visitors enter the building in front of the map and they became witnesses to the treatment of the artwork. Before treatment (Figs. 2, 3, 3) the map was a bright glossy didactic tool that had been updated periodically to represent the commerce of the state, while at the same time, disguising and altering the original artwork under layers of overpaint and varnish. After treatment (Fig. 5) the original soft matte surface was again on view.
Figure 1. Rail around topographical map in the atrium of the Louisiana State Exhibit Museum [1].

Figure 2. The topographical map before treatment covered in layers of overpaint and additional didactic design elements.
Figure 3. Madison Parish overpainted and covered with synthetic overlays and a plastic corn icon.

Figure 4. Iberia Parish with multiple generations of didactic icons.

Figure 5. The topographical map after treatment.
The treatment project was organized as an advanced work-study for nine conservation interns spanning two nine-week summer seasons. Mary Zimmerman, Museum Director was at the site at all times. A conservator, Shelley Reisman Paine, sculpture conservator and project Director, James Bernstein, painting conservator and mixed media or Richard Wolbers, decorative surface conservator came to the Museum every other week and often together, to lecture, train, guide and supervise the work being performed by the students. They were also available for twice weekly conference calls and daily email updates. The conservation interns came from New York University and Queen’s University training programs, and pre-program students from Emory University’s Michael C. Carlos Museum. They included, Erin Falbaum, Jennifer Lis, Hillary Ellis, Dave Turnbull, Marie-Catherine Cyr, Emily Nomura and Kate Moomaw. Jennifer Lis returned the second season as site coordinator and Erin Falbaum as assistant site coordinator. In addition, throughout the project, to maintain continuity, each student had specific jobs in documentation and preparation of the materials being used. This level of organization allowed each student to focus on the treatment and not the availability of materials or the quality of their supplies. The diligent work of each collaborator permitted the project to be completed successfully.

Project goals

Five major goals were established to reveal the original artwork buried underneath layers of overpaint, varnish and decorative applications. The first and primary goal was to focus the team to work in “one hand” that is, treating the map in such a way that it appeared as if only one person performed the treatment. The second was to work slowly and watch for new information as the overpaint was removed. This methodical approach allowed Erin to find the first icon delicately painted on the artwork – a surprising and defining moment in the treatment. Third, to stop periodically throughout the project and document all surfaces insuring that no vital information was lost. Fourth, to be sure that everyone took breaks periodically to look at the entire map to evaluate and discuss the treatment, and to prevent fatigue and accidents in the well. Fifth, it was crucial that each team member ask any question at any time to fully understand any part of the project.

Timeline and project requirements

The treatment took three years to complete. In general, primary research and analysis was done during the year to prepare for treatment in the summer. During the first season, six layers of overpaint and varnish were carefully removed from the original surface, and areas of loss filled with Modostuc polyester putty. Six months later, during a site visit to the Museum, the map was sprayed with an isolation layer of varnish, and permitted to cure for six months until the next summer when the team inpainted the map and applied a final coat of varnish.

Technical studies were an integral part of the entire treatment. The project began with a review of the research on the map that had been carried out by the Director, and a thorough analysis of the paint film, using microscopic cross-sectional analysis and Fourier Transfer Infra-red spectroscopy, to identify the original presentation layer and later additions to the artwork.
Analysis continued throughout the project as new conditions were observed. Written documentation included a project summary and 56 individual conservation reports, each including analytical data, condition and treatment information along with extensive photographic documentation, for each parish and landform depicted on the map.

The site did not allow a scaffold to be used causing the team’s work to be done directly on the map. A minimum of four team members was in the well, with equipment, extraction systems and treatment materials, at any one time. Therefore, it was important to define safe, effective working conditions. The toxicity of all materials was reviewed to provide appropriate safety supplies and fume extraction at every work area.

The map is illuminated by daylight through full height atrium windows and 82 fluorescent ceiling lights. The ceiling lights included a variety of tubes providing a wide range of color. To limit the color temperature and provide a consistent and effective work and display lighting, the 82 fluorescent ceiling lights were replaced with tubes having a 92 Color Rendering Index and a color temperature of 5,100 degrees. For additional task lighting, full spectrum MR16 low-voltage halogen light fixtures, color temperature 4,700 degrees and 100 Color Rendering Index, were placed at each work area.

**Condition**

The plaster artwork was made in five sections: four parts attached to a central diamond, and is attached directly to the concrete foundation of the building. Separations were noted along each seam, probably due to settling of the foundation. The foundation was examined by an engineer and determined to be stable. The plaster was coherent; however, exposure to water from a Christmas tree displayed on the map, caused extensive damage to a 20.3 cm x 50.8cm (8”x20”) area of the map (see Fig. 6), coincidentally located in the Gulf of Mexico.

![Fig. 6. Delamination of the plaster due to water damage.](image)
The condition of the overpaint was carefully examined, tested and documented to understand its interaction with the original artwork underneath. It appeared that the overpaint and the original paint film have expanded and contracted at a different rates causing moderate delamination overall. Further, there are numerous minor and moderate areas of loss adjacent to the delaminations overall. Once the overpaint was removed, the original presentation paint layer was examined. This paint film was coherent and adherent to the plaster substrate. However, approximately a third of the paint layer was missing or abraded.

**Research and analysis**

The Director provided and dated two black and white reference images of the map. One, on the basis of the clothing worn by the people in the picture, was considered to be from the 1960s (Fig. 7). It displays a multi-colored painted surface, and a darker painted well surround. The second image (Fig. 8), considered to be from the 1940s on the basis of a notation on a library record, had a multi-colored painted surface and three-dimensional icons attached to the surface that reflected the commerce of that parish.

Figure 7. This photographic image, assumed to be from the 1960s, does not show any three-dimensional icons (Louisiana State Exhibit Museum Library).
Determining whether the map originally had icons, as well as answering other questions relating to the paint layers, was accomplished by using microscopic cross-sectional analysis and Fourier Transform Infra-red spectroscopy. Approximately 35 samples were analyzed using these techniques. For example, these analytical techniques determined that the well surround, that appeared a dark cranberry color (see Figs. 9, 10), was originally a warm gray. The original gray was matched to Munsell 4.5Y 6.3/2.2, L* a* b* L64.90 a-1.46 b16.40 using a Minolta CR-241 microscope colorimeter, with the closest commercial match to Benjamin Moore HC 98 Providence Tan, that was used to repaint the well surround.

Figure 9. Microscopic cross-section of the well surround in normal light at 125x (photograph by R. Wolbers).
The three-dimensional icons were also examined analytically. Analysis determined that the icons were created in at least three generations and most likely cast from similarly shaped icons. This information agreed with our observations and their relocation on the map confirmed by a reference image. Two generations of painted and overpainted icons are illustrated by comparing the cross-section of a pine tree icon (Fig. 11), showing an original green paint under a layer of overpaint, and an icon of corn with only one layer of green paint below a polyurethane coating. The green paint on the newer corn icon matches the overpaint in the second paint layer of the older tree icon.

A cross-section of the paint film before cleaning (Fig. 12) reveals 8 distinct layers. From the bottom, these are original glue-sized plaster, original green parish color, overpainted blue green,
overpainted purple, varnish layer, overpainted purple, polyurethane coating and a top layer of glue and soil. Stained cross-sections (Fig. 13) using TTC, ALEXFLUOR 488 and RHOB stains [2] indicate the location of glue, polyurethane, oil and natural resins. FTIR spectroscopy [3] of the sample (Fig. 14) confirmed polyurethane as the uppermost map coating, and the original paint film as an emulsion of linseed oil and casein paint.

Figure 12 (left). Cross-section of the paint film, normal light at 125x, with eight individual layers. Note the original glue-sized plaster and the original green paint covered by six layers of paint and varnish (photograph by R. Wolbers).

Figure 13 (right). Stained cross-sections of the paint film at 125x using TTC, ALEXA and RHOB stains (photographs by R. Wolbers).
Figure 14. Left: FTIR data confirming the outermost coating as polyurethane (the red spectral trace is the map coating and the blue is the polyurethane standard). Right: FTIR data confirming the original paint layer as an emulsion of linseed oil and casein paint (the red spectral trace is the map paint, the green spectral trace is aged linseed oil).

Cleaning

The goal in cleaning was to safely remove the three oil-base overpaint layers and polyurethane coating to recover the casein/linseed oil original artwork. After training in the history of the artwork, cross-sectional analysis and gel chemistry, the overpaint was slowly removed with three different gels [4]. To minimize exposure to solvents and to better control the process. As the students worked with the gels, we discussed their approach and then as a team, modified their timing and application to achieve the appearance that one hand did the entire cleaning project. The sequence of gel use followed the progression of over-paint materials in terms of their peak solubility. The pyrrolidinone gel was used to remove the polyurethane; the acetone and subsequently the methanol gels were used to remove oil emulsion, and oil over-paints respectively. Scalpels and wood tools were also used to separate stubborn paint. However, if the original surface was in danger, or prone to softening or dissolution, the overpaint was left and would be minimized during inpainting (Fig. 15).

Early in the cleaning process, a painted icon of a pine tree on the original surface of the artwork was discovered. Samples were taken and (Fig. 16) and the analysis indicated that the painted icons were located between two layers of the original paint, the lowest being the original presentation surface of the map A dirt layer was noted over the icon, demonstrating that the icon was a presentation surface for some period of time until it was overpainted with original paint materials. The Director determined that painted icons were the original symbols of commerce. Why they were overpainted is not known. However, after extensive deliberation and examination of the cross-sections, the Director decided to archive the three-dimensional icons and reveal the painted icons.
Figure 15. Over half the overpaint has been removed.

Figure 16. Cross-section of the paint layer showing a painted icon in normal light at 125x (photograph by R. Wolbers). There is dirt on the surface of the paint, indicating that this was an original presentation surface.

**Varnishing**

During cleaning, the overpaint protected the artwork from direct contact by the team. However,
it was clear that for any further treatment, the team had to be separated from the map to prevent abrasion to the surface and heat transfer to treatment materials. Therefore, mats were made and tested to determine how to isolate the map from heat to insure that the team’s body temperature would not soften any treatment material used (Fig. 17).

Outlast Phase Change Material was tested. This fabric includes a phase change material that distributes and restricts heat. Therefore, a test mat was created by placing the Outlast fabric under a 3” block of Esterfoam that had a pocket for a data logger. The entire mat was then covered with a soft cotton fabric. As the students worked on the mats, the data logger measured the temperature at the map surface. Mervin Richards, conservator, National Gallery of Art, provided the data loggers and the test results. This information was used to choose the glass transition temperature of the isolation varnish and inpainting materials and to design the work mats to be used during inpainting. Tests revealed that the mats kept the surface of the map below 90 degrees F. Therefore, because Tg is an additive process, Golden MSA Varnish, Tg 101F and Golden MSA Hard Varnish, Tg 122F, blends of Rohm and Haas Acryloid B67, an isobutyl methacrylate polymer and F-10, butyl methacrylate, were mixed to achieve a Glass Transition Temperature (Tg) of approximately 110 degrees F.

The 2005 season ended with the map cleaned and all small areas of loss were filled with Modostuc White patching putty and the large area of loss in the Gulf of Mexico with plaster. Four months later, during a site visit, a thin, saturating, isolation layer of the varnish Golden MSA Gloss/Golden Hard MSA Gloss/Golden MSA Satin 5:1:1 in 5 parts VM & P Naphtha and a few ounces of xylene was applied with a HPLV spray gun fed with warmed compressed air (Fig. 18).
Inpainting

To prepare for inpainting, the colors of the mural were judged and the benefits and drawbacks of potential retouching systems were considered. A plastic, polymer medium was selected, as it would be likely to perform better over time in the Foyer setting than one of the lower molecular weight resin inpainting systems. Color swatches to match colors on the map were prepared using Golden MSA colors and Kremer powdered pigments. The range of pigments offered by Kremer proved essential to arrive at close matches of the mural palette. Study of the outdoor frescoes (also painted by Albrizio), with remarkably similar colors and tonal harmonies, confirmed the inpainting palette choices.

Inpainting in one hand, just as cleaning in one hand took training and collaboration to accomplish successfully. The team was given instruction in compensation theory and practice, in the form of Bernstein’s intensive ‘Mastering Inpainting’ workshop. This training included lectures, demonstrations and study of the Mastering Inpainting Workshop Manual (Bernstein and Evans 2008). The training continued with preparation of new sample color reference boards, resin and solvent mixtures and development of painting techniques. A formidable issue in this stage of the treatment was the horizontal orientation and smooth, non-porous character of the mural surface. These characteristics meant fighting gravity and the inevitable running of color off the brushes upon contact with the map. To counter these concerns, a relatively fast evaporating solvent mix and small brush sizes (Winsor Newton series 7 sable #’s 1, 0 and 00) were selected, permitting rapid application of the paint as dots and strokes.

The inpainting process included multiple layers of paint. All areas of the mural were brought up with initial toning that was slightly lighter in value than the desired final tone. This enabled
perception of color, value and image gradations that were not possible due to the extensive interruptions of image, including areas of abrasion, damage and white fills. Further, working as lean as possible, and loading proprietary colors, when used, with more pigment, guaranteed effective coverage in the early stages of inpainting. Color, value and sheen were then built up and corrected with successively richer paint applications. Each area of loss required from 3 or 4 applications of paint, moving from a lighter-toned, pigment-rich paint, continuing with increasing amounts of medium in glazes until the desired gloss and color was achieved (Figs. 19-22).

The inpainting medium was a 4:1 blend of Golden MSA Gloss Varnish, a blend of Rohm & Haas B-67 (an isobutyl methacrylate) and F-10 (an n-butyl methacrylate), and an additional amount F10. The Golden varnish includes Paraloid B67 (Rohm & Haas) which helped raise the Tg and hardness of the retouches, and includes small amounts of Benzotriazole and Tinuvin 292 HALS providing some ultraviolet light protection. The map was retouched with color mixtures from 43 dry pigments dispersed in this medium, supplemented by 18 colors from the available Golden MSA Colors.

The final steps of inpainting were the reconstruction of the painted icons, map and road features, and lettering. Golden Fluid Matte Acrylics, pigments and a few drops of Liquitex Acrylic Airbrush Medium were used for the roads and letters. These details were inpainted with an aqueous acrylic dispersion retouching system, different from the solvent-based one selected for the field colors. This enabled the fluid painting of fine detail work on top of the Paraloid compensation without lifting or altering the underlying work. Further, if a feature did not go on exactly as desired, it could be removed promptly and safely with water, and then redrawn. When inpainting was completed, every pigment and material used in compensation on the map was documented in each parish report for future reference.
Figure 20. Assumption Parish after cleaning. A painted sugar cane icon is visible on the right.

Figure 21. Assumption Parish after inpainting, with a detail of the sugar cane icon on the right.
Most students are not asked to painstakingly clean overpaint or inpaint every day for nine weeks. The hands-on experience of inpainting the map reinforced their training. The students who were part of this project were given an invaluable learning opportunity and they rose to the occasion, mastering the subtleties and nuances of these techniques. At the end of the project they were asked to list their ten most important issues for inpainting. Each list included the essential ingredients for successful compensation, and are consolidated below:

1. A bad fill cannot be inpainted correctly. It is critical to prepare fills correctly honing them to perfection under raking light.

2. Understand the properties of your materials and customize them before you start each project.

3. Use the best quality brushes, colors, media and diluents. Know the properties of each pigment and use as few as possible to achieve the desired color. Mix diluents each day to insure the proportions remain correct, replacing working solutions often to avoid color contamination.

4. Prepare color and paint-binder reference sample boards, painting colors and coatings all the way out to the edge of the boards.

5. Work in thin layers starting with a lean, lighter-in-value color, building image and gloss gradually in successive glazes.

6. Be aware of the artwork at all times. Step back from the work regularly to read the appearance of colors and transitions from viewing level.

7. Work with generous amounts of uniform and correctly color-balanced light.

8. Be aware of ambient temperature and humidity to adjusting paints, varnish and diluents accordingly. Also, use clean diluents for inpainting to avoid contamination.

9. Pay attention to and retain the appearance of paint character and age.

10. Be aware of occupational safety. Contain colors and fluids against spills, provide adequate ventilation, wear solvent and particle respirators, manage waste disposal and take breaks often.

**Final varnish**

A thin coating of a harder-than-usual painting varnish was selected for an overall seal. This was done as a precautionary measure, due to concern for the horizontal orientation of the surface, the tendency for convection currents to deposit airborne matter into the sunken well, and for durability, knowing that regular dusting and maintenance of the map would be required in the future. A final varnish was a 6:1:1 blend of Golden MSA Hard Gloss Varnish Golden MSA Hard Satin Varnish and Golden MSA Satin Varnish in 5 parts VM & P Naphtha and a few ounces of xylene. This mix was applied using a HPLV spray gun fed by warmed compressed...
air. This produced a beautiful, lustrous, pearly finish that maintained color clarity while bringing
down sheen and not introducing an undesirably toothy, dust-collecting surface.

Conclusion

The success of the project was due to intensive planning, training, oversight and a true spirit of
dedication and collaboration. The conservators continually researched and re-evaluated every
component of the project to insure that appropriate methods and materials were used. The finest
materials were provided and techniques were customized to allow the team to focus on technique
and to work with one hand. However, it was the perseverance and camaraderie of the students, as
they worked in stressful and difficult physical conditions, which allowed the project to be done
timely and successfully.

Acknowledgments

The conservators wish to thank the students for their accomplishment in being the hands of the
project, and the staff at the Louisiana State Exhibit Museum for their support. And, a special
thank you to Nederman & Co. for their generous donation of much of the ventilation equipment
and to Mervin Richards for his help with the data loggers.

Endnotes

1. Editor's note: All uncredited photographs were taken by Dave Turnbull, Erin Falbaum or
Shelley Paine. The authors were unable to provide more specific information.

2. Acronyms: RHOB (Rhodamine B Sigma-Aldrich Cat No R4252, a general lipid soluble
fluorescent dye), TTC (Triphenyl Tetrazolium Chloride, Sigma-Aldrich Cat No. T8877, as
general redox sensitive dye which can be used to indicate reducing sugar moieties), and
Alexafluor 488 (Invitrogen, Eugene OR, a proprietary fluorescent dye, as a succinimdyl ester,
which can covalently react with free amino groups on proteins) (see Wolbers 2000; 167-182).

3. Equipment: Thermo Nicolet IR100 FTIR, Thunderdome ATR Cell Run Conditions:
Resolution 4 cm-1; Transmission Mode; Gain 4; No of Scans = 32. Software: EZ
OMNIC, proprietary Thermo Nicolet software used for conversion to absorbance mode;
baseline smoothing and corrections; peak assignments; library searches, spectral
subtraction, and interpretation. Libraries: Hummel Polymer Library; User Defined
Library; IRUG Artist materials (see Wolbers 2000).

4. 1-Methyl-2 Pyrrolidinone gel:
   100ml solvent (Southern Scientific)
   20ml Ethomeen C-25 (Talas, NYC)
   2g Carbopol 954 (Talas, NYC)
   7ml de-ionized water
Acetone Gel:
- 100ml solvent (Home Depot)
- 20ml Ethomeen C-25 (Talas, NYC)
- 2g Carbopol 954 (Talas, NYC)
- 10 ml de-ionized water

Methanol gel:
- 100ml solvent (Home Depot)
- 20ml Ethomeen C-25 (Talas, NYC)
- 2g Carbopol 954 (Talas, NYC)
- 10 ml de-ionized water

References


Suppliers

Ethomeen C-25, Carbopol 954:
Talas, 20 West 20th Street, New York, New York 10011

Esterfoam:
Ashley Distributors, 5722 W. Jefferson Blvd., Los Angeles, CA 90016-3107

Nederman extraction units:
Nederman, Inc., 39115 Warren Road, Westland, MI 48185

Methyl pyrrolidinone, N-Methyl pyrrolidinone:
Southern Scientific, P.O. Box 150176, Nashville, TN 37215, 615-665-4400
(Kathleen@southernsci.com)

Modostuc White: a proprietary wall filling putty manufactured by Plasveroi International, Via Camussone 38 Frazione Giovenzano, Vallezzo Bellini, Italy. Tel 0382 926 895 Based upon calcium carbonate with a polyvinylacetate dispersion binder, said to contain amounts of Barium Sulfate, Kaolin and almond oil (preservative). Plasveroi@iol.it; available through: Peregrine Brushes and Tools, 1211 North 60 West, Wellsville, UT 84339-0200, 888-389-5222 www.brushesandtools.com

Outlast Phase Change Material
www.outlast.com
Pigments:
Sinopia Pigments and Materials, 321 7th Street, San Francisco, CA  (415) 824-3180
www.sinopia.com
Kremer Pigments, 247 W. 29th Street, New York, New York, 10001  (212) 219-2394
www.sinopia.com/kremer.html

Winsor Newton Series 7 sable watercolor brushes:
Available from art supply sources (including www.MisterArt.com)

Golden Artist Color Products:
Golden MSA Conservation Colors (pigments in Rohm & Haas butyl methacrylate  Paraloid F10)
Golden Matte Fluid Acrylics.
Golden MSA Varnish (Gloss and Satin);  Golden Hard MSA Varnish (Gloss and Satin);
Available from Golden Artists Colors, 188 Bell Road, New Berlin, NY 13411. Tel. (800) 959-6543.  www.goldenartistcolors.com

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