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Technical Analysis of a Ptolemaic Child Sarcophagus and the Identification of Ancient and Modern Reuse

A thesis submitted in partial satisfaction of the requirements for the degree of Masters of Arts in Conservation of Archaeological and Ethnographic Materials

Catherine Scott Mallinckrodt

2014

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ABSTRACT OF THE THESIS

Technical Analysis of a Ptolemaic Child Sarcophagus
and the Identification of Ancient and Modern Reuse

by

Catherine Scott Mallinckrodt

Masters of Arts in Conservation of Archaeological and Ethnographic Materials
University of California, Los Angeles 2014

Professor Ellen Pearlstein, Chair

The goals of this project are the technical analysis of a Ptolemaic child coffin lid, development of a conservation strategy, and realization of priority stabilization interventions. Early in the process of evaluation and analysis irregularities in the appearance and structure of the coffin suggested re-use of components. This thesis proposes that there are incidences of ancient and modern reuse of structural elements in this coffin lid, and substantiates this assertion through the results of a technical analysis.

Non-destructive and destructive methods of analysis were used including UV induced visible fluorescence, Infrared and Visible-induced luminescence (VIL) imaging. Particle samples were investigated microscopically, and using XRF or X-ray Fluorescence spectroscopy, XRD or X-ray Diffraction, FTIR or Fourier Transform Infrared spectroscopy and GC-MS or Gas Chromatography-Mass Spectrometry technologies were used for elemental and molecular analysis. Egyptology scholars, conservators, and materials scientists were consulted.

The text establishes the historical context, and the use and meaning of the artifact. The object is described, the pigment analysis is presented, and prior interventions to the object are

elaborated. The collective results of the technical analysis, observation and consultation are interpreted to substantiate the assertion of modern and ancient reuse.

Technical analysis supports the observation that face of the deceased is inconsistent with the Ptolemaic period and that is was created in an early dynastic period and reused on this coffin in antiquity. The components of the foot-block are identified as ancient but not associated with this coffin, and 20th century adhesives and hardware are evidence that it is a modern addition.

Social and economic demands in antiquity, and also in the post-excavation period of the late 19th and 20th centuries, have motivated alterations to objects of cultural and economic importance. This thesis provides substantial evidence of ancient and modern reuse and contributes information about ancient materials and methods of manufacture and distinctions between modern and ancient materials.

The thesis of Catherine Scott Mallinckrodt is approved.

Kathlyn Cooney

Marie Svoboda

David A. Scott

Ellen Pearlstein, Chair

University of California, Los Angeles
2014

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1. **Introduction**

This subject of this thesis is the lid of a painted, anthropoid, wood child sarcophagus from the Ptolemaic period of Egyptian antiquity, in the collection of the San Diego Museum of Man (hereafter SDMM) (fig.1). The museum record states that it is one of only seven known examples of child sarcophagi from the Ptolemaic period.

Although this object is titled a "sarcophagus", the term "coffin" is used throughout this document to refer to this and similar objects. In scholarly literature the term "sarcophagus" most commonly indicates a stone container that contains one or more wood coffins, and the coffin contains the remains of the deceased (Ikram & Dodson 1998, 244). The word "sarcophagus" derives from the Greek meaning "flesh eating" because it was thought that the stone of the funerary containers caused the bodies to decompose (Ikram & Dodson 1998, 244).

The original goals of this project were to (1) carry out a technical study of the object, (2) develop a conservation treatment strategy, and (3) undertake priority conservation interventions. These goals are outlined in the Conservation Treatment Proposal submitted to the SDMM in the spring of 2012 (Appendix I).

The first phase of evaluation of the coffin, however, introduced the possibility that irregularities in the object and method of manufacture were evidence of both ancient and modern reuse, possibilities that were introduced in consultation with advisors, notably with Egyptologist and advisor Dr. Kathlyn Cooney, Assistant Professor of Egyptian Art and Architecture at UCLA, and Dr. Lorelei Corcoran, Director of the Institute of Egyptian Art & Archaeology at the University of Memphis. These possibilities focused the project toward an exploration of ancient and modern reuse. This thesis argues that the carved face of the coffin was repurposed in antiquity from a more ancient coffin, exemplifying ancient reuse, and that the foot-block is a modern construction composed of ancient parts, and that it exemplifies modern reuse.



Figure 1 Ptolemaic Child Sarcophagus San Diego Museum of Man 2001.063

This project has several phases that are (a) preparation and transportation, (b) evaluation and consultation, (c) stabilization treatment and design of a treatment proposal, (d) complete documentation, and (e) discussion and public presentation of findings. The preparation phase included two on-site evaluations in San Diego, prior to moving the object, as well as the preliminary treatment to stabilize fragile areas of the paint surface before the artifact could be safely transported from San Diego to the UCLA/Getty student lab in Malibu, California. A permanent mount and crate were designed in collaboration with SDMM to secure the object for transportation. The mount allowed the coffin to be observed and treated without direct handling (Appendix II.).

The SDMM acquired this coffin as a gift in 2005. No documentation of prior ownership or any record of prior interventions accompanied the gift. A brief, unsigned evaluation included in the museum record has proven to have inaccuracies (appendix III.).

This coffin is thought to be over two thousand years old and is predictably fragile. The polychrome is deteriorated, damaged, and partially lost. There is visible evidence of modifications and interventions to the structure and surface. There is no record of a trough, or bottom part, of a coffin, nor of an associated interior or exterior coffin, or of associated human remains. The object has been assigned to the Ptolemaic Period, which extended from 332 BCE to 30 BCE (Ikram and Dodson 1998, 11). This period commenced with the conquest of Egypt by Alexander the Great, and his reign, along with that of his two successors, constitutes the Macedonian period. The Ptolemaic dynasty, from 310 to 30 BCE, concluded with the death of Cleopatra VII and the commencement of Roman, imperial rule.

The face on the coffin is finely carved. The shaping of the torso, leg, and foot are abstracted, and the figure is standing on a low pedestal (fig. 2). It is 51 inches or 130.0 cm. in height. The external surface is entirely covered with a polychrome layer that is densely patterned with vignettes, figures, and text. There is no coating or paint layer applied to the interior surface of the coffin.

2. History

This object exhibits the characteristic Ptolemaic features of an anthropoid shape retained from the 25th dynasty (747-656 BCE) and to some extent displays the stylized thickening of the torso and disproportionately large head sunken into the neck with the ears nearly parallel with the shoulders (Taylor 2001, 241). The shape of the wig and lappets, the absence of hands, the presence of the painted depiction of the beaded broad-collar that begins low on the chest, and the presence of a low pedestal are features characteristic of the Ptolemaic retained from the twenty-third dynasty (818-715 BCE) (Ikram and Dodson 1998, 242) (fig.2). Scholars have noted the relative dearth of systematically excavated funerary objects from this period, compared with other dynastic periods, from which precise chronologies, dates, and locations would have been derived (Manley and Dodson 2010, 95).

The Ptolemaic leadership from Alexander the Great forward embraced Pharaonic religion and culture, but the government and language of the laws became Greek. The scholarly debate about the impact of the cultural and governmental transition on the retention or dilution of Egyptian iconography is outside the scope of this project, but it does offer insight into the amalgamation of iconography and the garbled text on this object. While major temple complexes, including Edfu and Dendera, were built during this period, Ikram and Dodson (1998, 50) contend that the quality of anthropomorphic coffins diminishes over the Ptolemaic period, and anthropomorphic coffin use disappears in the Roman period.

Although this coffin is not a highly refined example, in antiquity the ability to purchase a coffin was an indication of wealth. Based on its quality, this coffin is likely to have been made for a family of some social rank, although not royalty (Cooney 2012; Corcoran 2012). The diminutive size of the coffin, at slightly over four feet, has been interpreted, prior to this analysis as evidence that it was made for a child, although children were rarely provided with such expensive funerary furniture. Kathlyn Cooney (2012) has suggested the expense of a coffin could have been justified if this child had already entered into adult society, which would have been

unlikely for a male but possible for a female, if she had gained status beyond her chronological years through marriage. While there are some inconsistencies in the gender associations in the iconography on this coffin lid, the depiction of a vulture headdress strongly indicates the deceased was female (fig.3).

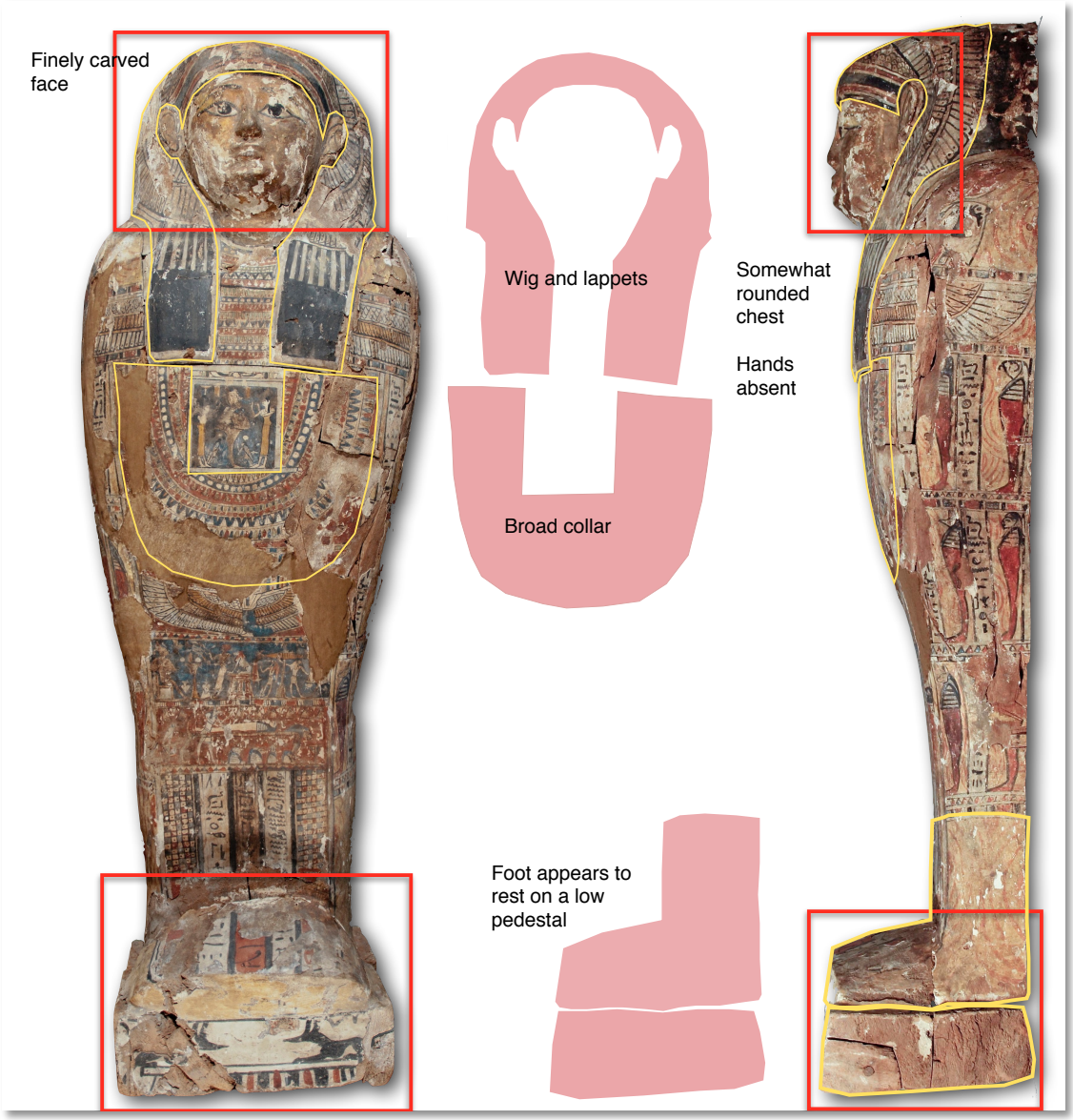


Figure 2 Characteristic features



Figure 3 Vulture headdress with ancient colors enhanced

This ancient history of tomb robbery and the documentation of the reuse of plundered funerary goods is important in considering the history of this artifact and inquiry into the possible re-use of structural components. There are records from excavations in the late 19th and early 20th century chronicling tombs that were plundered prior to being sealed as part of the burial ceremony, and ancient papyri chronicle laws regarding tomb robbery, legal committees convened to investigate related crimes, and specific trials in different periods. Relevant 21st Dynasty legal documents include the Papyrus Leopold II-Amherst, Ambras, and Papyrus Mayer A and B (Brand 2010, 3,7; Cooney 2013; Lippert 2012, 9; Ikram & Dodson 1998, 62-63).

3. Iconography

The iconography on this coffin (Appendix III) is consistent with traditional Egyptian funerary practices, although it combines elements that are more strongly associated with several earlier periods. The text is somewhat nonsensical, but this is not uncommon on funerary objects from the 21st dynasty through the Ptolemaic period (Corcoran 2013; Cooney 2012). Again, the degree to which Egyptian beliefs and religious practices were retained or diluted during this

period is a challenging topic for scholars, but may help explain the inconsistencies in the imagery and text, affirming rather than disqualifying its authenticity (Cooney 2013).

The imagery on the coffin depicts spells or chapters of the Egyptian Book of the Dead that derive from the myth of the death and resurrection of the god Osiris (fig. 4) most notable is spell 125 that describes the weighing of the heart. Osiris was killed and dismembered by his brother Seth. His sister, and future wife, Isis, reassembled and revived his body. They then conceived a son, the god, Horus (D'auria et al 1988, 50; Taylor 2001 26, 27).

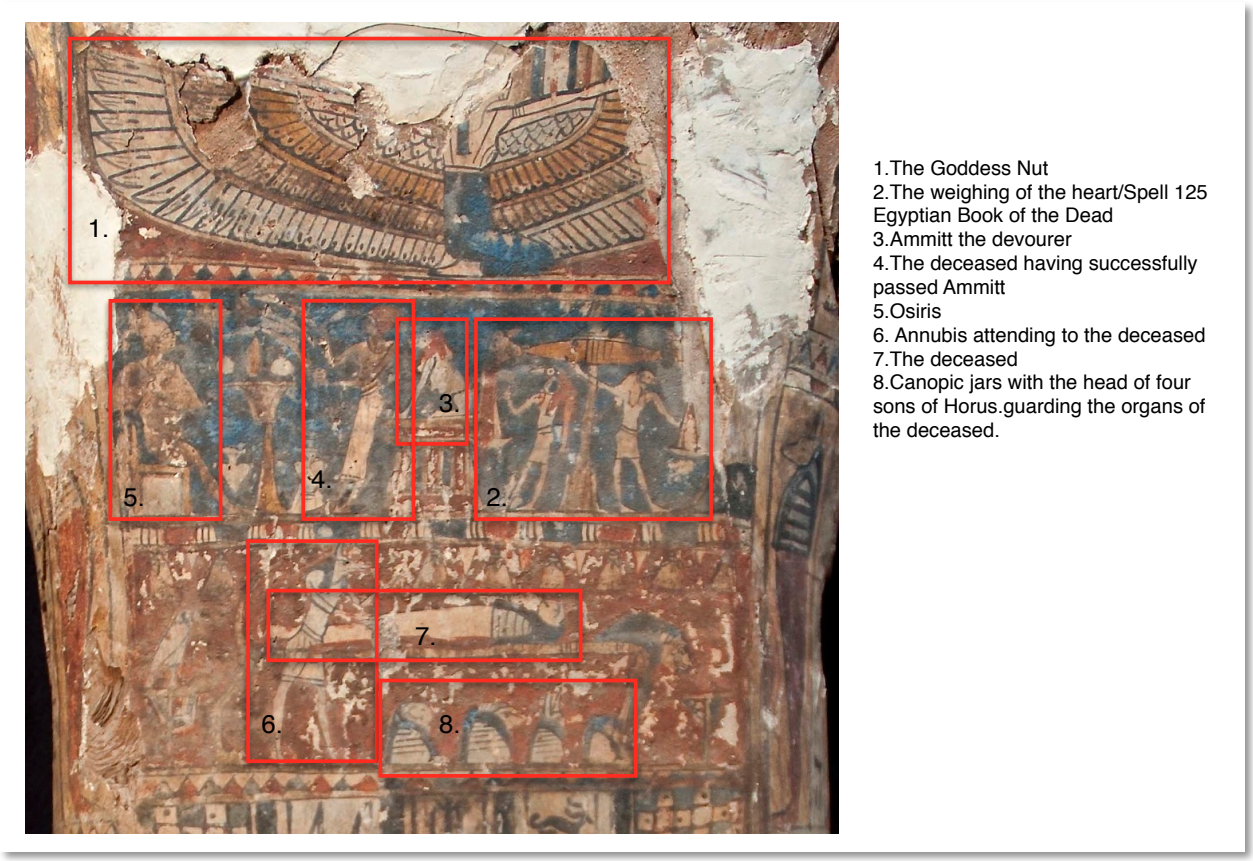


Figure 4 Imagery in the vignettes on the front lower torso

The study of the purpose, meaning, and importance of funerary iconography is a complex field of scholarship, and it is not the goal of this thesis to argue for a particular interpretation of the iconography on this coffin. But a simplified explanation is that the iconography served to aid the deceased through the process of rebirth as a god. John H. Taylor (2001) has described the

coffin as a sacred environment that could be considered “an eternal house,” “a miniature tomb,” “a substitute body,” and an idealized manifestation of the deceased, in the god form they would achieve in resurrection (Taylor 2001, 214-215). Each component of iconography played a role in facilitating the successful passage of the deceased to divinity. Osiris was the first mummy, and the embalming and wrapping of the deceased is a reenactment of the embalming and wrapping of Osiris. The relevant processes and spells are contained in the Egyptian Book of the Dead.

4. Materials and Manufacture

Analysis of the coffin lid has identified ancient and modern materials. The term “ancient” refers to materials used in the manufacture of the object or applied during antiquity. “Modern” describes materials added or applied to the object post excavation, from the mid-nineteen century to the present.

The ancient materials are wood, mineral pigments, including Egyptian blue, calcite based gesso, textile, a granular mixture of organic and inorganic materials, and a heterogeneous clay compensation material.

The modern materials are metal hardware, polymer adhesive, paint, coating materials, gypsum-plaster, and synthetic polymers.

4.1 Structure

The coffin lid is comprised of a base structure, hollowed and carved from a single cross section of wood. Eighteen carved and shaped wood pieces are attached to the base structure with to create the face and head, and the shape of arms and the chest, and the foot-block. Knots and irregular growth has caused irregularities in the wood used to make the base structure and some of the added pieces, and there are residues of compensation ancient materials in some of the

associated recesses. These details provide information about ancient resources and manufacturing practices, and provide a counter example when identifying modern interventions.

With the exception of the foot-block all of the added pieces are attached with wood dowels. The pieces are presented in Figures 5 and 6, and are described below. No additional pieces of wood have been applied to the "leg" and the surface layer is applied directly to the base structure in this area.

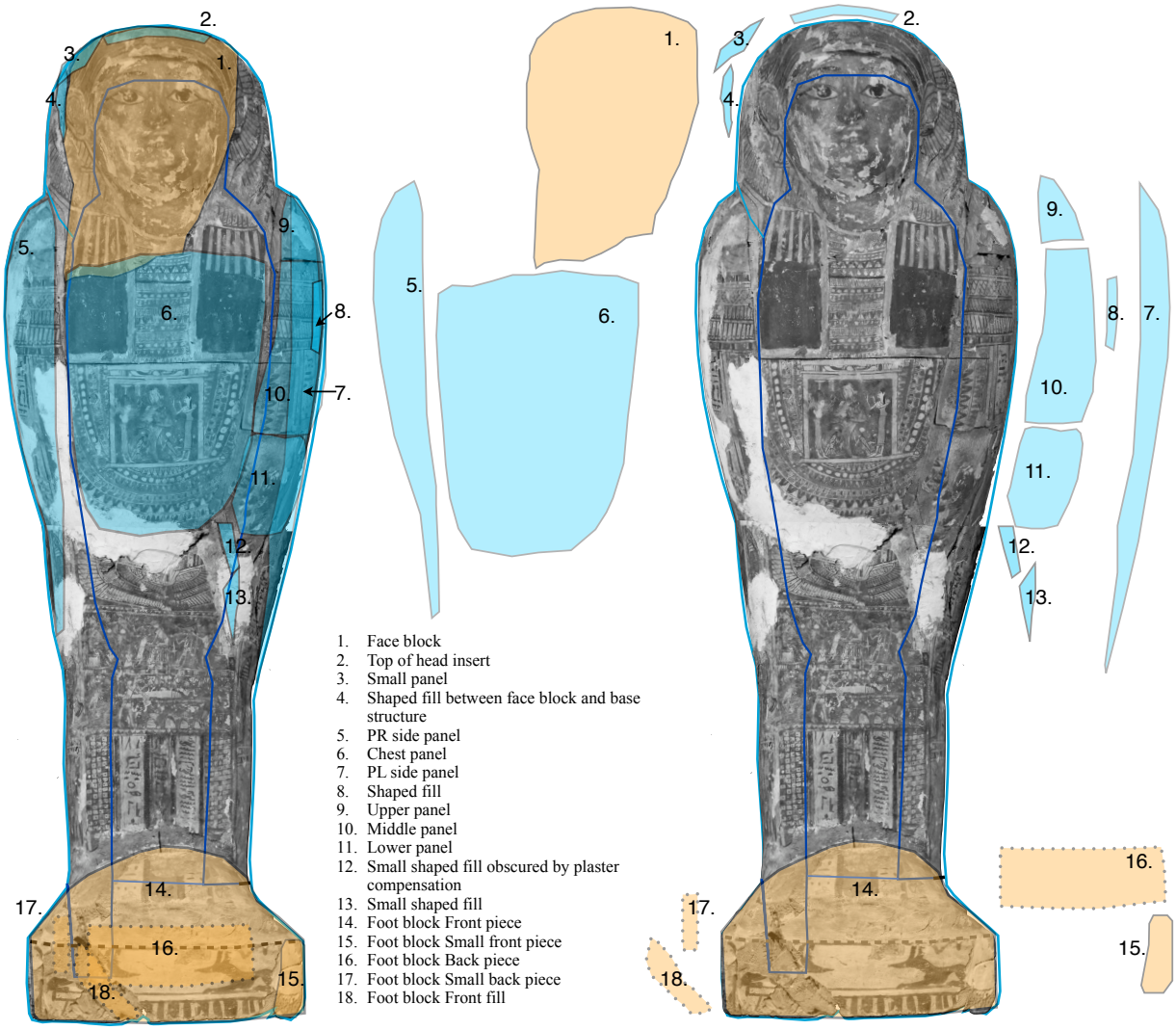


Figure 5 Structural components

The bottom of the base structure has been partially removed to accommodate the attachment of the foot-block (figs. 5 and 6). The loss area is 10.0 cm on the vertical axis and includes the PL side and front of the base structure. The remaining section of the coffin is 8.0 cm on the vertical axis, 8.5 cm deep from the edge to the front surface, and 6.0 cm wide. It extends through the foot-block to the bottom surface of the object. Rough, uneven cuts on the bottom of this piece indicate that 2.0 cm were removed.

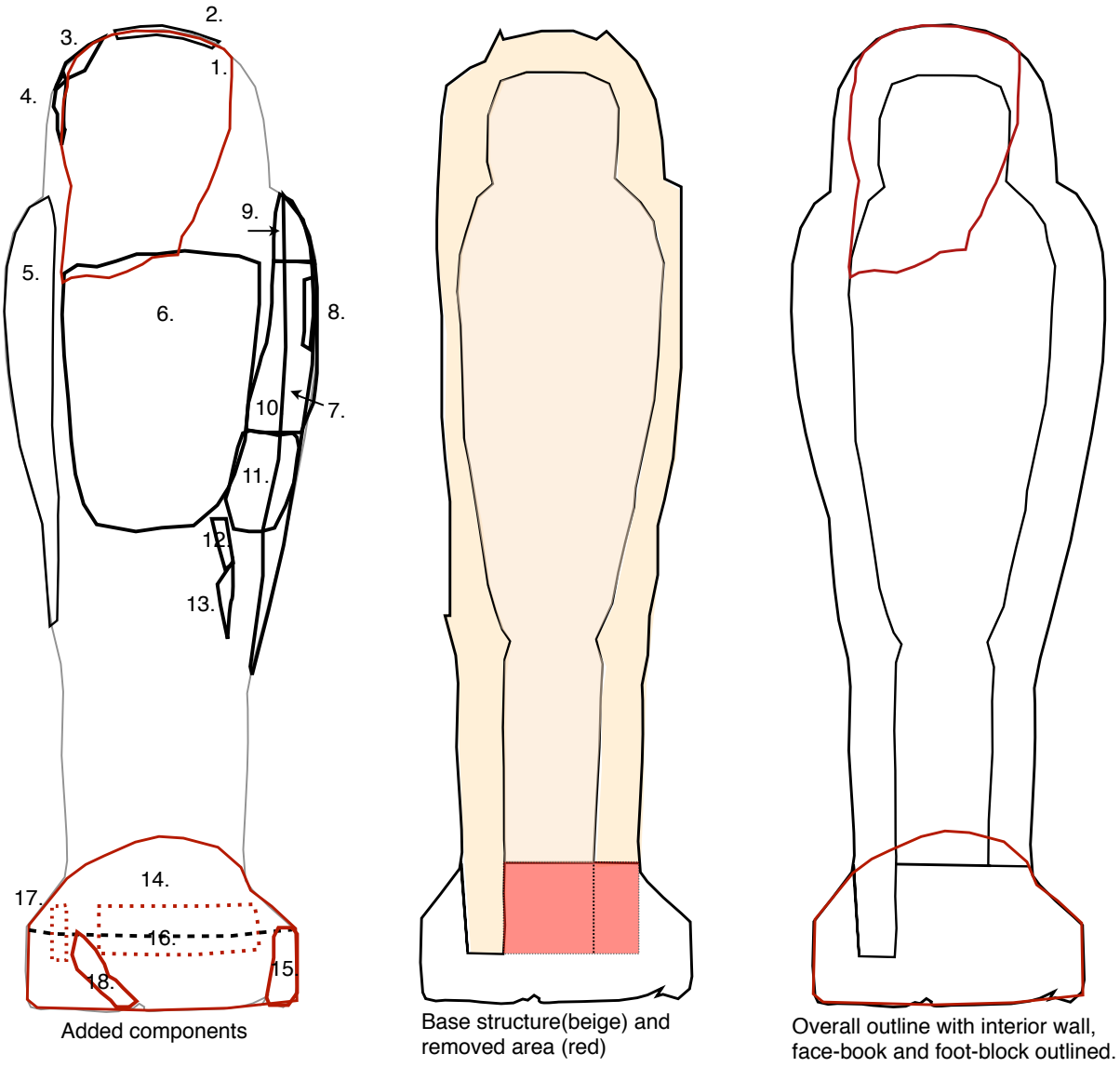


Figure 6 The structure with components (l), base structure with removed area (m), and overall outline with face-block and foot-block indicated in red (r).

4.1.1 Joinery

The added component pieces of the structure, excluding the foot-block, are secured in place with wood dowels, and no ancient adhesives have been observed. The dowel ends are visible on the interior surface, and some can be observed on the exterior where movement or impact has caused losses to the paint layer. When viewed in cross section, the asymmetric shape of dowels is evident (fig.7). This feature enhances their holding capacity. The wood of the dowels has not been sampled for identification.



Figure 7 Asymmetry of dowels in cross section.

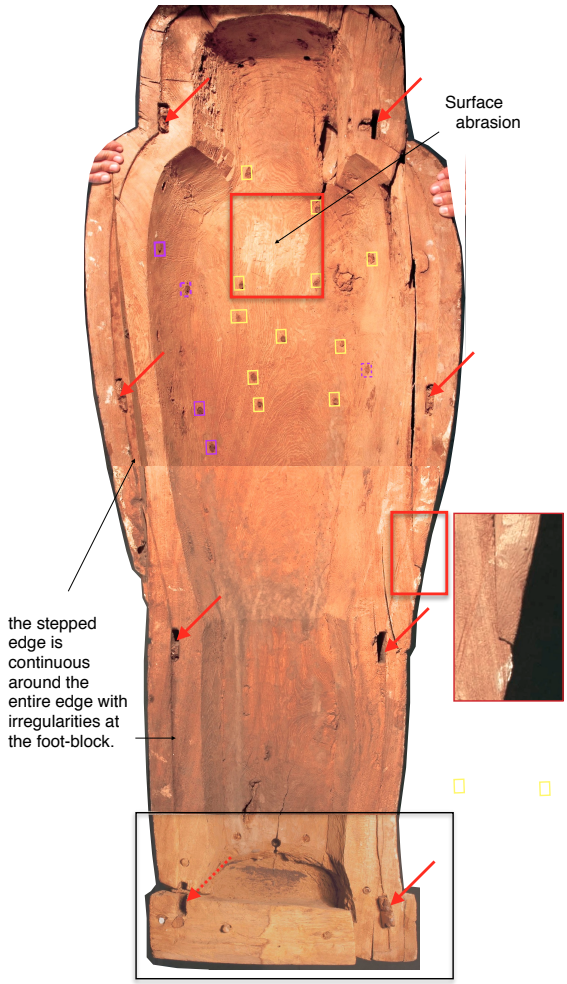
The components of the foot-block are secured together with a modern polymer adhesive, and modern metal screws attach the foot-block to the base structure. Drips of the adhesive are visible on the interior surface of the foot-block and between the components and micro-chemical tests identify the materials as a polymer, probably polyvinyl acetate adhesive.

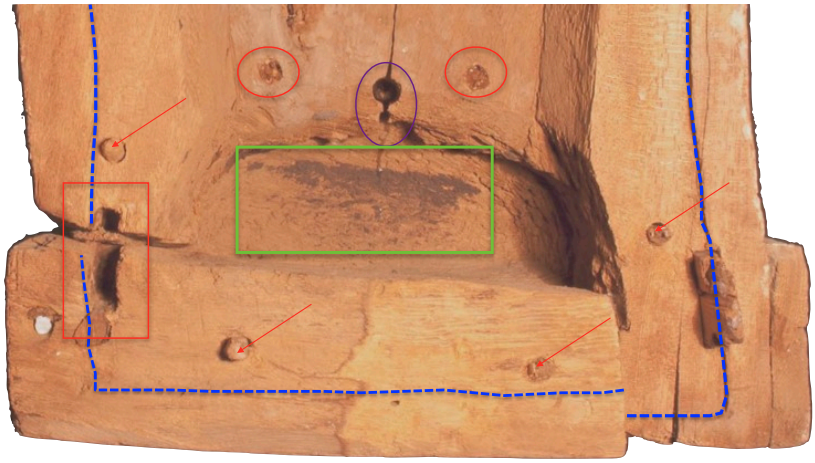
The lid was keyed to the trough, now absent, by a chiseled step (4.0 mm) along the edge, and with eight mortise and tenon joints (fig.8). These are paired along either side, with two at the head, the torso, the leg, and just above the bottom edge. The bottom PL mortise is not functional; it was created by aligning the remaining half of the mortise on the base structure with the half

mortise on the foot-block. Also there are the remains of four round pegs that would have secured foot-block to the trough. Two of the pegs are placed in the foot-block and two at the foot end of the base structure (fig. 8). These pegs are unique to the object and their placement indicates that they were added with the foot-block. The pegs appear to be machine made and therefore modern, which would support the thesis that the addition of the foot-block is modern. The wood of the dowels has not been sampled for evaluation.

4.1.2 Interior manufacture

Chisel marks are visible on the unpainted interior surface, consistent with woodworking techniques depicted in ancient imagery, and information about the type of surfaces created in antiquity that have been determined from surviving tools (Gale 2000, 354;Lucas and Harris 1962, 448-449). The structure is between 6.0 cm and 7.0 cm thick measured at the edge, and the interior shape reflects the exterior profile (fig.8). The interior depth is 12.5cm beneath the face, 14.3 cm beneath the chest, and 7.5cm beneath the leg, measured 18.0 cm from the bottom of the coffin. There is a stable area of surface abrasion on the interior center of the torso. This area is not discolored possibly indicating it is freshly exposed from a recent abrasion to the surface.





Stepped edge is misaligned with the base structure (blue broken line).
The mortice spans a joint with a large gap.(red box)
Four round pegs: unique to the foot-block area (red arrows)
Fragments of two non-functioning dowels (red circles)
Empty dowel hole (purple oval)
Accretion (green box)

Figure 8 Interior image of joinery (upper) and foot-block construction (lower)

4.1.3 Exterior Manufacture

The eighteen added pieces of wood that create the face and the contours of the head, the volumes that suggest the arms and chest, and the foot-block, are described in the following section and identified in the diagram in Figure 9. The four pieces that create the form of the head and face are identified as 1-H through 4-H, the nine pieces that create the torso are identified as 5-T through 13-T, and the five pieces that make up the foot-block are 14-F through 18-F.

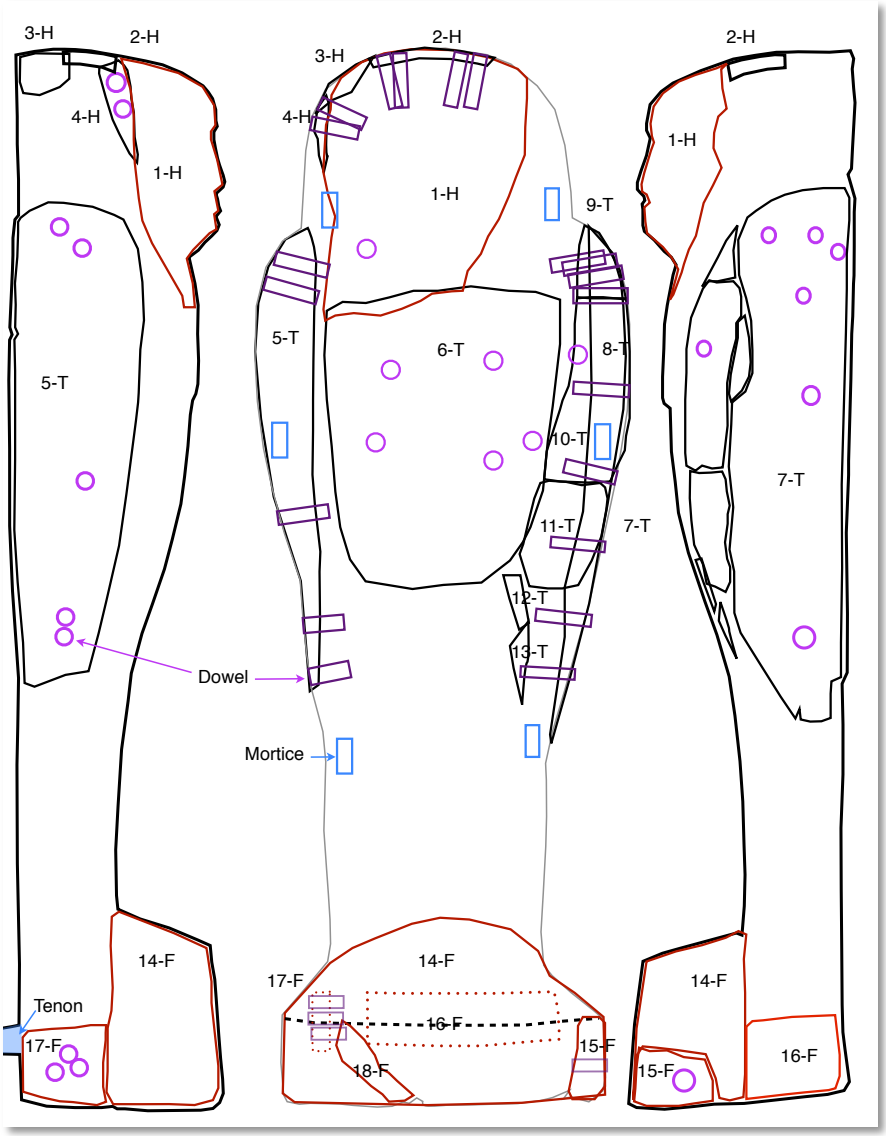


Figure 9 Added segments and dowels

4.1.3.a Head

The face is finely carved onto the face-block, which is the longitudinal cross section of a single piece of wood. The face block is 12.7 cm (or 5”) thick when viewed at the top of the head. It extends 31.75 cm (or 12 ½”) from the top of the head to the upper chest, and includes the forehead and part of the wig (fig 10).

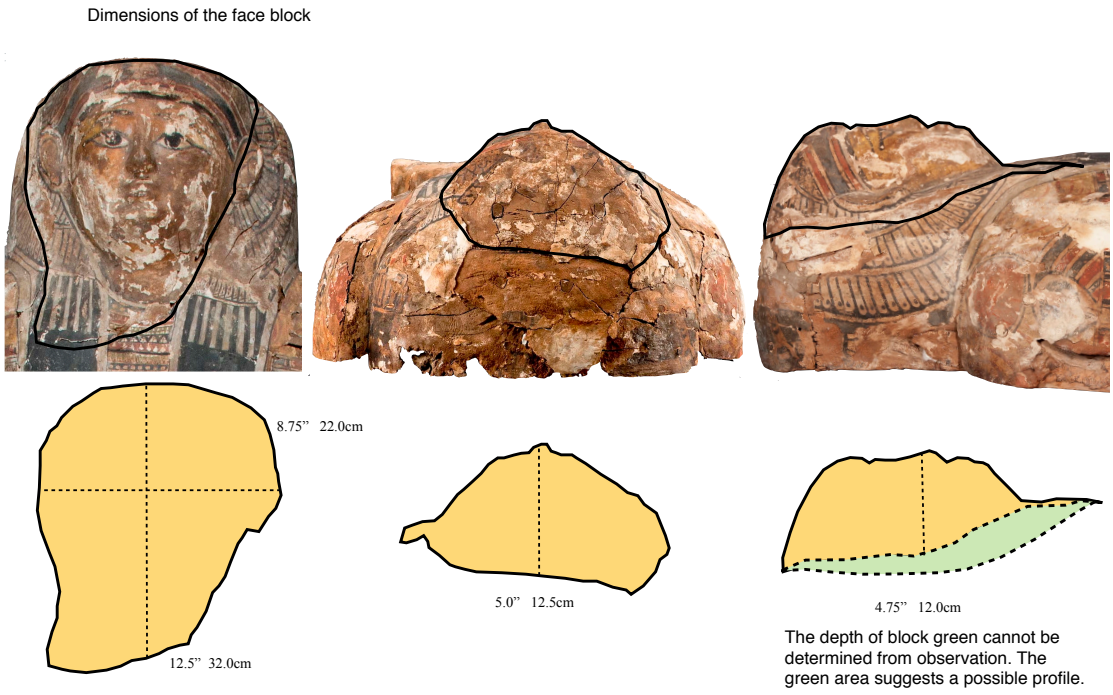


Figure 10 the face-block

The face block is secured in place at the top of the head with two dowels, visible on both the exterior and the interior, as well as in x-ray imaging. Two empty dowel holes immediately adjacent to these are visible on the interior surface, but are not present on the exterior. There is also an area on the PL cheek (fig. 11) that is visible in x-ray images, which may identify a vertical dowel. The face-block extends laterally from 2.0 cm outside the PR ear to the PL edge of the cheek at the neck. The PL ear is not part of the face-block. The wood grain of the ear and the base structure appear continuous in x-ray imaging, although the paint layer and restorations obstruct direct observation.

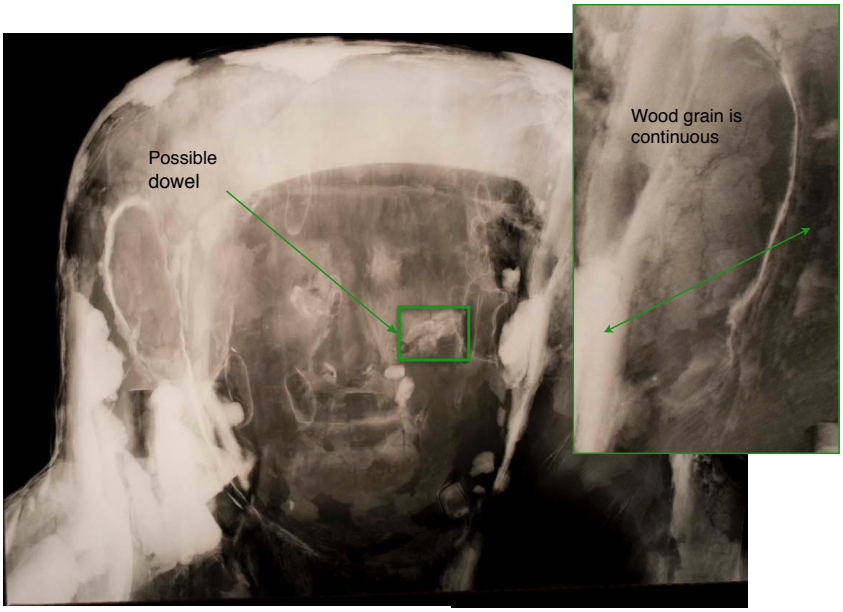


Figure 11 X-ray of face block and details

Of note is the hole in the outer, middle part of the PL ear, which may have served to hold an earring. There is no corresponding hole on the PR ear (fig. 14).

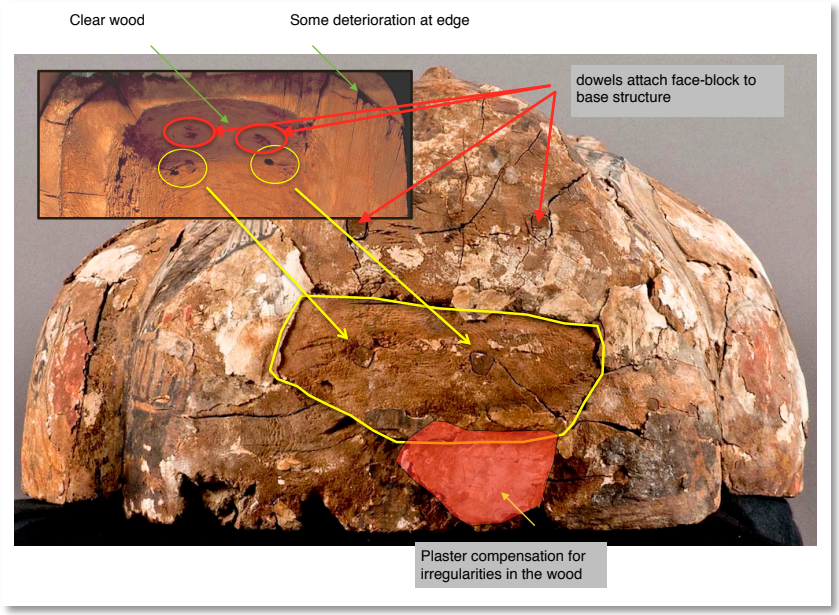




Figure 12 Top of the head, details

Figure 13 Interior head, wood irregularity, detail

Surface losses on the PR side of the head have exposed a wood piece (4-H) shaped to fill the gap between the face block and the base structure. There is grey fill material around the wedge that is somewhat proud of the original polychrome layer indicating that it is modern, and a

white plaster layer extends partially over the grey fill, which identifies it as a later campaign of intervention (fig.12).

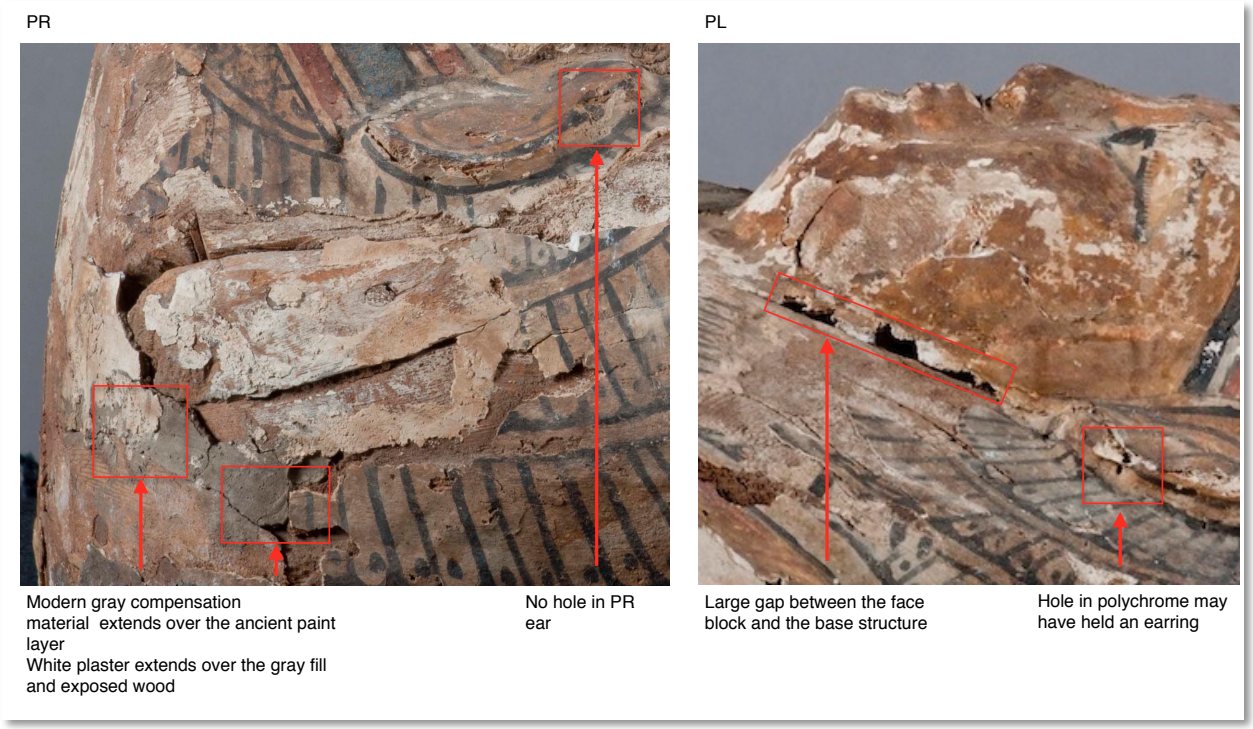


Figure 14 Details of ancient fill materials and possible earring hole (r) on the head

The gap between the face-block and the base structure can be observed on the PL side of the chin below the ear, where there is a loss of the fill and polychrome layer. Residue of ancient fill material is also visible in the gap (fig. 14). It is not possible to observe the connection of the face block to the base structure above the ear because of the contiguous intact restoration.

A void behind the PR side of the face-block can be probed, somewhat, through an interior gap in the base structure, providing evidence that the block is beveled down and back from the sides, not contoured to the base structure; rather, it has been carefully integrated with fill materials to create a cohesive appearance. This gap through the base structure is visible only on the PR interior of the head. It is obscured on the exterior by the bottom PR part of the face-block and surface materials. A piece of wood, not included in the structural diagram, is roughly fit into the gap and is secure, though it is unclear whether this is a structural component of the wood or

added, and, if added whether it is an ancient or modern addition. There is no observed evidence of any associated compensation material (fig.13).

At the top center of the head, an irregularly shaped piece of wood (2-H), approximately 17.0 cm wide by 7.0 cm thick, fits flush with the surface. It abuts the back edge of the head block, and it covers and compensates for the void between the head block and the base structure. This piece of wood is attached with two dowels that are visible on the interior surface (fig. 12).

There is a large area of plaster compensation between this piece (2-H) and the edge of the object, suggesting it may also compensate for more exaggerated irregularities or pre-existing damage to the outer surface of the base structure (fig.12). An adjacent piece of wood (3-H) is attached with four dowels along the PR edge of the head, at the curve from the top of the head to the side; this covers and compensates for irregularities in the wood. The interior surface of the top of the head is overall sound, clear wood, although there are irregularities along the edge.

There is a naturally occurring irregularity in the wood visible in an area of paint loss on the front surface of the neck, slightly to the PL of center. This irregularity resembles a dowel and is flush with the surface (fig. 15).



Figure 15 Irregularity in the wood at the neck

4.1.3.b Body

Nine pieces of wood have been applied to the base structure to add a shaped volume that suggests arms and a rounded chest. These pieces are numbered T-5 to T-13 on the diagram

(fig.16) and progress from the PR to the PL. These pieces of wood all taper to the leg, which has no added wood pieces.

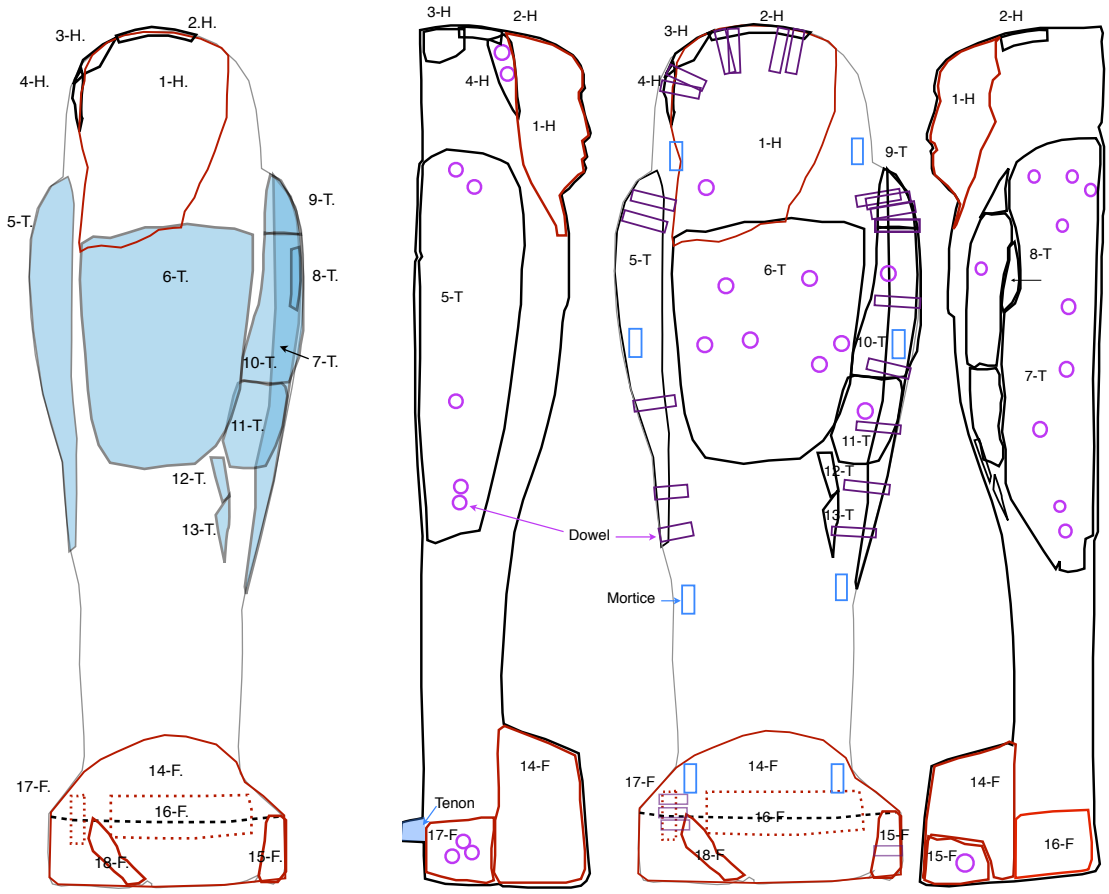


Figure 16 Added elements of the Torso in blue (l) and joinery (r)

The wood on the chest was shaped to create a smooth surface without arms or hands that are features of earlier dynastic periods (Ikram and Dodson 1998, 230-231,240-242; Taylor 2001 240-241; Niwinski 1988). The lappets are an exception; the shapes are carved in low relief and the grainy, brown paste described in Surface Description (4.2) is applied in a thick layer to add definition (fig.26).

A single carved piece of wood (5-T) creates the contour of the PR side from the shoulder to the top of the leg. It is worth noting, in order to better understand the types of wood and ways they were accommodated, that this piece of wood contains a significant irregularity at its edge 9.0 cm from the shoulder. This irregularity is 14.0 cm long, with a maximum width of 4.5cm, and

maximum thickness of 1.5 cm. Residue of a grey clay-like, ancient compensation material is adhered in the recesses (fig. 17).

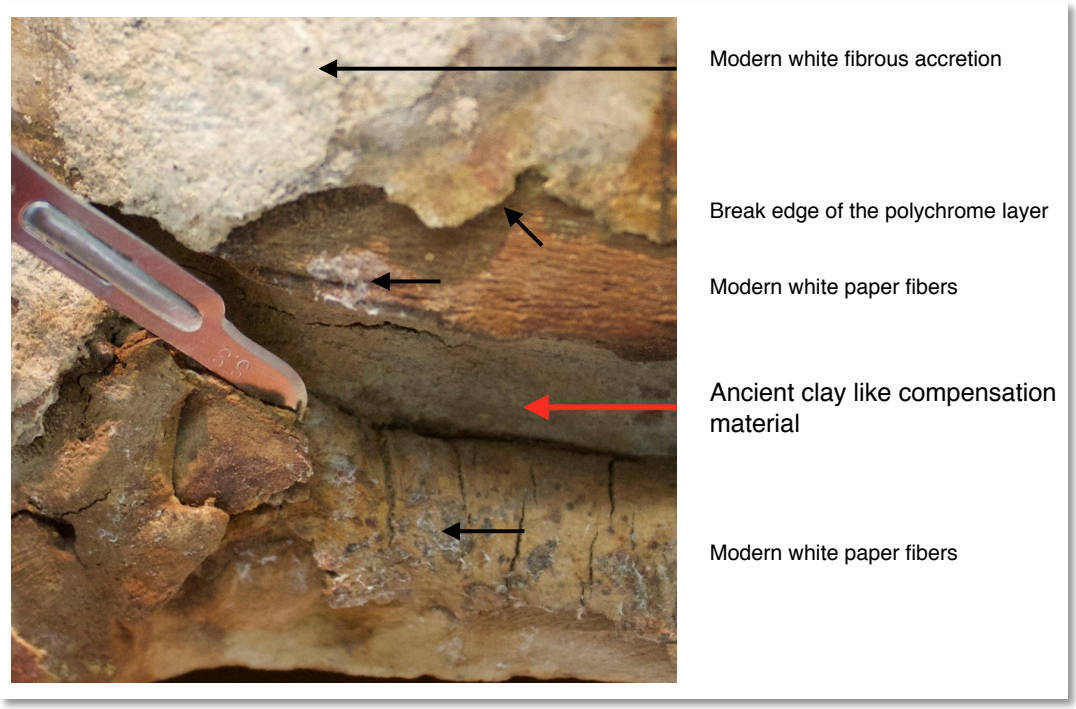


Figure 17 Residue of ancient grey compensation material (PR shoulder)

Segment 5-T is secured with five discernible dowels and a single dovetail joint at the foot end that is observable on the edge. A modern, white, plaster-like material is applied over the end of the segment and the surrounding area. It is unclear whether this compensates for loses to the paint layer, or if it covers and secures lifting of this end of the segment. The shape of the segment is visible observed in UV light (365nm) because of the fluorescence of the surrounding "plaster".

A thin panel (6-T) makes up the front of the chest. The panel is secured with seven dowels, which are visible in x-ray images and from the interior surface. This panel is slightly lifted, which has caused damage to the polychrome layer along the periphery. The lower edge has been covered by modern plaster compensation material, although breakage and losses to this material indicates ongoing movement. The overall thickness cannot be observed although it tapers to approximately 2.0-3.0 mm at the lower edge, which has been exposed by surface losses.

Seven wood pieces have been added onto the PL side. The longest piece (7-T) runs along the side and edge; it is 63.0cm (24 ¾“) long, 4.5cm thick and 16.5 cm at the widest point. Toward the foot, the piece tapers in thickness to 0.2 cm and in width to 4.5 cm. The step on the edge extends onto this piece and it contains a mortise and tenon. It is attached to the base structure with seven dowels, which can be observed on the interior surface, in x-ray images, and on the exterior where movement has caused losses to the paint layer.

The piece 8-T is a small compensation for an irregularity in the shape of 7-T that has created a gap between it and the abutting sections. These three pieces, 9-T at the top, 10-T in the middle, and 11-T at the bottom of the torso, are applied to the front PL side of the torso. There is a gap where the upper (9-T) and middle (10-T) pieces abut, which is primarily caused by deterioration of the top edge of middle piece (10-T). It is unclear whether this damage predated ancient construction, although there is significantly less damage to the abutting piece, and also very little similar deterioration on other parts of the object, which suggests that it was a pre-existing condition of the piece. Lastly, the two small segments, 12-T and 13-T, are integrated into the structure and 13-T is obscured by fill materials and only visible in x-ray (fig.18).



Figure 18 Section 13-T is identifiable in x-ray imaging (l)

4.1.3.c Foot-block

The foot-block is a modern assemblage of ancient materials (fig.19). Comprised of five pieces of wood attached together with modern adhesive and dowels, and the foot-block is attached to the base structure with contemporary metal screws and adhesive (fig. 20).

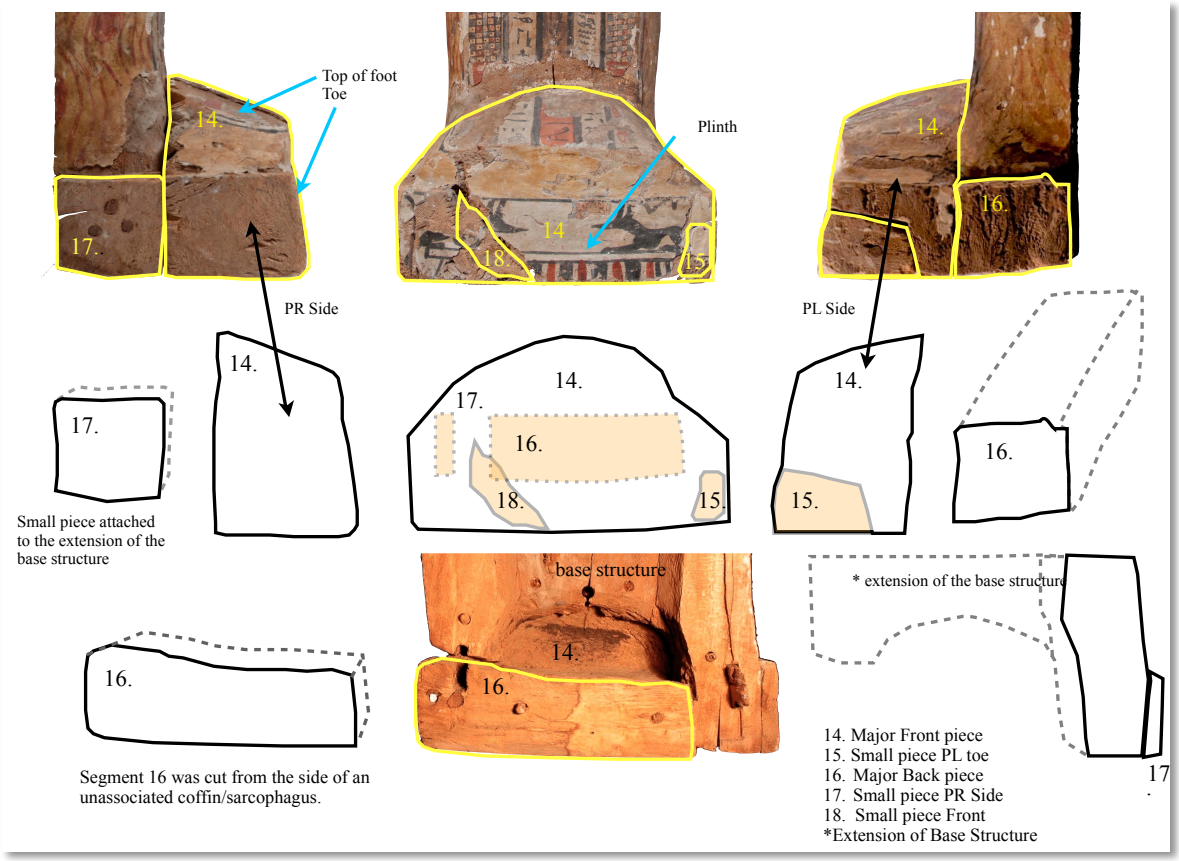


Figure 19 Components of the foot-block

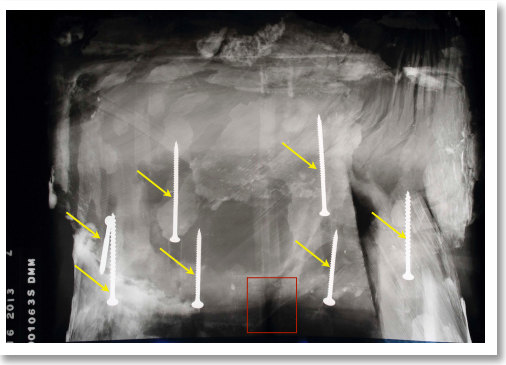


Figure 20 X-ray image of the foot-block showing modern screws

The two large components, 14-F and 16-F in the diagram, are the primary structural elements of the foot-block, and there are three small pieces, 15-F. 17-F, 18-F, that compensate for gaps or irregularities.

Section 14-F is a shaped block applied to the front surface; it is carved and painted to suggest a foot standing on a low pedestal. Viewed from the front, the carving describes the front of the foot and the pedestal (fig.19), and appears, falsely, to be two discreet pieces of wood.

Segment 16-F is not visible from the front. This segment completes the stepped edge of the coffin, although the step on the edge of 16-F is shallower and more deteriorated than the step on the base structure, and out of alignment (fig.8). The shaping of this piece indicates that it was removed from another, thicker-walled coffin. There is distinct water staining across half of the exposed surface, but there is no evidence of water damage to any other components of the foot-block.

The differences in joinery of the foot-block have been discussed in section 4.1.1 (Joinery). Again, these include the use of modern adhesive, modern metal screws, the creation of a false mortise between the base structure segment 16-F, and the presence of four round pegs unique to the attachment of the foot-block. All of these factors support the argument that the foot-block is a modern addition to the coffin.

The small wood piece on the PL front corner of the foot, 15-F, compensates for a gap in 14-F. The piece is attached with a round dowel and is loose, but not at risk becoming detached. A small segment (17-F) is attached to the PR side of the base structure for aesthetic purposes. It provides visual symmetry to create the impression of a pedestal. Three round dowels are clearly visible on the outside surface. Only one dowel is discernible in x-ray imaging, but appears not to continue to the interior and therefore plays no mechanical role.

A partial, now empty, dowel-hole is centered in the bottom edge of the base structure. It was partially cut off with the removal of the bottom of the base structure to accommodate the foot-block. Also, there are two non-functional dowel holes on either side of it with remnants of

dowels in them. Taken together, these findings strongly indicate that there was a different foot attached here at a prior time. Finally, the roughly executed join of the foot-block to the base structure created a jagged gap, which required extensive compensation material and surface coatings. There are residues of three failed campaigns here, and all appear to be modern; they were coarsely applied in a manner that is inconsistent with the ancient manufacture of this object.

4.1.3.d Wood

The base structure, the face block, and the ancient components of the foot-block are believed to be *Ficus sycomorus*; however, this attribution is based on a limited set of definitive observations and has not been confirmed by a specialist. Exposed wood of these components was observed with binocular magnification and photographed macroscopically, and the gross morphology was found to be very similar to *Ficus sycomorus*, which is a deciduous hardwood with irregularities in its structure. Growth rings are closely spaced, and the early wood is distinctly darker than the late wood. It is semi ring-porous, with large pores visible without magnification (fig. 21). These characteristics are consistent with *Ficus sycomorus* (Cartwright and Middleton 2008, 66; Inside Wood 2004).

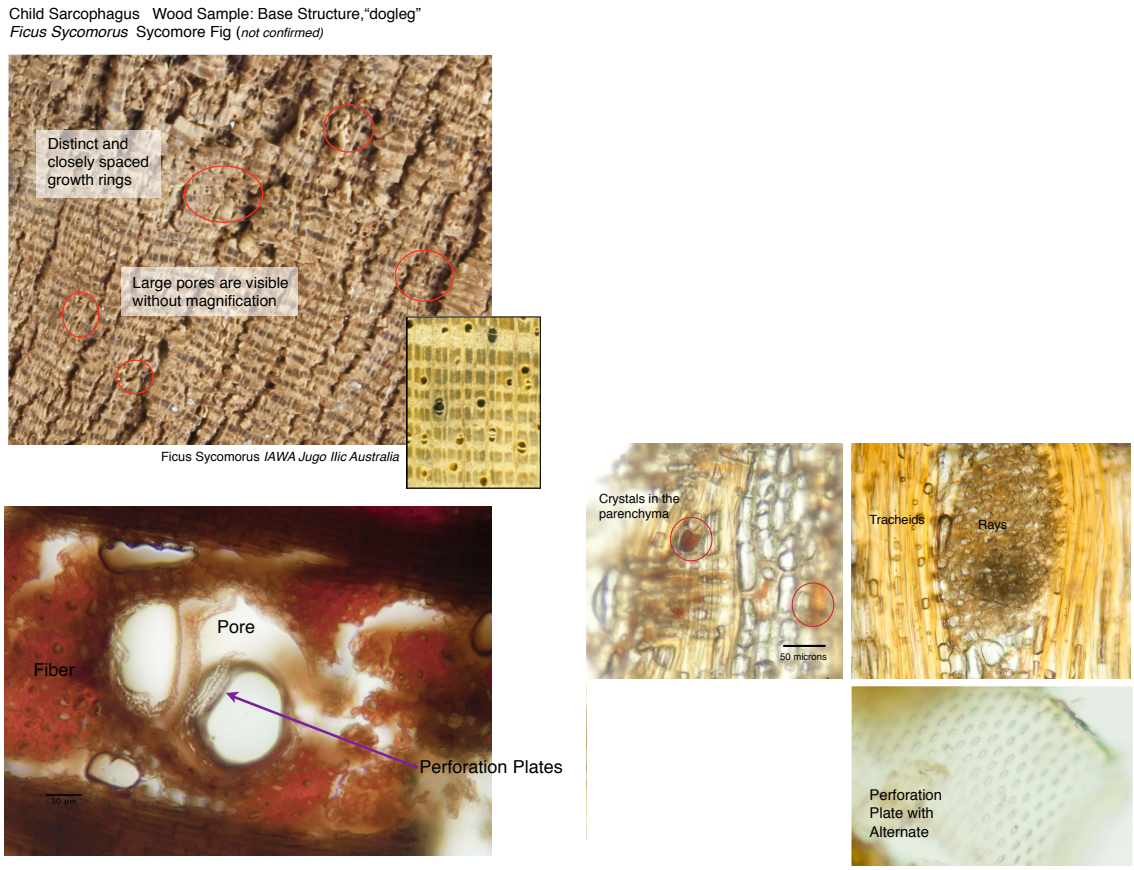


Figure 21 Detail images of the base structure wood

Viewed under magnification, it is possible to discern simple perforation plates and crystals in some parenchyma cells in a sample taken from the base structure. Photomicrographs of *Ficus sycomorus* in the IAWA online database of wood (Inside Wood, 2004) illustrate characteristics very similar to those observed in the sample from this object, and *Ficus sycomorus* has been identified in funerary materials throughout the dynastic periods (Gale et al 2000, 340-34; Ikram and Dodson 1998, 242; Lucas and Harris 1962, 440, 446-7).

A detached splinter associated with an added piece of the PR (11-H) was also removed for observation. The wood is reddish, and it releases a red-brown color in water. It was observed under binocular magnification in a transverse section. The absence of pits and the uniform radial array of tracheids identify it as a gymnosperm, or softwood. Because of the fragility of the wood it was not possible to identify more refined details of the sample.

Rowena Gale et al. (2000, 348-351) list five softwoods used in Egyptian antiquity and three of these might have been used in constructing this type and size object. These are the Aleppo pine [*Pinus halepensis* Mill. (Pinaseae)], Cedar of Lebanon [*Cedrus libani* A Richard (Pinaceae)] and Cypress [*Cupressus sempervirens L.*(Cupressaceae)] have been identified in sarcophagi of the later dynastic and Ptolemaic periods (Lucas and Harris 1962, 430). Cedar of Lebanon was imported for the manufacture of boats and funerary furniture in Egyptian antiquity (Gale 2000, 349; Ikram and Dodson 1998, 242). It is known to have been more expensive than native woods, and therefore less widely used. This sample resembles Cedar of Lebanon, although this attribution has not been confirmed by analysis.

4.2 Surface

4.2.1 Interior Surface

The interior is not painted, nor is there is evidence of a prior paint layer or coating. The wood is overall in excellent condition and has retained a light color and has very little soiling (fig.22). There is an area of staining with a small amount of white powdery materials, possibly dissolved gesso that extends from the PR shoulder to the top of the foot-block and there is a stable area of surface abrasion on the interior center of the torso. This area of abrasion is not discolored which may indicate that it occurred recently, within the post excavation period.

There is a stable, black, granular accretion on the interior of the foot-block (fig.8). This material has not been analyzed and it is unknown whether it is ancient or modern.



Figure 22 Interior staining is outlined in purple. The abraded area, center chest, is outlined in blue.

4.2.2 Exterior surface

In antiquity, a polychrome layer covered the entire exterior surface of the coffin. Because of the differences in the manufacture of the foot-block from the head and torso the surface will also be described separately. Deterioration of the ancient materials, combined with the effects of damage and modern interventions, have resulted in a complex surface that is highly variable in strength and appearance.

On the head and body, only approximately 65% of the ancient polychrome remains due to damage and significant loss (fig. 23). The surface also includes exposed wood, imitative restorations, and extensive areas of unsightly white "plaster" that compensates for losses to the ancient polychrome layer, as well as losses of modern restorations. The plaster is concentrated on the top of the head the PR side and middle of the torso, and PL lower torso.

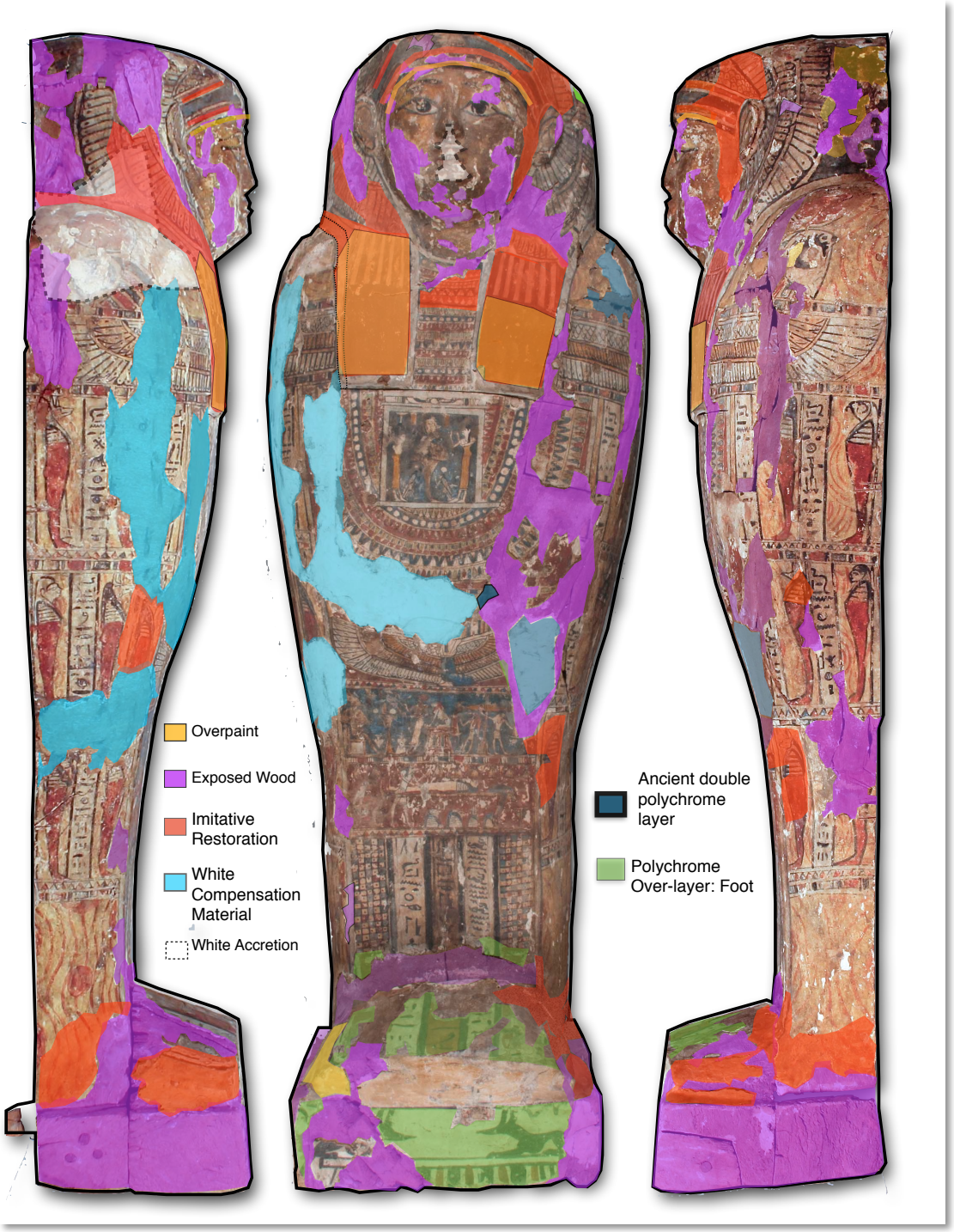


Figure 23 Surface areas

The ancient polychrome consists of a granular brown substrate layer, gesso, and paint as well as pieces of textile applied locally to support the paint layer. The substrate, gesso, and paint layers are water-soluble. The materials and the application of the ancient polychrome layers are

consistent with documented ancient Egyptian practices for the manufacture of polychrome coffins (Lee and Quirke 2000, 116-117; Stein and Lacovara 2010, 7; Watkinson 1995, 37).

A small remnant of an under-layer of polychrome is visible at the lower chest at the bottom edge of the applied chest panel along the break edge of the paint layer (fig. 24). This is the only example of an earlier or more ancient polychrome layer that has been observed to date on the head and body of the coffin. This double layer is very likely to indicate reuse of materials from another funerary object and it warrants further study; however, these materials have not been evaluated during this project. A conservation intervention was carried out to remove plaster that was placing the ancient materials at risk and to secure the fragment from disruption or contamination. A description is included in the treatment report.



Figure 24 Ancient double polychrome layer, detail and x-ray (l, lower) on lower torso

4.2.2.a Substrate

A dark-brown, granular, paste-like material, mixed with fine sand-like particles and plant fiber, is applied directly onto the wood as a base for the gesso and paint layers (fig.25). This layer is consistent with similar layers described in the literature (Narkiss and Wellman 1995, 174) and

has been observed on 21st Dynasty Theban coffins in the Rijksmuseum Van Oudheden, Leiden, the Netherlands. The surface layer on face is a notable exception; it does not have an observable preparation layer of this material (fig. 25).



Figure 25 Brown granular coating on the PL side below and to the side of the lappet (l) Absence of granular residue on exposed wood on the PR side of the face (r)

Although the adhesive properties of this granular paste are now very weak, a residual layer has been retained over most of the areas where the polychrome layer has been lost. Exceptions are areas where modern compensation materials or restorations have failed. In these locations the granular layer may have been removed prior to those applications.

Different thicknesses of the application indicate this material was used to smooth the surface before the gesso was applied in order to build up the low relief of the lappets, and as a fill for gaps (fig. 26). It is noteworthy that the residue is present at losses to the under-layer of polychrome on the foot indicating a similar method of manufacture of the ancient painted components of the foot.



Figure 26 the bottom edge of the PL lappet demonstrates the use of the brown grainy material in manufacture to create relief of the lappets.

4.2.2.b Textile

Pieces of textile were applied selectively on top of the granular layer to support the paint layer over transitions where wood components abut, and where naturally occurring irregularities in the wood were filled with compensation materials.

Textile has been observed on the face-block, torso, and foot-block. Fiber residues, as well as the impression of a textile layer, can be observed on the PR cheek near the chin where loss of the paint layer has exposed the ancient fill-material. Textile is also visible along break edges of the polychrome layer on the PL side of the chin, the outside edge of the PL lappet, the center and PL torso, and on the PR of the toe. Fibers are evident around an insect exit hole on the PR side of the torso. In addition to macroscopic observation, some areas of textile on the chest and the lower torso have been identified in x-ray imaging as grids of fine cracking in the gesso.

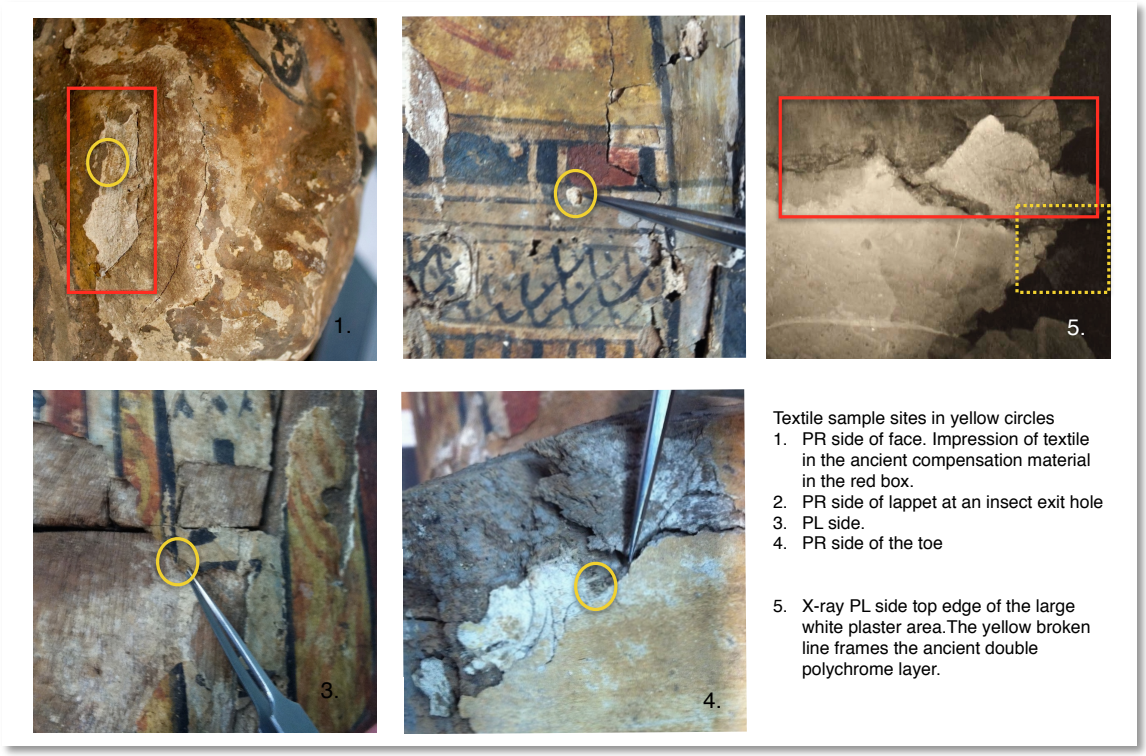


Figure 27 Textile sample locations (1-4) and x-ray presence of textile (5)

Fiber samples were taken from the face, PL chest, and from the toe for microscopic examination (fig.27). All textiles are simple weaves. The thread count varies slightly, but identification of the twist and ply was not possible. Although there are differences between the dimensions of the fibers, the spacing of the nodes, and the degree of degradation, are all are consistent with linen, which is a textile made from the bast fibers of the *Linum* genus of the *Linaceae* family (fig. 28) The use of linen in ancient Egyptian funerary objects is well documented in the literature and in collections, and the process of manufacturing linen cloth, from cultivation to weaving, is depicted in ancient tomb paintings (Lucas and Harris 1962, 142-5; Nicholson and Shaw 2001, 269- 271).

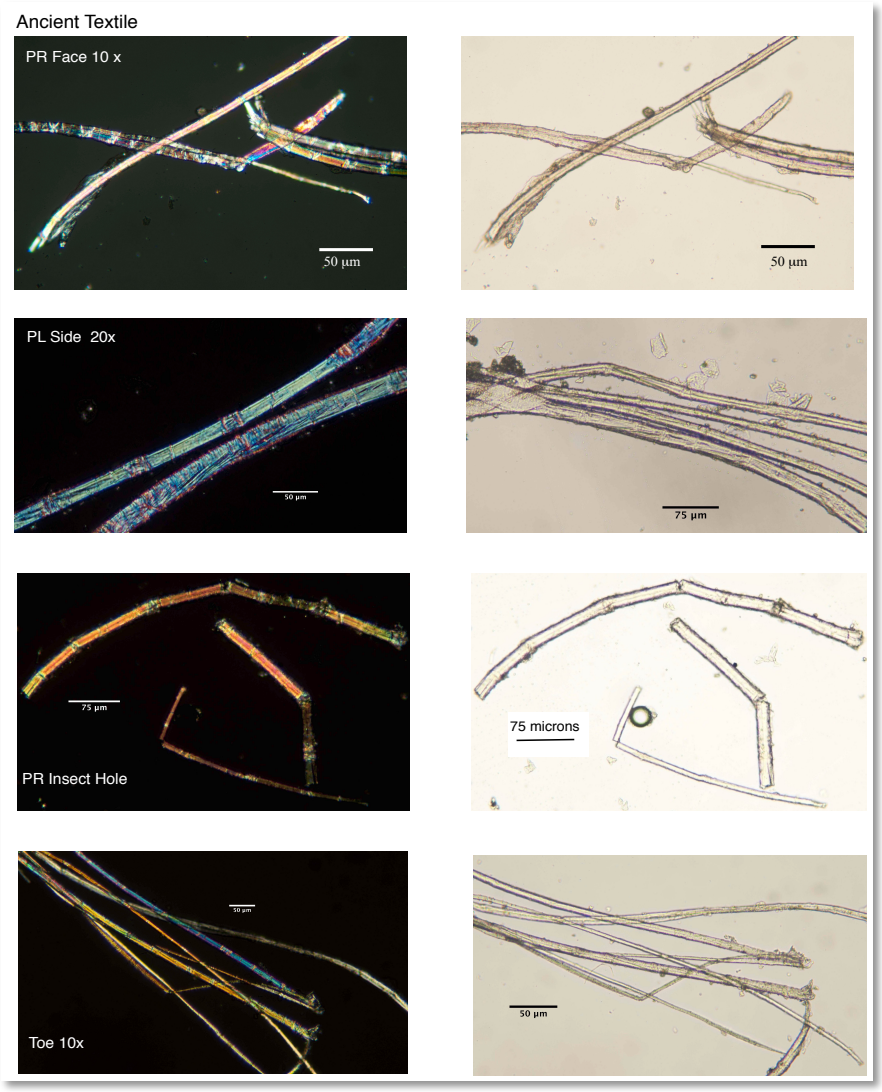


Figure 28 Fiber samples are consistent with bast fibers.

4.2.2. Gesso

The white gesso layer is ubiquitous as the substrate for the ancient paint and together the gesso and paint form a cohesive surface layer referred to as the paint layer or polychrome layer. In x-ray images the gesso layer is slightly radio-opaque and readily distinguished from more radio-opaque white modern fill and restoration materials (fig. 29). XRD analysis has identified quartz, gypsum, and the calcium-carbonate polymorph, calcite $CaCO_3$, which is the dominant compound in the gesso.



Figure 29 Opacity of ancient gesso and modern compensation materials.

4.2.2.d Paint: Palette and Pigment Analysis

The paints are a mixture of pigment or colorant and a water-soluble binding media consistent with well-documented methods of manufacture in ancient Egypt, including the Ptolemaic period (Nicholson and Shaw 2000, 105; Lucas and Shaw 1962, 338).

Pigment analysis successfully identified the colorants that make up the ancient palette and distinguished differences between the colorants on the head and body, and on the foot-block. Modern over-paint was identified as well as obscured ancient paint. In addition, an unpredicted presence of Egyptian blue was identified in some gesso layers.

As evidence was discovered of the repurposing of structural materials, the pigment analysis was evaluated to determine what contribution this information could make to confirming or refuting reuse, and to aid in the discovery of the object's history.

This section summarizes the pigment analysis and conclusions, emphasizing information relevant to identifying reuse including the predicted pigments based on those used in antiquity, and the application of each color on this object. Analysis of each colorant of the ancient palette is presented sequentially, non-pigment and modern colorants are briefly described, and overall conclusions are presented at the end of this section.

4.2.2.d (1) Palette

The ancient color palette of the head and body of the coffin is made up of blue, pale blue, green, red, red-orange, yellow, black, and bright white applied onto the white ground of unpainted gesso. All text, linear elements, and outlined figures are black paint. Red and blue are repeated as theme colors in decorative elements over the head and body (fig. 30).

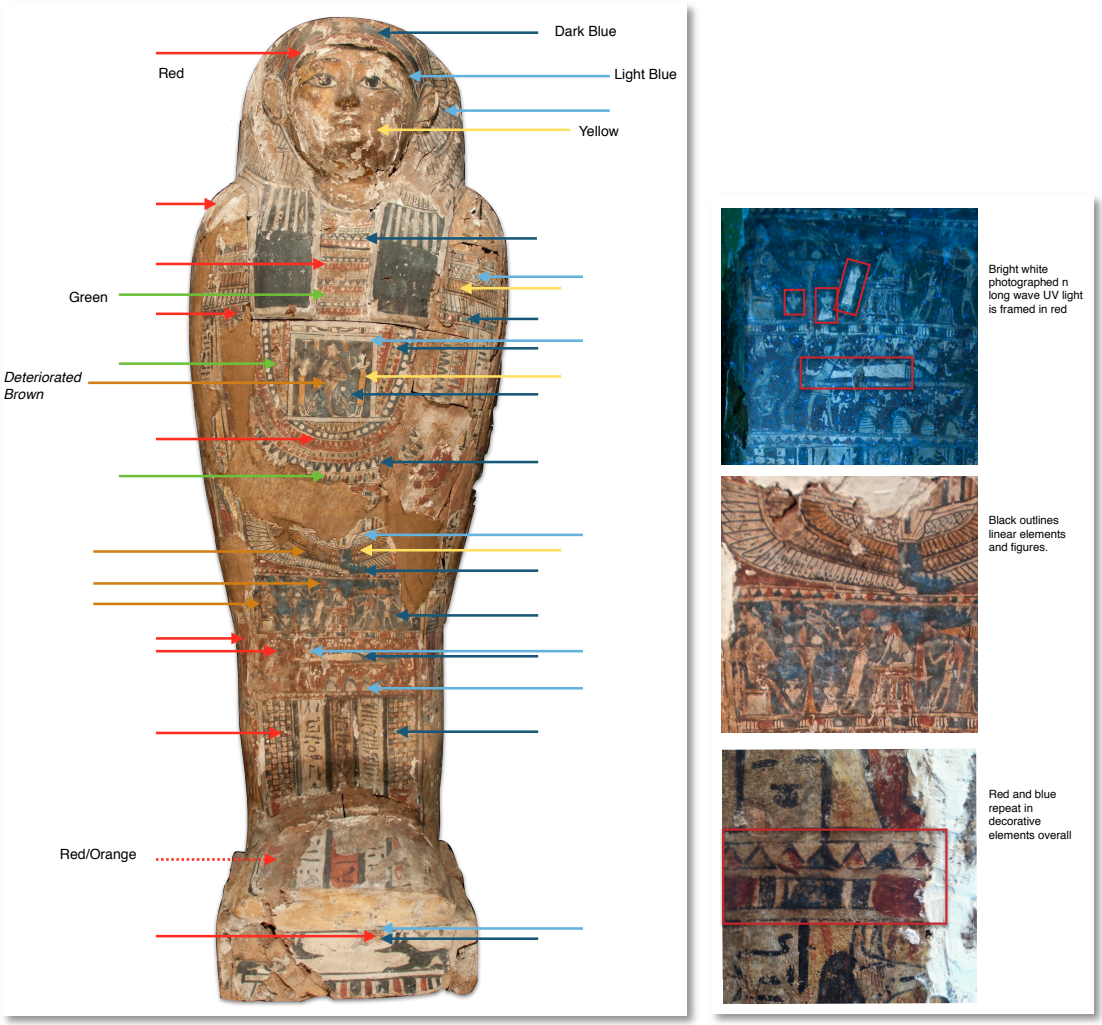


Figure 30 general color locations (l) and applications (r)

The palette of the under-layer of paint on the foot-block is blue, pale blue, red, red-orange, and black, also applied onto the white ground of unpainted gesso. Red, black, and white are the only colors of the outer polychrome layer. The colorants of the ancient palette are presented in chart 1 below.

An ancient color or surface effect on the torso was created by a material that is now deteriorated, brown, and mottled. This material was applied intentionally in areas that are significant to the design and its iconographic meaning. These include the Osiris figures, coloring of some of the registers of feathers, and details in the broad collar and image panels (fig. 40).

Chart 1 Ancient Palette		
Color	Identified Pigment/Colorant	
Blue	Egyptian Blue	$CaCuSi_4O_{10}$
Green	Atacamite (deterioration product of Malachite)	$Cu_2Cl(OH)_3$
Red	Red Ochre, Hematite	Fe_2O_3,
Red/Orange	Realgar	As_4S_4
Yellow: face, wings, figures	Orpiment	As_2S_3
Yellow: sides	Yellow Ochre, Goethite	αFeOOH
Black	Carbon Black, Charcoal	C
White	Calcite	$CaCO_3$
Deteriorated Brown	*Unknown Organic with Calcium Carbonate, Calcium Oxalate, Clay and Gypsum.*	

4.2.2.d (2) Pigment Analysis

This pigment analysis process and results are described in depth in a separate document. This chapter presents aspects of the pigment analysis relevant to the thesis.

Several methods of non-destructive and destructive analysis were carried out to acquire comparable and corroborating evidence (appendix V.). The non-destructive forensic imaging techniques include: Visible-induced Luminescence imaging (VIL), which identifies Egyptian

blue; Infrared Reflectance imaging (IR), which identifies highly absorbent carbon materials under the surface layer, most notably under-drawings; Ultraviolet-induced Visible Fluorescence (UV), which locates or identifies materials by characteristic fluorescence; and X-radiography imaging (X-Ray), which identifies structural components, including individual wood elements and dowels, metals, and other radio-opaque materials.

The destructive analytic techniques include Powder X-ray Diffraction (XRD), Polarized Light Microscopy (PLM), Fourier Transform Infrared Spectrometry (FTIR), and Gas Chromatography Mass Spectrometry (GC-MS). Relevant analytic results are summarized in the appendices.

A. Blue

Egyptian Blue; Calcium copper tetrasilicate, cuproriviate $CaCuSi_4O_{10}$ and residual glass and quartz.

Egyptian Blue is the predominant, nearly exclusive, blue colorant on ancient Egyptian artifacts and was used continuously into the Roman period until approximately 800 CE. There is documented use of cobalt blue only during the Eighteenth Dynasty (Lee & Quirk 2000, 111).

Egyptian Blue is the first known synthetic colorant, developed in ancient Egypt or Mesopotamia and first documented in Egypt in the 4th Dynasty, which is dated to approximately 2600 BCE (Daniels 2004,73-84). Silica and copper with an alkali flux are heated together to manufacture Egyptian blue and these materials were readily available locally during Egyptian antiquity (Daniels 2004,73-84). The resulting heterogeneous mixture is primarily cuproriviate with residual quartz and glass phases. The color varies from pale to dark blue, and its covering power is poor, meaning the intensity of the color weakens as the particle size is reduced. Because of this characteristic, Egyptian blue particles are usually observably larger that other pigment particles, and the paint is applied in a thick layer.

Egyptian blue paint may develop a characteristic blackening, or a dark crust may form over the blue. This is largely the effect of darkened varnish or binders, not the result of an alteration in the pigment (Daniels 2004, 73-84).

Egyptian blue mixed with white to make pale blue, has been observed on Romano Egyptian funerary objects (Svoboda 2012), and is prevalent on this object. This counters observations by Pages-Camagna and Guichard (2011, 30) who found that no mixtures of Egyptian blue with other colors were discovered on three hundred Egyptian artifacts in French collections.

Blue Locations

Blue and pale blue have been used extensively on this object and are found on the head, the body, and the under-layer of polychrome on the foot. Neither blue nor pale blue are present on the over-layer of polychrome on the foot-block. Examples of these locations are illustrated in Figures 31-37.

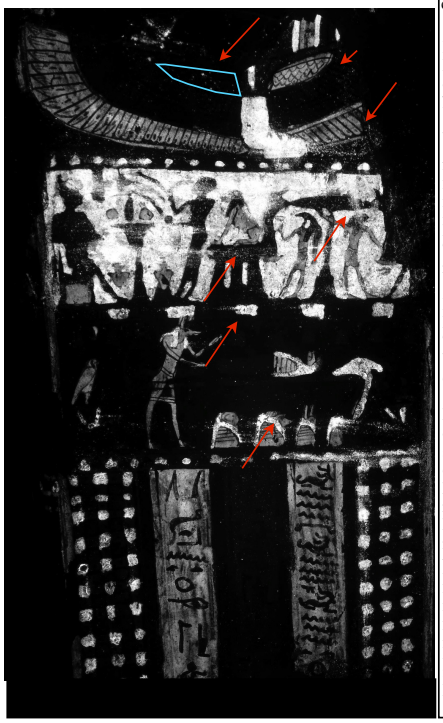
There are bands of blue along the forehead and back of the head, in details in the broad collar and vignettes, the backgrounds of the pectoral and the upper vignette, and the garment of the goddess Nut. Dark blue paired with red is used overall as a theme coloration added to liner elements and to the checked pattern on the front of the leg.

The whites of the eyes are pale blue, as are the background color of the bird heads on the PL and PR shoulders, the feather registers, registers of the broad collar, and all text except the center panel on the leg. Pale blue color bands are visible around the lappets and the pectoral. Pale blue colors the flesh of the deceased and the gods other than Osiris, the upper torso of the canopic jars and mummy figures as well as some details in the vignettes.



Figure 31 Blue and pale blue on the face and shoulders: VIL image (l) and visible light (r) with blues enhanced

Egyptian Blue/ VILS Child Sarcophagus Lid
515 nm wavelength band



Blue:
Torso and wig of the Goddess Nut.
Upper image panel: Background
Lower image panel: Anubis wig, the wig of the canopic figures and the deceased.

Pale Blue:
Pale Blue background color to the upper register of the Goddess Nut's wings.
NOTE the absence of blue of the viewers left

Upper image panel: Left to right:
Area under Osiris's throne
Details of the offerings: jars, lotus flowers,
Detail on the front of Osiris's crown.
Head of the deceased
Monster god Ammit
Torsos of the figures (Thoth and Horus) to the right.

Lower image panel:
Falcon
Torso of Anubis
Upper body and face of the deceased and the canopic jars.

NOTE: only the eyes and forehead of the deceased are pale blue. This may be the result of scraping off a beard from a prior use of the coffin to be reused for a female.
NOTE: absence or horizontal details on the far right jar
Note: Egyptian blue particles have been mobilized in patterns that suggest fluid or wiping:
Downward over the the face of the deceased
Laterally across the middle of the image.
Right at Nut's knee
Right over canopic jars.
Left over the decorative band between the images.
Right over the decorative band below the images



Figure 32 Egyptian blue on the lower torso and leg including notes on iconography. Movement of particles with the application of a modern coating is indicated.

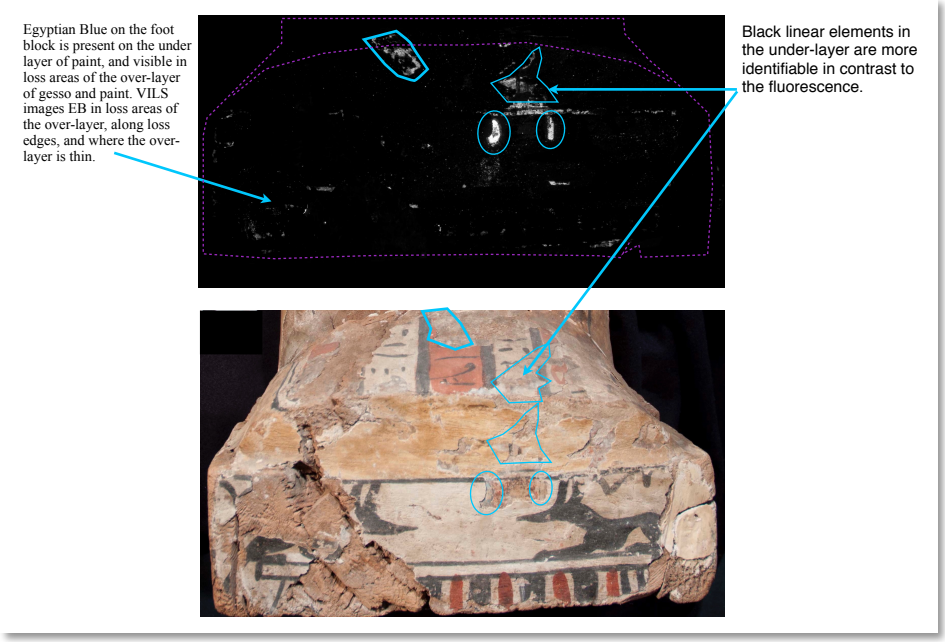


Figure 33 Egyptian Blue on the foot-block in VIL image (upper) and visible light (lower)

Blue Application

The blue paint is made up of large, thickly applied particles. The blue details between the lappets, on the broad collar, and in the checked pattern on the leg show uneven darkening, characteristic of Egyptian blue, with some details appearing almost black and others grey blue (fig. 34). The vivid color of the pigments is revealed at some cracks and surface chip losses.

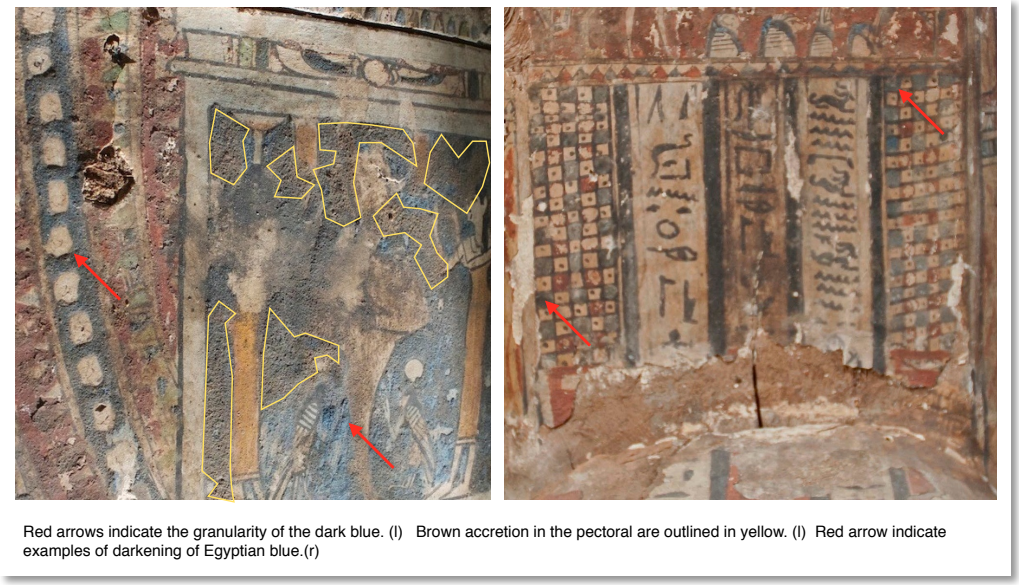


Figure 34 Characteristic darkening of Egyptian blue (l, r) accretions in the pectoral

The blue background of the pectoral is obscured by a thick, brown accretion of unknown origin and material. A modern coating has saturated and brightened the blue of the garment of the goddess Nut and the upper part of the adjacent vignette. The coating is described in the section Modern Interventions (5.) below

Pale blue is applied as a thin paint layer over the ground that is observed in microscopic cross sections (fig. 39).

Blue Analysis

Visible induced luminescence imaging (hereafter VIL) of the sarcophagus captured luminescence or fluorescence consistent with the observable applications of dark and light blue, and captured fluorescence in areas of on both lappets that are over-painted black. Distinct blue particles of an under-layer are visible along the edge of some losses in the lappets viewed with low magnification (fig. 35).

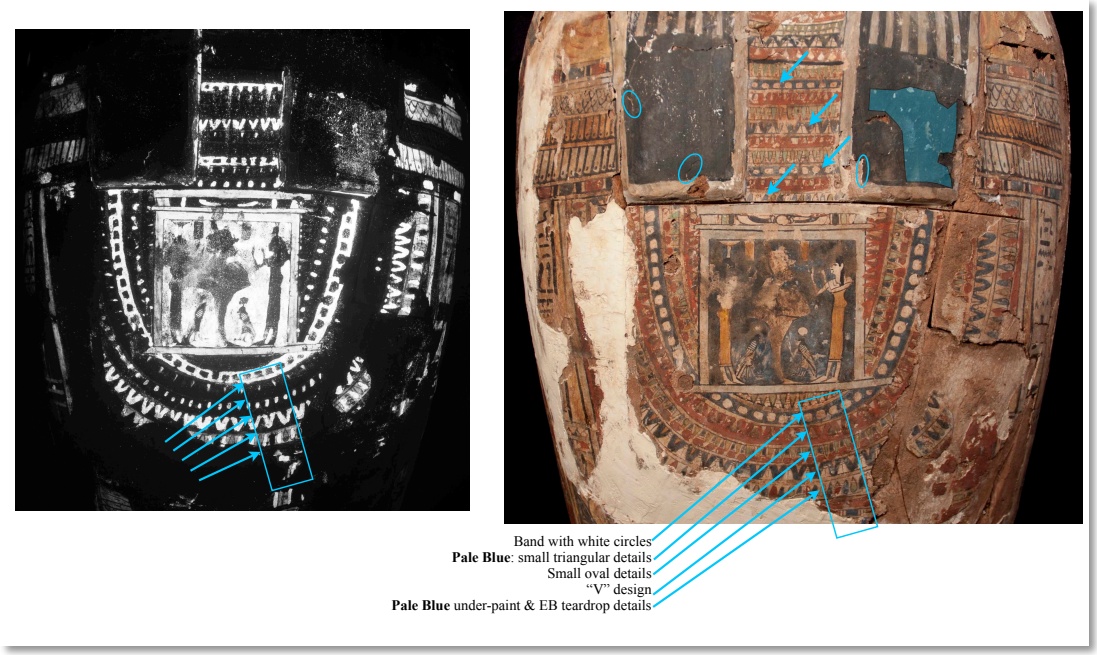


Figure 35 VIL imaging (l) reveals blue under the lappets and clearly identifies blue and pale blue in the broad collar.

VIL imaging has also revealed information about the method used to apply the blue paint and nearby colors. Examples are the faces of the reclining mummy figures that are drawn in black

line applied over a ground of pale blue (fig. 36). VIL image of the falcon head on the PL shoulder reveals that it has been repainted to a smaller profile (fig 37). The light colored band along the outer curve of the associated feather motif is partially fluorescent indicating the yellow was applied after, and on top of, the outer curve of the wing.

An unpredicted result of VIL imaging has been the identification of distinct particles in a sparse but even distribution over the face and more densely concentrated in the yellow background on the PL side (fig. 38). Blue particles are not visible macroscopically in either of these locations. This fluorescence is absent from areas where the surface is lost on the face, and this effect is also absent from the ancient yellow paint on the PL shoulder.

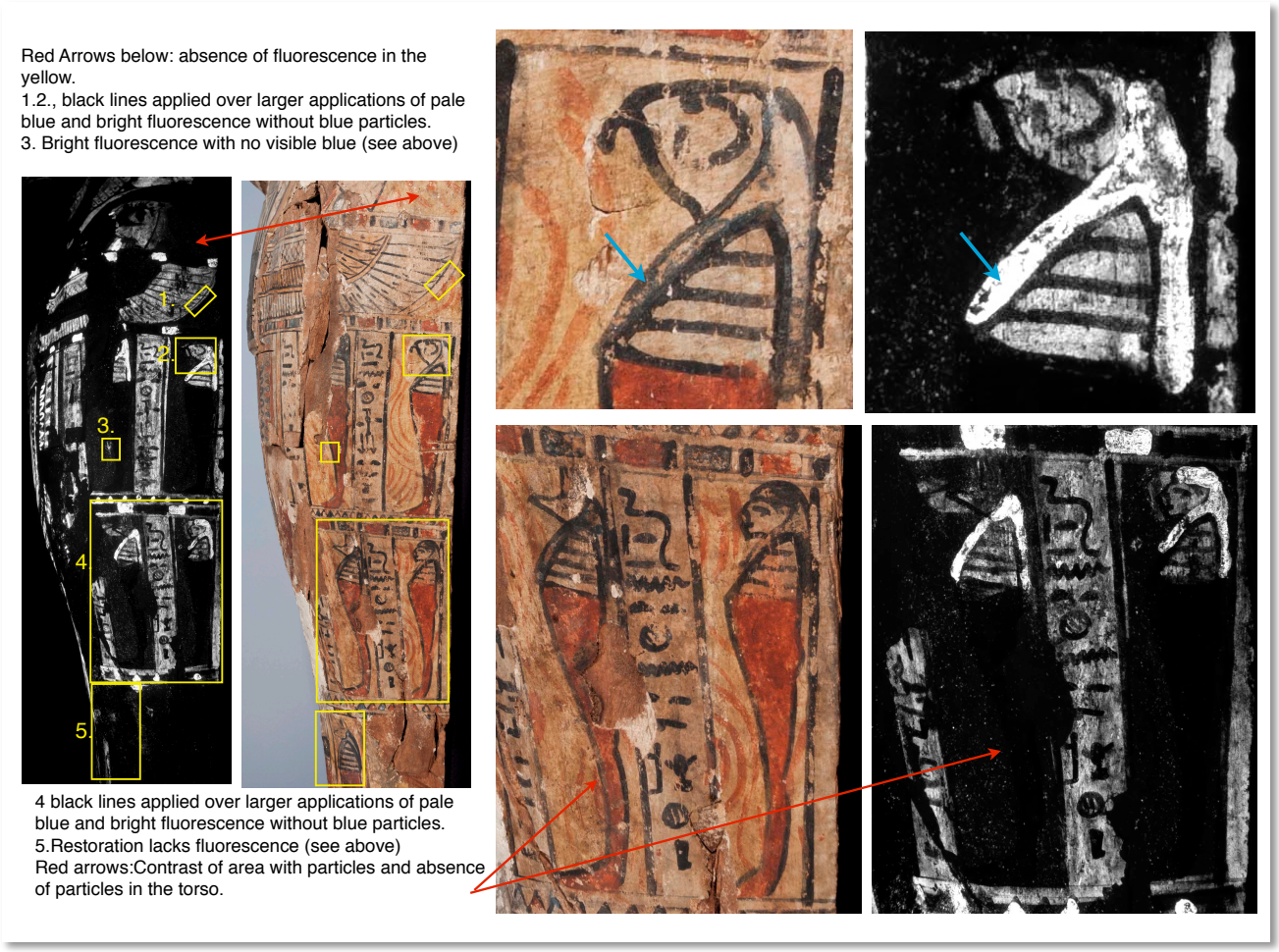


Figure 36 VIL (l, far r) and visible light images (m)



Figure 37 repainting revealed in VIL image (r) of the bird head on the PL shoulder.

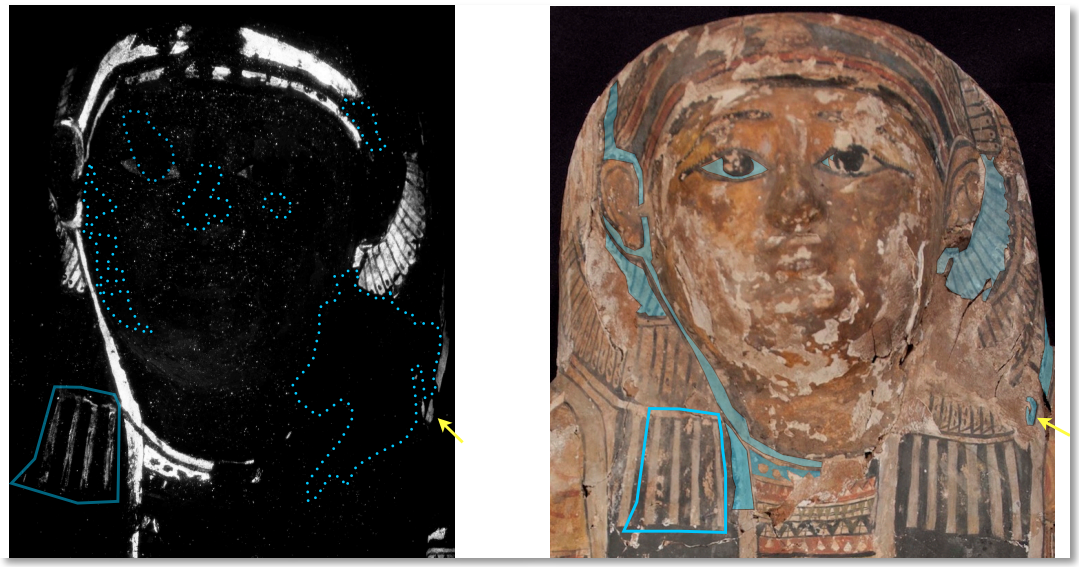


Figure 38 luminescence, or fluorescence, of particles in the face visible in VIL in broken lines (l) indicate an absence of the particles and correlate with surface losses.

XRF analysis of the blue identified major peaks of copper and calcium, as well as silicon, consistent with predicted results for Egyptian blue (see appendix VI summary of all XRF analyses). XRF analysis of the lappets identified similar peaks in areas of the lappets with fluorescence in VIL images, supporting the presence of an over-painted Egyptian blue layer. XRD analysis of a sample of blue identified Cuprariovate (appendix (Appendix VII.a). Viewed under magnification (fig. 39), samples from both the body and from the foot-block are consistent with known characteristics of Egyptian blue; the particles are transparent and isotropic, large and irregularly sized, ranging in from <10.0 to 40.0 µm, and exhibit conchoidal fracture. The Becke index is lower than the medium (<1.66) showing that the refractive index is less than 1.66. The

particles are paler colored than cobalt prepared in a similar dispersion sample and viewed at the same magnification. The pale blue was examined in a cross-section taken from the decorative band immediately below the PL lappet along an existing loss. Blue particles in this sample are smaller than those observed in samples of the dark blue [~ 6.0nm or less], and are mixed with white particles.

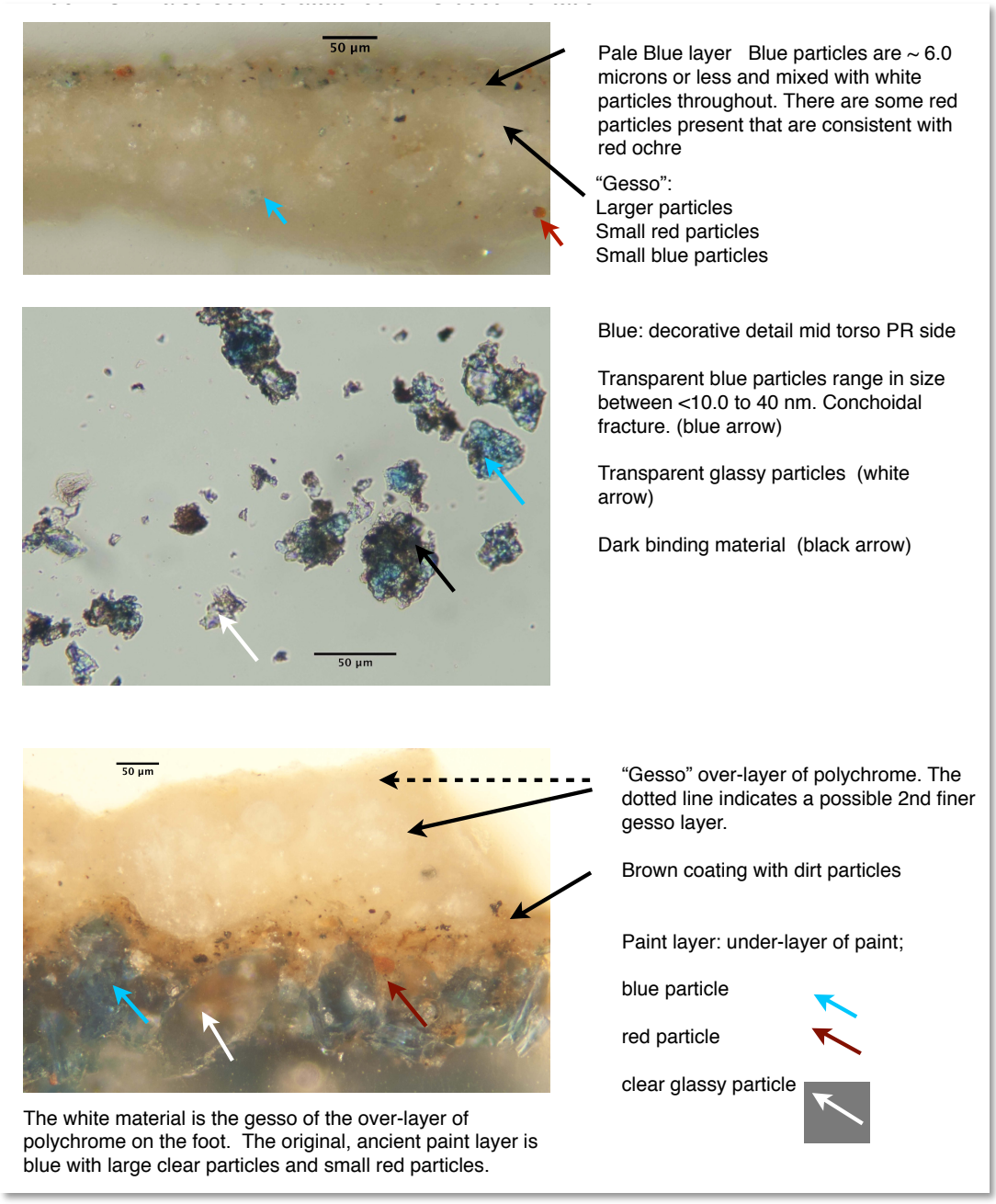


Figure 39 Photomicrographs of blue (middle, bottom) and pale blue (top)

Blue Summary

Several methods of analysis and observation have confirmed the identification of Egyptian blue as a dominant colorant on this artifact. XRD analysis provided a definitive identification of Egyptian blue. XRF analysis, the observation of known macroscopic and microscopic characteristics, and the characteristic fluorescence captured using VIL imaging corroborate this identification. VIL imaging has proven to be a powerful and precise tool for locating obscured or covered applications of Egyptian blue.

Identification of Egyptian blue on the foot-block is considered significant evidence that this structural component is ancient. It is assumed that all Egyptian blue found on this object was manufactured and applied in antiquity. Also new understanding of the ancient coloration of the lappets has resulted from VIL imaging of blue beneath the black paint.

The VIL imaging of Egyptian blue particles dispersed over the face may provide more evidence that distinguishes this component by manufacture. This fluorescence on the face and PL side raise questions about manufacture that warrant further inquiry.

B. Green

Malachite
Identified: deterioration products:
Atacamite, copper trihydroxychloride $Cu_2Cl(OH)_3$
Copper-organometallic

Several materials have been identified that were used as green paints during the later Egyptian dynasties through the Roman period. Of these, the synthetic pigment Egyptian green, with malachite (copper carbonate), the mineral chrysocolla, copper trihydroxychlorides, verdigris (copper acetate) and copper organo-metallic compounds derive their color from copper. (Scott 2011, 36; Lee and Quirk 2000,105,112; Leach 2008, 40) Green earth is the only green pigment colored by iron. Pigments were also mixed to create greens (Green 1995, 88; Scott 2011, 41).

The ongoing transformation and degradation of copper-based green paints has complicated their identification and led to disagreement among scholars (Middleton 2011, 12; Scott 2000; Scott 2011, 34-6, 41). Atacamite, a deterioration product of malachite is the most stable of the trihydroxychlorides and Scott contends that all copper-chlorides are present as deterioration products of malachite or Egyptian blue and green (Scott 2011, 36,41).

Egyptian green (copper silicate) is a synthetic pigment similar to Egyptian blue. Its use dates to the second intermediate period (1773–1550 BCE) (Scott 2011, 32). Pages-Camagna & Guichard (2011, 31) reported finding no Egyptian green in the examination of three hundred Ptolemaic Egyptian antiquities in French collections.

Copper organometallic compounds have been indentified on Late Period artifacts and are understood to have developed as deterioration products of copper containing paints that have interacted with a varnish, binding medium, or applied waxes (Scott 2011, 37).

Mixtures of orpiment and Egyptian blue have been identified on late Ptolemaic artifacts (Lee and Quirk 2000, 112-113). The combination of orpiment and indigo to produce green has been identified on Roman funerary artifacts (Corcoran and Svoboda 2010, 52).

Green Location

Green paint on this coffin lid is exclusively present as small-sized droplet shapes, or triangular decorative details, in three bands of the broad-collar and five rows of the decorative pattern between the lappets (fig. 40). These green details range in size from 3.0 mm to 1.0 cm and are applied directly onto the ground, except in the lowest register of the broad collar where the green details are applied over a layer of pale blue, which would have produced a subtle shift in the color. The location of green paint on a clearly identified modern restoration at the neck precluded the need for pigment analysis to distinguish it from the ancient paint.

The green is a pale tint that is degraded in a spectrum to light brown in all but a few details not covered by a modern animal glue coating. The green in this area was sampled for

analysis (fig.40). Observed with binocular magnification the uncoated green is opaque, fine grained, and the surface is finely cracked but stable.



Figure 40 Location of green details (r) and the green sample site (l)

Green Analysis

XRF, FTIR, and microscopic analysis contributed to the identification of the green paint. XRF analyses of green details consistently identified copper. FTIR analysis of two green samples identified the copper chloride hydroxide atacamite (appendix VIII.a).

In microscopic cross section, the green appears as a light green band approximately 4.0-6.0 microns thick comprised of light green particles and some white particles in a green matrix (fig 41). The green appears somewhat yellow on the boundary with the gesso substrate. A dispersion sample of the discolored green is a mixture dominated by a transparent, brown, resinous material. There are clusters of fine green particles within the resinous material, which may indicate the formation of a copper proteinate as a result of the interaction of copper ions with an animal glue coating.

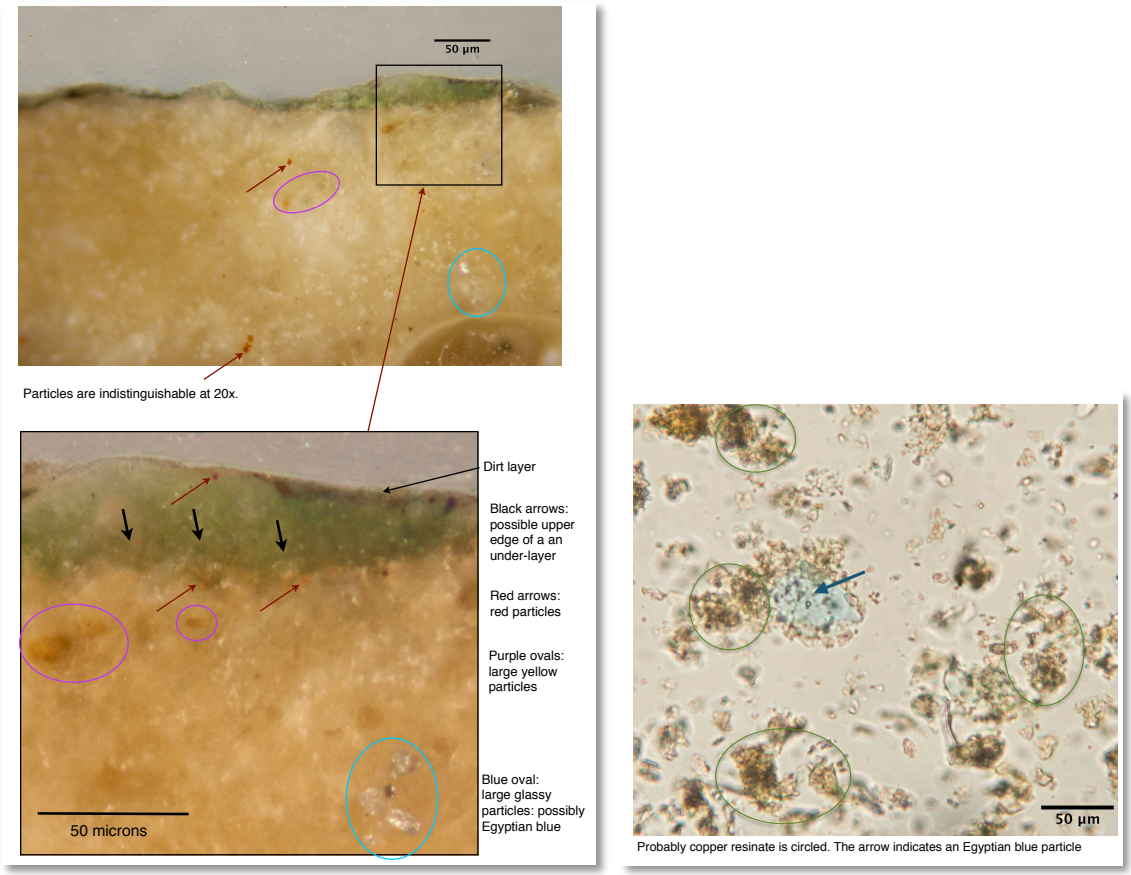


Figure 41 Cross section of green paint (l) Dispersion sample with probably copper resinate (r)

Green Summary

FTIR analysis has provided a definitive identification of atacamite, which is understood to be the deterioration product of malachite. The deterioration of the green paint to yellow-brown strongly indicates interaction between the paint and the coating to form copper-organometallic compounds. Identification of the green as deteriorated malachite strongly confirms its antiquity. The absence of green from the face and from the foot-block further distinguishes these two components from the body of the coffin.

C. Red

Red Ochre, Fe_2O_3
Hematite
Realgar, Arsenic Sulfide, As_4S_4
Possible Red Lead

Red iron oxide, or red ochre, a heterogeneous mineral comprised primarily of hematite, Fe_2O_3 is the predominant red colorant identified on Egyptian funerary objects from all dynastic periods (Lee & Quirk 2001, 114). Realgar has been identified on Egyptian funerary antiquities[1], and papyrus (Green 2001, 46). Red lead or minium, mercury sulfide or vermilion (cinnabar is the naturallyl occurring colorant and vermillion the sythetic), and the organic colorants alizarin derived from madder, and carminic acid derived from the insect, *kermes vermillo* have also been identified on late Ptolemaic and Roman objects (Green 1995, 89; Corcoran and Svoboda 2010, 46).

Red Locations

Red paint is a dominant color on the coffin as it was in antiquity, and there are now areas of extensive modern red over-paint and red in imitative restorations. Because these modern applications significantly impact the current appearance and understanding of the ancient red paint they are described in this section, and more briefly in Modern Interventions, section 5.

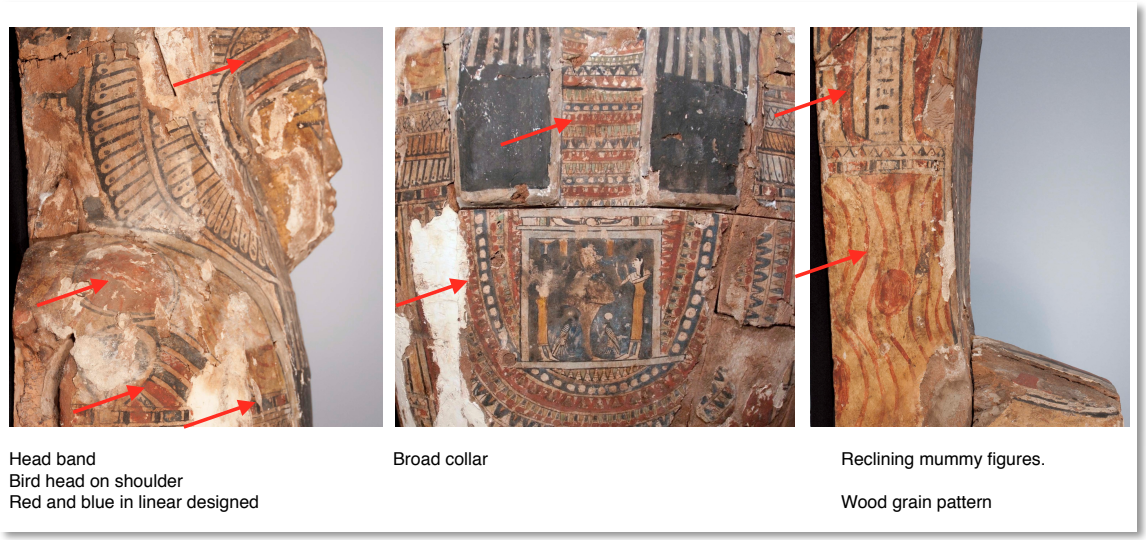


Figure 42 Red locations

[1] Extensive use of realgar has been identified by the Vatican Museum conservation department on 21st Dynasty coffins in the

On the head, the ancient red is present only as two stripes in the headband. On the torso, red paired with dark blue, is the theme coloration applied into linear and geometric elements including the checked pattern on the front of the leg. There are red details in the broad collar and vignettes, solar discs on the shoulders are red, red is the background color of the lower vignette, and of the lower bodies of the mummy figures on the sides of the object. All of these areas are defined by black outlines. Undulating red lines and circles, without black outlines, are applied over a yellow background on both PL and PR sides to create a wood grain pattern (fig. 42).

Two ancient reds on the under-layer the foot-block paint can be observed at losses of the over-layer. Red on the toe resembles the red on the torso in color and application inside black linear patterns. The second is a bright orange-red that is only present on the top of the foot-block and appears to have been applied inside an outline of the feet. This paint is coated with a pale brown material and the color can only been seen at small chip losses to broken edges (fig. 43).



Figure 43 Exposed chip of orange-red realgar top of foot (l) Surface qualities contrast notable between foot (l) head and body (PR chest detail r)

All of the red paint on the head and torso exhibits some degree of cracking, cupping, and loss, which is unique to the red. This ancient red paint on the front of the torso and in the repeating red details is characterized by extensive losses from failure of the binding material leaving only the edges of the original paint where the binding media would have been more

concentrated (fig. 44). The red in the headband, on the mummy figures, and the red in the wood grain pattern appear to be a thinner paint, and all are stable although a possible over-paint may mask deterioration and losses.

There are three discernable applications of modern red paints on the sarcophagus. The over-paint layer that covers the failed ancient red on the torso, red associated with imitative restorations, and the red on the over-paint layer on the foot-block.

The paint that covers the lost red is characterized by rough strokes that are broader than the ancient paint area, and extend over the black lines and over adjacent colors, indicating this paint was applied with a larger and rougher brush than was used to apply the ancient paints (fig. 45).

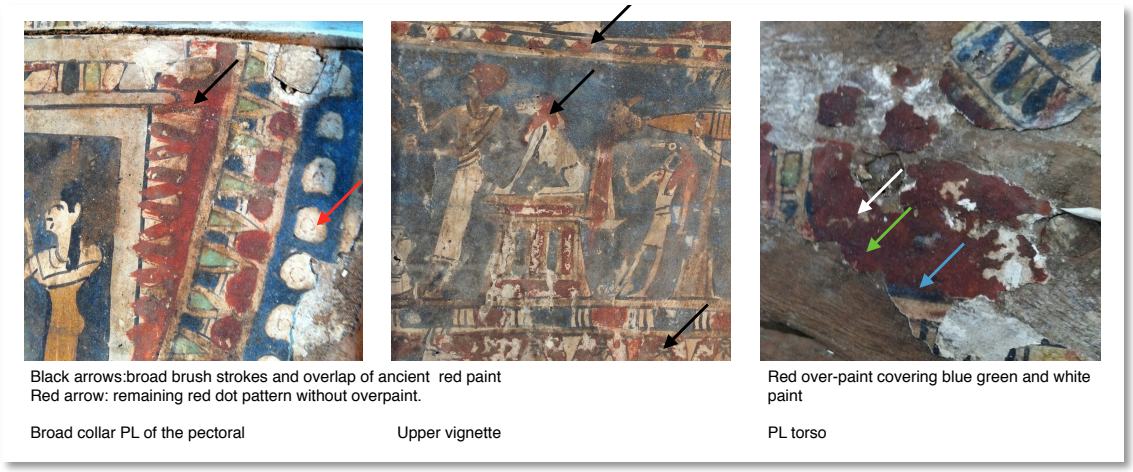


Figure 44 Rough application of red over-paint (black arrows) Residue of failed ancient red (red arrow) white, green and blue paints obscured by red over-paint on PL mid torso (arrows by color)

The paint that covers the lost red is characterized by rough strokes that are broader than the ancient paint area, and extend over the black lines and over adjacent colors, indicating this paint was applied with a larger and rougher brush than was used to apply the ancient paints (fig. 44).

On the PL mid-body this over-paint covers an area of blue, green, and white (fig. 43). The red over-paint on the vignettes is severely cupped and lifted, and the background of the lower

vignette is severely cracked with losses to the surface that have been exacerbated by a concentration of insect exit holes (fig.44).



Figure 45 Red over-paint in the upper and lower vignettes is cupped with losses exacerbated by insect exit holes.

A similar colored but thinner and more stable red paint was used to create a new third mummy figure middle PR, and the restoration of the middle front PL mummy figure. It appears to have been used to recolor other mummy figures and the headband, although the extent of this repainting is not clear. This application is distinguished from the over-paint described in the paragraph above by more careful application of the paint, and by black outlines added after the red paint. Both of these over-paints are absent from the foot-block.

The red on the outer polychrome layer of the foot is distinguished from other reds on the object by a slightly orange hue, and a smooth and cohesive surface without the deterioration present in all other red applications (fig.43).

Red Analysis

XRF analysis of the red on the head and torso consistently identified a strong presence of iron. XRD (appendix VII.b) analysis identified hematite, Fe_20_3 (hydrated iron oxide). FTIR analysis of the red over-paint identified the mineral as consistent with red ochre. Microscopic observation of dispersion and cross section samples also identified particles consistent with red ochre. Particles in the ancient layer varied in size and color and included particles of quartz. Particles in the over-paint layer are finer and more homogeneous.

Lead particles appear to be present in a dispersion sample of red taken from over-paint layer on the PL side, although lead is not identified in XRF or XRD analysis.

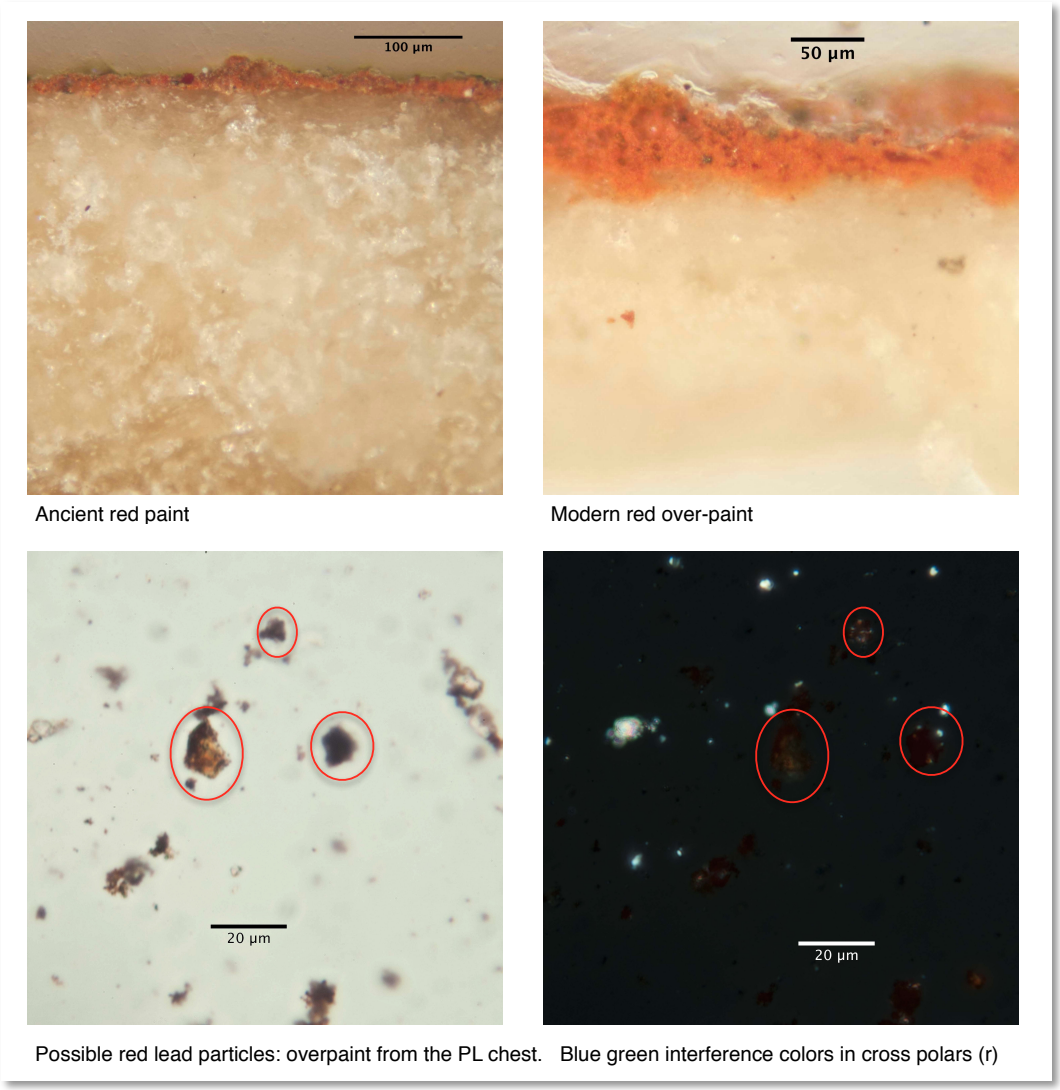
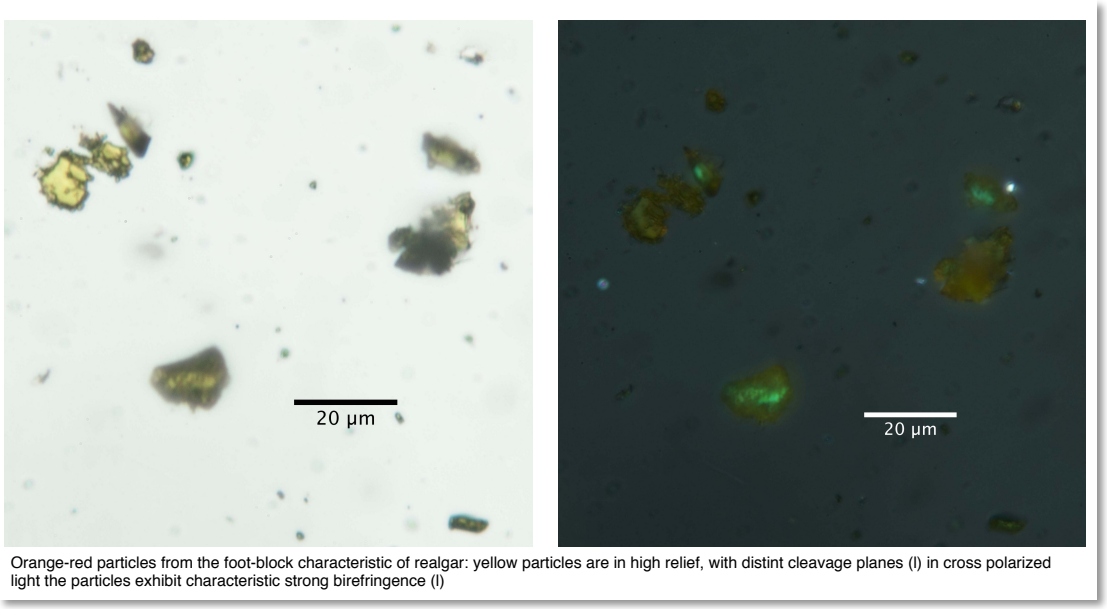


Figure 46 Photomicrograph ancient and modern red paint (top l, r) Possible red lead particles (bottom l, r)

XRF analysis of the orange-red on the foot identified arsenic and sulfur, which support the presence of an arsenic sulfide pigment. XRD (appendix VII.c) analysis identified realgar, As_4S_4, or arsenic sulfide. Particles characteristic of realgar were identified in microscopic dispersion samples.



Orange-red particles from the foot-block characteristic of realgar: yellow particles are in high relief, with distint cleavage planes (l) in cross polarized light the particles exhibit characteristic strong birefringence (l)

Figure 47 Realgar on the foot-block

Red Summary

Hematite and red ocher are the dominant red colorants detected on the object, consistent with ancient and modern use. XRD analysis identified hematite, Fe_20_3 (hydrated iron oxide), which is considered definitive. XRF analysis corroborates this identification and microscopic observation has also differentiated the ancient red paint from the over-paint layer on the body although the pigments cannot be distinguished as modern or ancient at this level of analysis. The possible presence of red lead requires further investigation.

XRD analysis of the red-orange on the under-layer of paint on the foot was identified as realgar, As_4S_4, arsenic sulfide, and this is considered definitive. XRF analysis and microcopy corroborate this identification. The presence of realgar is unique on the sarcophagus and it distinguishes the foot-block from the other components of the sarcophagus.

D. Yellow

Orpiment, arsenic sulfide As_2S_3

Yellow Ochre, Goethite, Iron Oxyhydroxide (αFeOOH)

Gold leaf or sheet, yellow ochre (αFeOOH), and orpiment (As_2S_3), or arsenic sulfide pigment, have been identified as yellow colorants on Egyptian funerary antiquities. The use of orpiment is dated to the 12th dynasty through the Ptolemaic period with 1900 BCE an accepted first date of use. Iron oxides, including yellow ochre, occur naturally in Egypt and were used extensively from the Old Kingdom through the Ptolemaic periods (Colinart 2001, 1; Lee & Quirk 2000, 115). The iron sulfates, jarosite and natrojarosite, have also been identified on objects dating from the Old Kingdom, which is dated as 2686 to 2181 BCE, to the Roman period (Middleton & Humphrey 2011, 13; Colinart 2011,1,2). Mixtures of orpiment and yellow ochre have also been identified on funerary objects (Colinart 2011, 3).

The color yellow was associated with the sun and vitality in ancient Egypt, and it was believed that the gods' skin was made of gold (Colinart 2001, 3). The faces of deceased were often depicted as gold and were covered in gold sheet, or painted in orpiment, which is vivid yellow and has a reflective, sparkling quality and was less costly than gold.

Yellow Locations

There are four distinctive applications of yellow on this object. These are (1) the face, (2) the garments of the goddesses and details in the pectoral and small details in the broad-collar, (3) registers of the feather patterns and (4) the background of the wood-grain pattern on the sides (fig. 48).

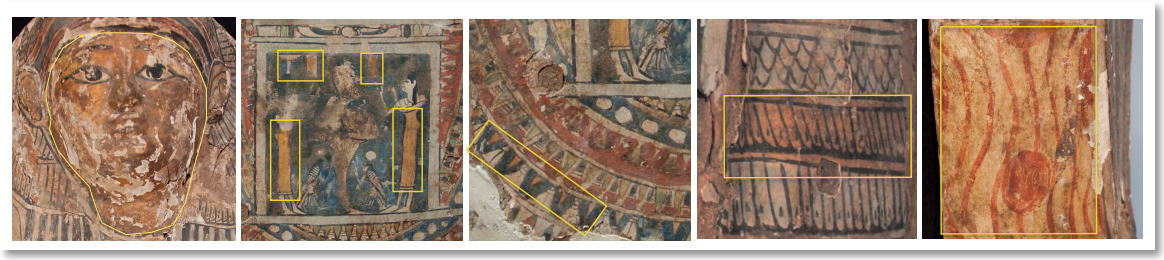


Figure 48 Yellow color locations (l to r) Face, figures and details in the pectoral, details in the broad collar, color of feather bands, back ground of the "wood-grain" pattern on the sides.

There is an obscuring brown coating over the remaining ancient paint surface on the face that is not present on other parts of the object. This is discussed in the section, Modern

Interventions (5) below. A concentrations of bright yellow particles adhered on the surface at the PR temple appear to have been mobilized or exposed by a liquid, possibly by the modern coating.

The figures and details in the pectoral, and elements of the broad-collar, have retained a distinct even yellow color. The yellow of the feathers is matte and dulled.

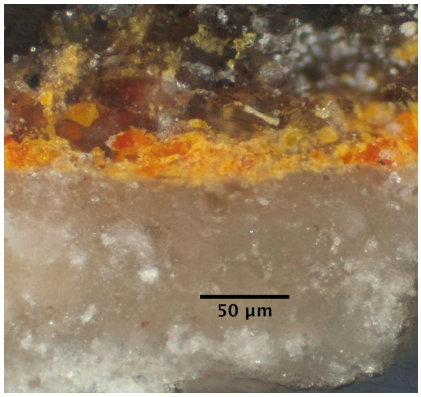
Yellow Analysis

XRF analyses of the face, the figures, and the feather images consistently identify both arsenic and sulfur as major peaks, which is consistent with arsenic sulfide. The figures and feathers have small peaks of titanium not present in XRF analysis of the face.

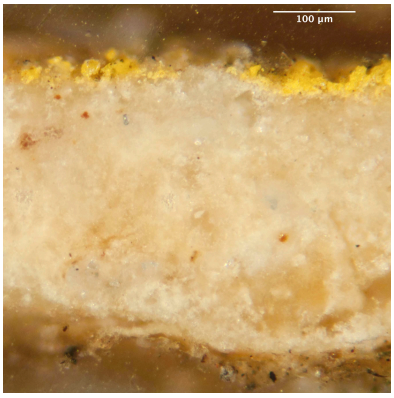
XRF analysis of the yellow on the sides of the object consistently showed a major presence of iron, which is consistent with yellow ochre. Sulfur and arsenic are also present in analyses of the yellow paint on the sides, which may indicate the presence of orpiment mixed into the yellow ochre, although orpiment has not been identified in microscopic analysis.

XRD analysis (appendix VII.d) of the yellow on the PR leg was identified as Goethite, (αFeOOH). No highly radio opaque materials that would identify gold are present in X-radiographic image of the face.

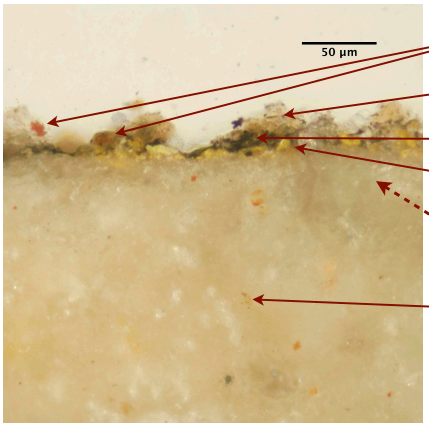
Particles consistent with orpiment were observed in both microscopic dispersion and cross section samples from the face, a spontaneous chip loss, and the feather patterns. In the cross section sample of yellow from the face include some red-orange particles that are consistent in appearance with realgar, which occurs naturally with orpiment and has been identified in orpiment found on Egyptian antiquities. The paint layer on the face is two to three particles thick. The orpiment on the PR wing of the goddess Nut is one to two particles thick which may partially account for the pale color. Also the red particles observed in samples from the face are absent from this yellow.



Face PR
The mixture yellow particles that are characteristic of orpiment (AsS) mixed with realgar [or red ochre]. There is no evidence of an under-layer to the paint of finer white/gesso.



Spontaneous loss shows a resin layer over large orpiment particles (up to 30um). Theres in no evident under-layer of finer white/gesso as can be seen in the images of white cross section samples. There are small particles of red in the gesso (hematite?). Residue of the sub-gesso layer is evident as a dark layer with fine black particles.



PR wing of the goddess Nut. This area appears pale yellow because of the thin paint layer.

Figure 49 Photomicrographs of orpiment on the face (upper l) a spontaneous chip loss (upper r), and the PR wing of the figure of Nut (lower image)

Yellow Summary

The observed color, XRF analysis, and microscopic analysis of the yellow colorant on the face, garments in the pectoral, and feather backgrounds have identified orpiment. X-radiography and XRD analysis have eliminated the possibility of gold on the face, contradicting the current SDMM object description. The yellows in these areas are distinguishable by appearance and application. There is a characteristic obscuring coating over the ancient paint on the face that is

unique on the object, and the orpiment on the face is further distinguished by the presence of red particles in the orpiment mixture that appear to be realgar. Both of these factors contribute to distinguishing the face block from the body of the coffin.

XRD identification of Goethite as the yellow colorant of the wood-grain pattern on the sides is considered definitive. XRF analysis is consistent with this identification, although the presence of sulfur and arsenic may indicate that orpiment is also present.

E. Black

Carbon, C, charcoal

Carbon blacks were used throughout Egyptian antiquity and were predicted on this object. Lucas and Harris (1962, 340) report a late nineteenth-century identification of manganese oxides. Middleton (2011, 12) reports that a black from pyrolusite a mineral that is predominantly manganese dioxide, has been identified in a twelfth century BCE Egyptian tomb.

Black Locations

Black paint was used extensively in the ancient paint layer and in the modern over-paint. Analysis of the black paint focused both on identifying the ancient paint and distinguishing the modern paint applications and because of this both ancient and modern black paints are discussed in this section. The modern applications are also discussed below in Modern Interventions (5.2.2.3).

All of the dark colored elements of the ancient paint layer on the head, body, and under-layer of paint on the foot-block are black paint. These applications include the delineation of the overall linear patterns and the figures that were filled with paint, the linear patterns applied over color fields used to create the feather patterns, and all text. The eyes and eyebrows were applied in a thicker line, and the hair of the goddess figures in the pectoral is painted black (fig.50).



Figure 50 Ancient black paint

The black paint on the lappets and the black paint on the outer paint layer of the foot-block are believed to be modern. There is a amorphous application of black paint on the PL side of the head that extends over exposed wood and remaining "islands" of ancient paint, and the PL headband above the ear is a restoration in which black paint has replaced blue (fig. 51).



Figure 51 Modern black paint locations

Black Analysis

IR imaging can be used to accentuate carbon based materials and slightly sub-surface paint layers, and has been used to identify ancient additions and corrections, and omitted details, as well as modern overdrawn lines. Some partial black lines appear more velvety than the contiguous lines of ancient black paint, suggesting they are modern over-paint. These areas include linear elements on the face and in the restoration between the lappets at the neck, on some details in the vignettes, in over-drawn outlines of some mummy figures on the sides of the object, and in the vertical black bands between the text panels on the leg. This application of black on the leg resembles the black areas on the top of the foot in style and tone, suggesting that it may have been enhanced when the foot-block was added.

The black paint on the lappets stands out as being very thickly applied and having a smooth surface and VIL imaging has revealed a remnant layer of Egyptian blue under areas of the black paint (fig.52).

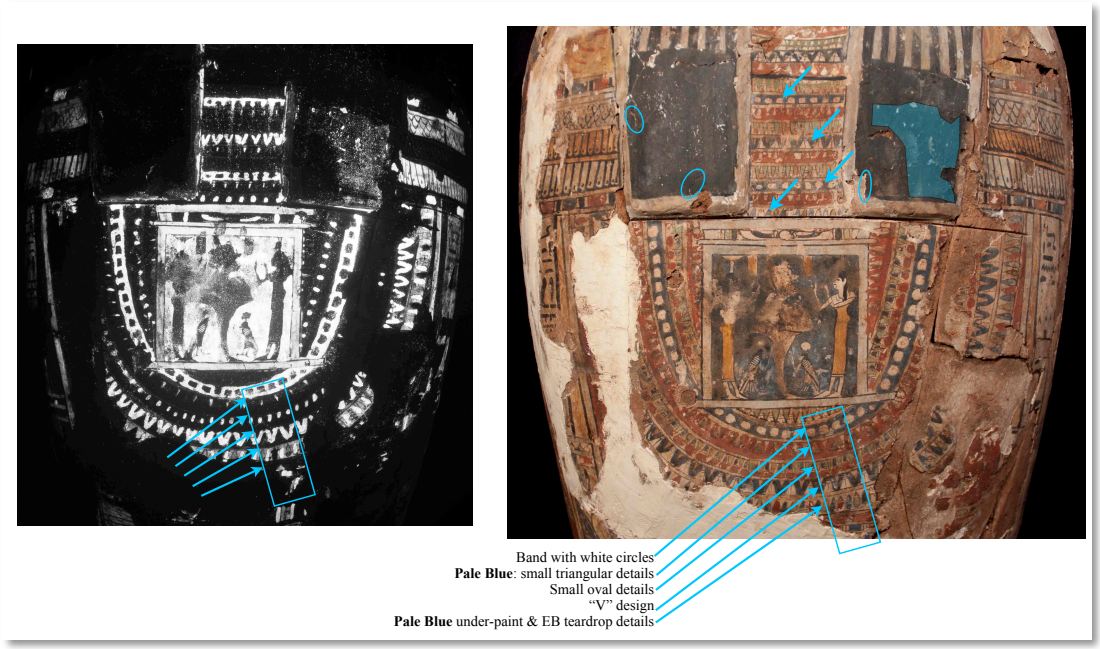


Figure 52 Egyptian blue is captured in the VIL image (l). The blue area and circled areas locate the fluorescence in a visible light image(r).

Titanium was identified in XRF analysis of black paint on the lappets and black paint on the restoration on the headband. Manganese (Mn), a major constituent of umber with iron oxide, was not identified by either XRF or XRD analysis of the black paint on the lappet.

Particles consistent with charcoal were observed in microscopic dispersion samples of black from the headband, lappets, and outer paint layer of the foot-block, although these varied in the shape of the particles. Particles sampled from areas associated with ancient paint on the headband and the pectoral are distinctly angular, while particles from the lappets and foot demonstrated more varied and indistinct edges (fig.53).

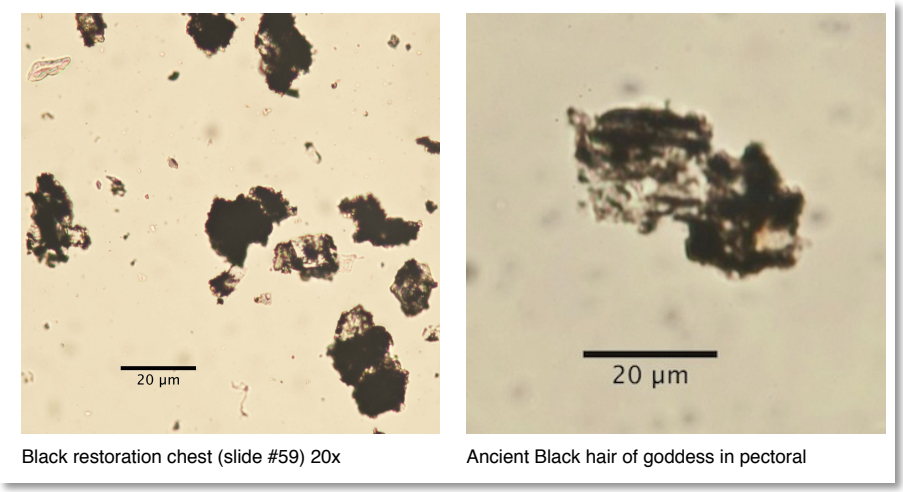


Figure 53 Photomicrographs of modern (l) and ancient (r) black paints

Black Summary

Microscopic analysis has identified particles consistent with charcoal in the ancient paint and modern over-paint and restorations (Winter 1984, 49-53; Scott et al 2004,182). The morphology of the particles distinguishes the ancient paint as having a characteristic angularity. The detection of titanium, which is associated with modern paints, in XRF analysis of the lappets and a restoration corroborates the assertion that the black paint on the lappets is a modern over-paint.

F. White/Ground Layers

Calcite $CaCO_2$
Gypsum: calcium sulfate dihydrite: $CaSO_4 \cdot 2H_2O$, Quartz SiO_2
Modern restorations and compensation material:
Gypsum, anhydrite: anhydrous calcium sulfate, $CaSO_4$

Calcite and gypsum are documented as the main components of gesso and of white paints used in antiquity (Lukas and Harris 1962, 353-4) (Pages-Camagna and Guichard 2011, 26). Huntite [$Mg_3Ca(CO_3)_4$], which has a brighter appearance, was also used as a white paint (Heywood 2011, 5). Lead white has been identified on objects from the Roman period (Green 2001, 47).

White Locations

The gesso functions as the white background on all components of the object, including both polychrome layers on the foot-block. Specific white details appear brighter in visible light and are notably brighter white in UV light (365nm). These details include the skin of the goddesses Nephthys and Isis in the pectoral, the skin of the goddess Nut, the garments of the deceased in the vignettes, and the background of two registers of the broad-collar and small decorative details.

White Analysis

Calcium is the dominant element identified in XRF analyses. Lead was not detected. In X-radiographic images the absence of a characteristic radio-opacity corroborates the absence of lead white paint.

XRD analysis of the ancient gesso layer consistently identified calcite ($CaCO_3$), quartz (SiO_2), and gypsum ($CaSO_4 \cdot 2H_2O$) in samples of the gesso. Anhydrite ($CaSO_4$) is only identified in analyses of modern compensation materials (appendix VIII.e).

Microscopic observation of a cross section sample taken edge of the bright white in the lower vignette shows two distinct layers, with the upper layer made of finer particles (fig. 54). Also small red particles are observed dispersed in the gesso layer of the torso and the under-layer of gesso on the foot, while fine blue particles are observed in the gesso substrate of the pale blue paint layer.

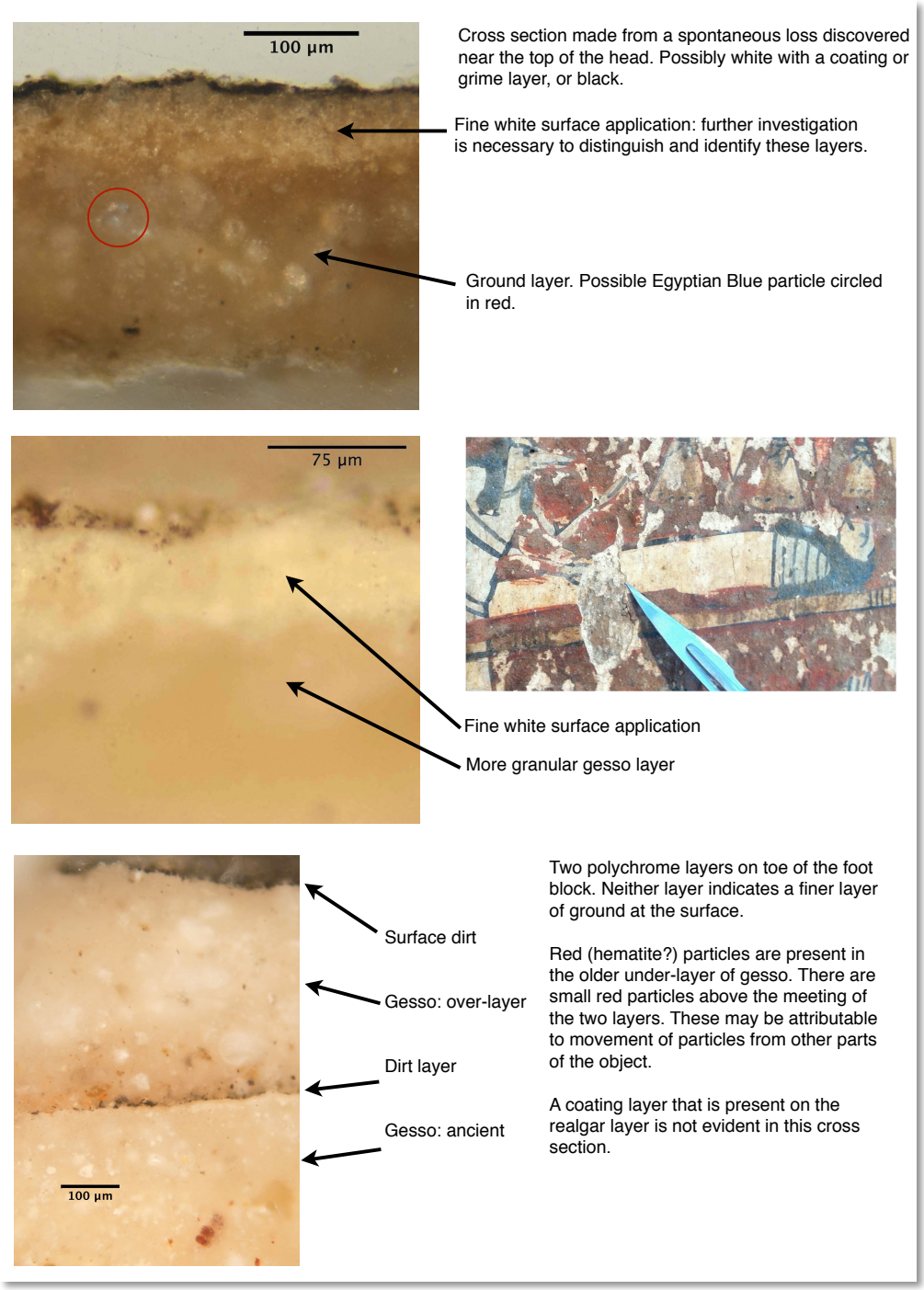


Figure 54 White paint and gesso layers

White Summary

Microscopy has provided evidence that surface layers were applied differently in some areas to create various whites, consistent with observation. XRF analysis and microscopic

observation together suggest the bright white is created by a different treatment of a calcite rich material, such as finer grinding, not a different pigment such as Huntite. Further investigation is required to identify the material and to evaluate how the palette may have been extended by selective use of a mineral layer, a specific binder, or a coating.

E. Other Colorants

Deteriorated Brown

As yet unidentified organic material
Calcium oxylate CaC_2O_4
Quartz SiO_2
Clay, Hydrous aluminum phyllosilicates and other elements
Calcite Chalk, Calcium carbonate $CaCO_3$
Gypsum $CaSO_4 \cdot 2H_2O$

The colorant of the areas that are now mottled brown has been generally identified as n organic material, not a pigment. It is included here because it is an intentional colorant of important elements including the Osiris figures, details in bands of the necklace and details in the image panels (fig. 55).

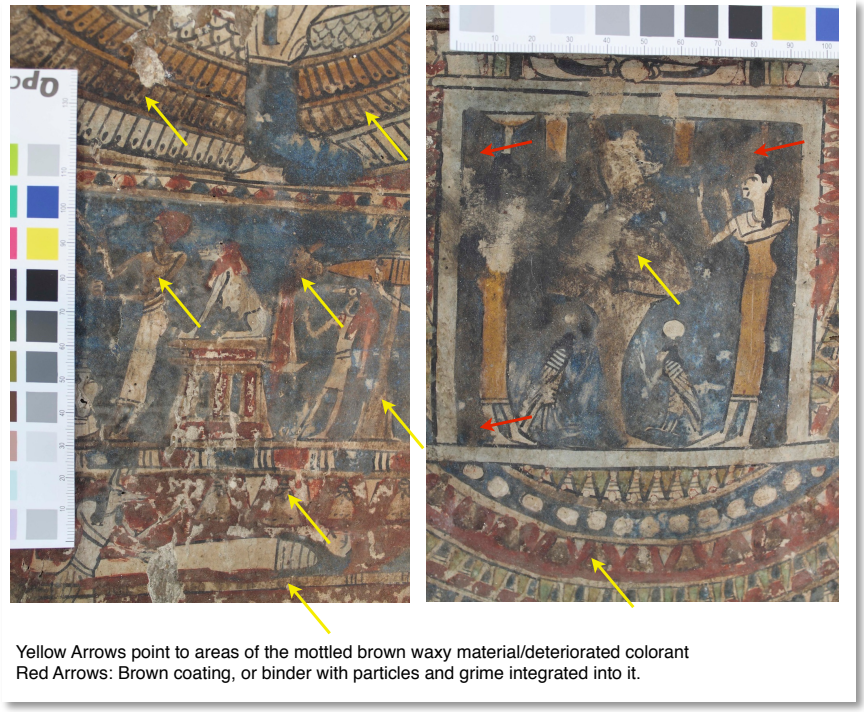


Figure 55 Deteriorated brown materials

A heterogeneous mixture with brown, orange and clear phases was identified in FTIR analysis of two samples. Calcium carbonate, gypsum and clay were identified as mineral elements present in both.

Grey

Modern paint

A grey paint compensates for losses to the band of pale blue at the shoulder and extends along the outside of the PR lappet (fig. 56). The paint is readily identified as modern; the surface is smooth with areas that are lifted, stretched, and buckled. It is soluble in acetone and not soluble in water. No fluorescence is detected in VIL imaging. XRF analysis shows a dominant peak for titanium, which may be associated with modern paints.



Figure 56 Grey over-paint



Figure 57 Photomicrograph of pink material

Pink

Unidentified

A transparent bright pink was also observed in two microscopic dispersion samples from two areas; in the lower vignette and in the modern fibrous material attached to the PR shoulder (fig.57). This bright pink resembles the color of the organic colorant madder, which was used in the Greco Roman period (Corcoran and Svoboda 2011, 36). No characteristic orange fluorescence

was observed under UV light, although the age, condition and complexity of the surface may obscure. This material has not been identified but warrants further evaluation.

4.2.2.d.(3) Pigment Analysis Conclusion

Pigment analysis was undertaken as a complimentary study to the technical analysis of the coffin lid. The pigments and ground material of the ancient polychrome layer were identified and confirmed to be consistent with documented use in Egyptian antiquity. Also, the absence of some possible colorants was established, including the absence of gold, which corrects the current museum record. Minerals and other materials were identified that provide strong evidence of modern paints.

Pigment analysis has contributed key information to a comprehensive understanding of this object. With the discovery that structural components might have been repurposed both in antiquity and post excavation, the results of this analysis were evaluated for evidence to support or refute those assertions. The contribution of pigment analysis to the identification and confirmation of reuse, carried out at this level of sophistication varies significantly from colorant to colorant, depending on the characteristics of the materials and how detectable or distinguishable they are.

The definitive identification of Egyptian blue has been made by XRD analysis and the use of VIL forensic imaging. The identification of Egyptian blue on the under-layer of the foot-block polychrome provides a *terminus post quem* that establishes the component as ancient. This is the most decisive information about reuse derived from the pigment analysis.

The two polychrome layers on the foot, and the absence of painted surfaces on the sides of the foot-block, as well as the absence on the foot-block of the red over-paint that is found on the head and body, distinguish the foot from the rest of the object. The unique presence of realgar

on the ancient paint layer of the foot-block compliments this information in identifying differences in the manufacture of the ancient paint on the foot.

Microscopic observation of the red ochre in the ancient and over-paint layer distinguished the two paints qualitatively, but because red ochre and gum binders are used in modern as well as ancient applications these qualities cannot definitively distinguish the ancient from a possible modern paint. The stratigraphy of the paint layers, and the stark contrast between the loose application of the over-paint and the careful order of the ancient graphics has proven to be the most convincing evidence that the red over-paint is a modern application. To substantiate this argument through pigment analysis would require a more sophisticated level of analysis capable of a making a meaningful distinction between the ancient layer and the red over-paint.

The areas of yellow paint are distinguished by observable differences in their appearance and by the microscopic characteristics of the paint make-up and paint layers. The orpiment applied to the face is distinguished from the orpiment on the body by the presence of red particles believed to be realgar. An obscuring coating over the orpiment on the face distinguishes it from all other paint areas on the object, not only from the other yellow areas on the head and torso.

The identification of titanium, which is associated with modern paints, contributes strong evidence that modern paints have been applied to the object.

This project has provided meaningful information relevant to understanding this object, as well as the effectiveness of different methods of investigation. The research carried out on this object has created data on which to base future inquiry using more refined methods of analysis that will allow more meaningful comparisons between this coffin and related ancient Egyptian artifacts.

Further studies that follow directly on this work include:

- Investigation of Egyptian blue in the gesso of this and other Egyptian coffins
- Continued exploration of the green paint

- Establishing distinctions between the different applications of red ochre and confirming the possible presence of red lead
- Identification of the "deteriorated brown" on this and other Egyptian coffins
- Investigation of the possible presence of madder as a colorant

4.2.2.4(d) Pigment Application

Four distinct methods were used to apply the ancient paint layer (Fig. 58). (1) An outline is applied in black over the ground and color is added within the lines. The vignettes, the necklace, and the linear banding are all applied in this way. (2) A color field is applied to the gesso and designs are applied in black line. The feathers are indicated in this way. (3) Linear elements are applied onto a color field in a contrasting color without a black outline. This is used to indicate the wood grain pattern on the legs. The eyes are applied in this manner, but with a broad black stroke rather than a color; i.e., there is no outline. (4) Text is applied in black onto a light background. With the exception of the center text panel on the leg, the writing is applied onto a pale-blue background.

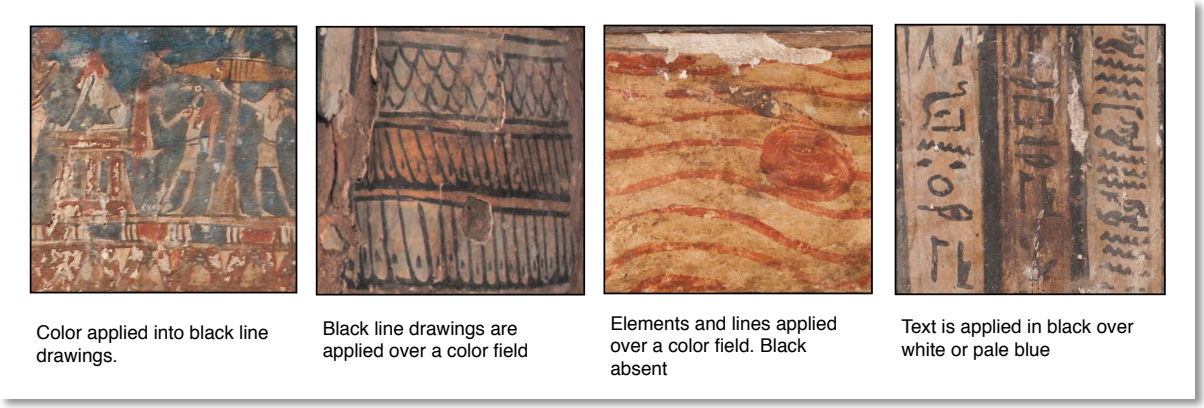


Figure 58 Four types of paint application

Brush fibers are adhered in the red paint on a reclining figure on the PR side (fig.59). The fiber was not analyzed during this project, but brushes that have survived from antiquity have been analyzed and the identification of these fibers and comparison to ancient

brush fibers may contribute to distinguishing the red paint layers (Lucas and Harris 1962, 133-4; Geldhoff Reinstein 2013).



Figure 59 Brush fiber PR side

The ancient polychrome includes missing inscriptions and design aberrations. These variations are assumed to be ancient based on the assumption that an imitation would strive to recreate an ideal, not a flawed version of an ancient artifact. Some of the flaws on the coffin that involve the palette and the paint layer include the following; names are absent from the name plaques above the goddesses Nephthys and Isis in the pectoral, the PR upper register of the wings of the goddess Nut lacks the pale blue of the corresponding PL wing, and in the lower image panel, only on the upper half of the face of the deceased is blue. In the lower image panel, the canopic jar to the observed right is overlapped by a leg of the lion-headed bier, suggesting a miscalculation by the artist of the space needed for the image. Additionally, the black horizontal elements are absent from this canopic jar (fig. 60).



Figure 60 Errors in the ancient paint

These variations may indicate a lower relative value of this particular coffin, and may provide information about the manufacture. Morgan (2013) has suggested these differences may be evidence that different artists applied the designs and paint on either side of a coffin, and that asymmetries and the lesser quality of drawings on one side, as is the case on this object, may have been the work of an apprentice craftsman.

Incongruities in the modern imitative restorations are described in the section Modern Interventions (5) below.

4.2.4. Binding Media

Binding media is added to the gesso, and to the individual paints, to provide adhesion. There is documented use of both plant gums and animal glues throughout Egyptian antiquity (Newman and Serpico 2000, 476). GC-MS and FTIR analysis of a small set of gesso and paint samples have determined that both plant- and animal-based binders are present on the object, in both ancient and modern applications.

Joy Mazurek at the Getty Conservation Institute carried out GC-MS analysis of the two polychrome layers on the foot-block. The summary of results is attached as appendix III.b, and the full report is submitted as a separate document. The samples were divided into two parts; one was prepared for analysis to identify plant gums, the other for proteins, oils, waxes, and resins. There was no evidence of waxes or resins in either sample. The over-layer was found to contain a high percentage of carbohydrates that match many gums, specifically Acacia gum. There is recorded use of this material as a binder in Egyptian Antiquity (Newman and Serpico 2000, 476). The binder of the under-layer of gesso on the foot-block was found to have a high correlation to animal glue.

Failure of the binding media of the ancient red paint may have caused its extensive and exclusive loss on the head and body, and further analysis may definitively show whether this loss

was ancient or modern. FTIR analysis of the red over-paint sampled on the PL side identified an animal-protein-based binder.

No modern polymer binding media were identified in these analyses. Both animal and plant binders are currently available and in use, and their identification here does not contribute positively to determining reuse. Analysis of the binding media in a larger sample set will be necessary to identify differences in the paints.

4.2.5 Ancient Coatings

A thin, brittle, brown coating can be observed on the surface of the ancient under-layer of paint of the foot-block where losses of the over-layer (fig. 61) have expose the older paint layer. This coating is smooth and cohesive, with no visible inclusions when observed under low magnification (20x). The coating is closely adhered to the ancient paint layer, but very weakly adhered to the over-paint, which is actively separated and lifted causing significant losses. A residue of fine particles of the over-layer gesso is adhered to the surface of the coating.



Figure 61 ancient paint layer and outline of the foot (arrows at right)

GC-MS analysis identified this as a plant gum with a close correlation to Acacia gum (appendix III.b), which is consistent with ancient materials from the period (Newman and Serpico 2000, 476-577). The location and analysis strongly indicate that this is an ancient layer.

The application of varnish to coffins and sarcophagi in Egyptian antiquity, as well as post-excavation, has been well documented (Newman and Serpico, 2000, 475, 490; Geldhof 2013; Lucas and Harris 1962, 356; Gilberg 1997, 38). No overall varnish layer has been identified on this lid, although particles consistent with varnish in color and shape (Scott 2013) have been identified in microscopic dispersion samples of the yellow paint of the garments in the pectoral. These particles are opaque, reddish orange, have break edges and cracks, and are very large relative to mineral particles (fig. 62). A varnish may have been used locally on these figures to enhance or alter the color.

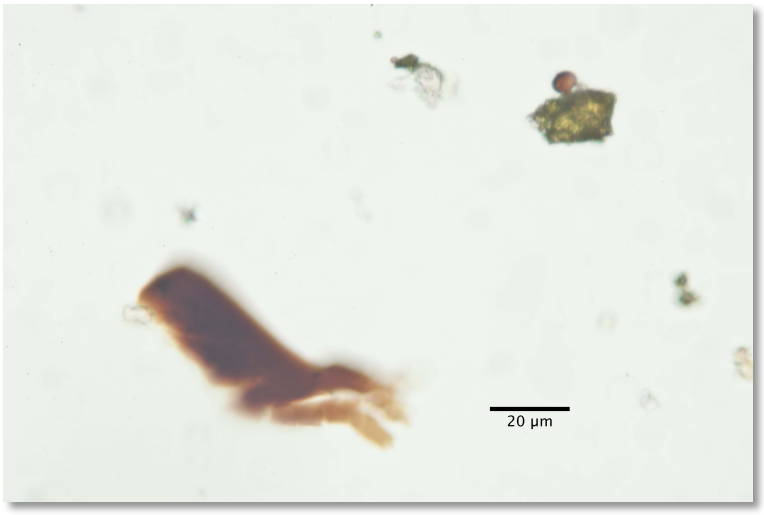


Figure 62 Large resin particle (l) yellow paint on pectoral

4.2.6 Ancient Accretions

There is a dark-brown accretion on the PR side. This brittle, granular paste extends from the foot end of the attached segment 5-T (fig.63) to the large crack, which is approximately 12.0 cm toward the foot. It is partially obscured by “plaster”. There is a “splash” of this material that is approximately 3.0 cm long between the larger application and the foot. This material has not been identified and it remains unclear whether it is an ancient or modern material.



Figure 63 Brown accretions PR side

None of this material has been observed on the interior surface at either the join or the crack. The material somewhat resembles the material applied to the wood surface as a substrate for the paint layer, although it lacks the grain and fiber inclusions. Also, the substrate material is deteriorated and has lost cohesion, and the substance on the surface has remained cohesive. This may be an ancient compensation or coating material but it has not been identified. FTIR analysis identified plant-based material but did not identify glue, mineral compounds, or synthetic polymeric adhesives.

5. Modern Interventions

There is ample evidence of modern interventions to this object. The term "modern", in this thesis, defines the period from excavation to the present, and it is presumed that the coffin was excavated during the 19th or early 20th century, although there is no written record of the excavation or of subsequent interventions. The three interventions to the structure are the addition of the foot-block, an even horizontal cut across the chest immediately below the lappets, and chisel marks on both PL and PR sides along the edge. Interventions to the surface are identified as removals or additions. The material that were used, and the methods and order of

their application serve as the sole forms of documentation in identifying the modern addition of the foot-block and distinguishing the ancient reuse of the face-block.

5.1 Interventions to the Structure

There are chisel gouges and associated loss of wood along the edge on both the PL and PR sides. These gouges appear to be incidental damage caused while separating the lid from the trough (fig. 64). There is no seal or evidence of an adhesive on the surface of the edge, suggesting the impact alone was the goal of the chisel blows. Also the bottom end of the added segment on the PL side of the torso is lost along a chisel mark.

These gouges are included in interventions for convenience. They were clearly not intended to enhance the artifact.



Figure 64 Blue frames identify gouges on the PR and PL sides. The enlargements provide more detail.

There is an even shallow saw cut along the bottom edge of both lappets (fig.65). The narrowness and precision of the cut, and absence of saw marks strongly suggest this is modern although there is no explanation for the cut.



Figure 65 Saw cut under the lappets

The foot-block has been described in Section 1.2.2. It is a complex addition that is intended to alter the appearance, and presumably the value, of the object. To accomplish this, original material was removed from the end of the foot-block, and non-original materials were introduced, including the wood components, joinery and compensation materials, and the over-layer of polychrome. Residues of this over-layer of polychrome on the head and torso indicate that it was used as an imitative restoration as discussed below in the section on restoration and over-paint (5.2.2). Figure 19 describes the adjustment of the base structure and construction of the foot block.

5.2 Interventions to the Surface

5.2.1 Removal

In addition to imitative restorations and the subsequent failure of the restorations, the surface has been altered by the active removal of ancient polychrome evidenced by deep scrape marks in the paint layer on the PR side of the torso and the PL side of the head (fig. 66). The gouges are uniform dimensions and appear to have been made with a narrow chisel or slot screwdriver head.



Figure 66 Gouge marks PR side (l) and PL side of the head (r)

5.2.2 Modern Additions

Four categories of modern materials have been identified as additions to the original object: (1) compensation materials, (2) imitative restorations and over-paint (3) coatings, and (4) accretions (fig. 67).

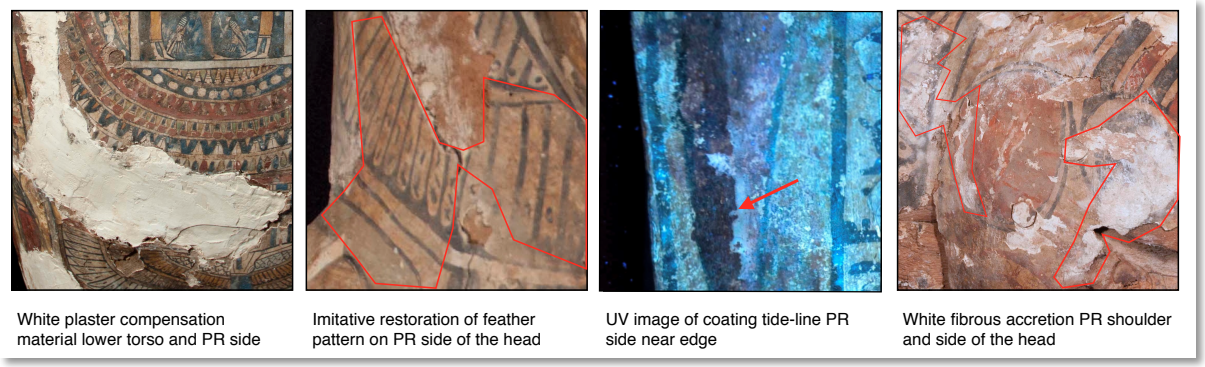


Figure 67 Modern additions to the surface

5.2.2.a Modern Compensation Materials

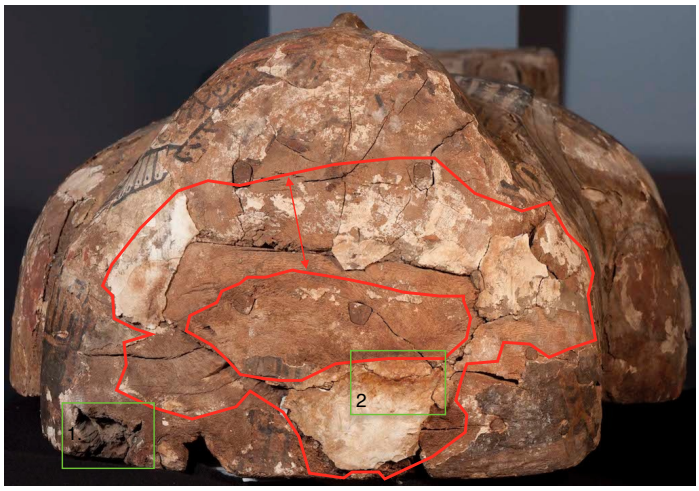
Five distinct modern compensation materials have been observed on the head and torso, and three materials at the join of the foot block to the leg. All of the materials were applied as

pastes and are now dry. On the head and torso the materials are white plaster, two types of gray material, a pink paste, and a beige paste.

The materials at the foot join are plaster-like and none are soluble in the organic solvents acetone or ethanol, which would indicate the presence of a synthetic polymer. Further analysis has not been carried out at this time, and for convenience these materials are distinguished by color and are gray, yellow, and beige.

Deterioration and movement from handling have caused loss of the surface layer at edges of some applied elements, and these losses have been exacerbated by the failure of prior modern restorations, and the scraping described in Interventions to the Surface (5.2) above. White plaster is the most extensively applied compensation material and is applied over the exposed wood in broad irregular bands concentrated on the PR side and extending across the torso at mid body and along the PL leg (fig. 23).

The plaster covers approximately 11% of the head and body. Approximately 5% of the white plaster on the body has been lost to breakage, and on the top the head more than 50% is lost. The remaining plaster on the head is colored mottled brown because of the coating and apparent water damage (fig.68). The white plaster also extends over the edges of the ancient paint along most of the interface (fig. 70) risking loss of the surface paint or sections of the paint layer with the removal or breakage of the plaster..



The roughly defined band between the two red lines estimates the area on the top of the head covered with plaster.
1.Irregularity in the wood with ancient gray compensation material
2.Brown coloration and mottling.

Figure 68 Compensation material and losses on the top of the head

A pink paste and a grey paste are associated with the white plaster (fig. 69) and are distinguished by being soluble in the organic solvent acetone. These materials are visible along some edges of the plaster, notably at the top of the horizontal band of plaster mid-body and at the edges of plaster on the PL leg indicating they were applied first although the extent of their application is unknown. There is a mottled UV-induced fluorescence of the plaster that may indicate that either or both of these pastes are present underneath most of the white plaster.





Red arrows indicate pink material and black arrows indicate gray material.



PR side. Mottling of the white plaster imaged in long wave UV light may indicate an extensive under layer of another material.

Figure 69 Pink and grey compensation materials (l.m) UV induced fluorescence (r)

A gray plaster-like material on the top of the head between wood components was pressed against, and slightly over the ancient paint layer when it was applied, identifying it stratigraphically as modern (fig.70).



Figure 70 Modern grey fill PR head (l) compensation material extends over the paint layer break edge (red broken line) and onto the paint surface (yellow line and arrows (r)

This grey material is not soluble in acetone or ethanol, which distinguishes it from the gray material described in the prior paragraph. Also it is distinguished by the quality and color of the paste from the residues of ancient gray clay-like material in irregularities in the wood, which is finer and less cohesive.

A beige acetone-soluble paste is also present on the PL side at the area of exposed wood (fig.71). The stratigraphy of the layers indicates that this material was applied before the plaster. The paste has been introduced under the lifted end of the wood panel, and a residue of this material, apparently inserted underneath as an adhesive, describes the end of the panel that subsequently detached and was lost.

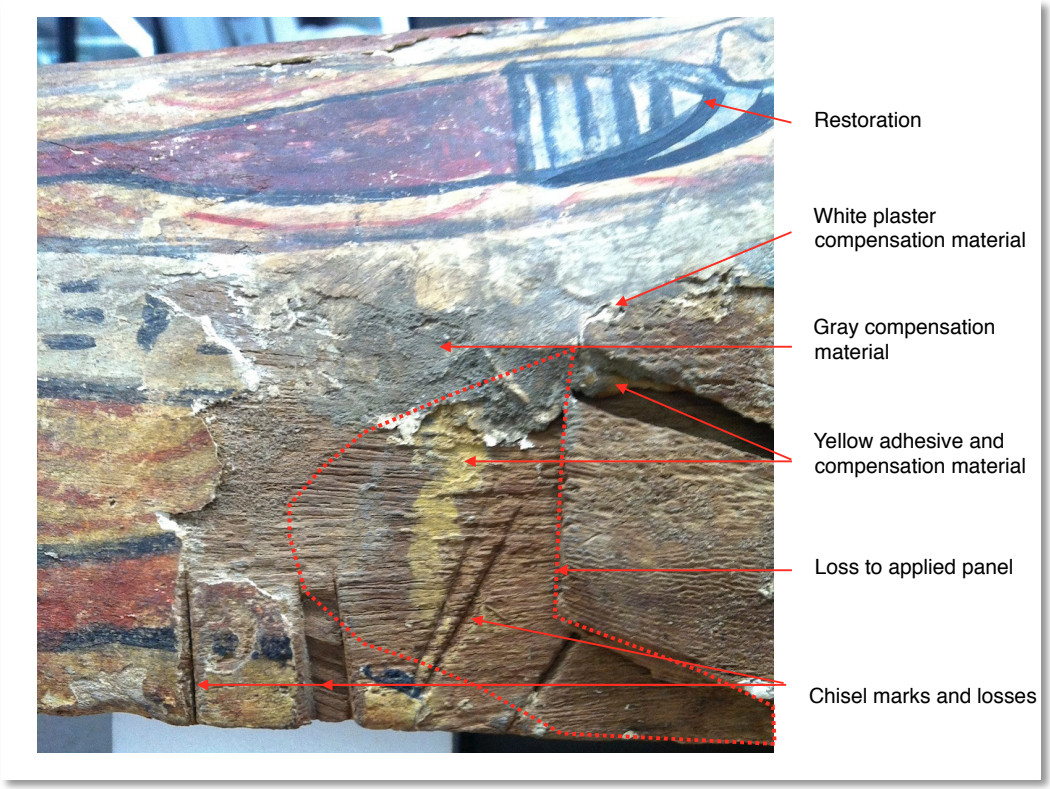


Figure 71 Beige adhesive PL side

Three successive materials were introduced to compensate for the gap between the body and the foot-block (fig.72). All of these have failed. These materials are comprised of two yellow

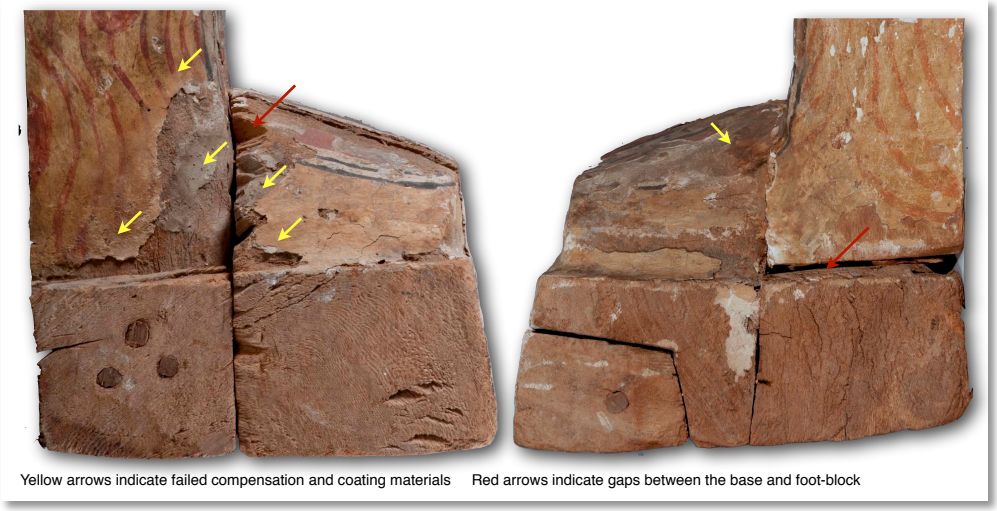


Figure 72 failed compensation materials. The far left two arrow identify remaining repainting to disguise compensation materials

plaster-like materials in distinct layers and a gray material visible on the PR side of foot-block and lower body. The gray material is the most recent application and it resembles the modern compensation material on the head, although microscopic analysis has not been carried out to confirm this assertion. These three applications are visibly distinguishable from the ancient paint by the colors, texture, and application, and by the stratigraphy of application.

A beige over-paint or toned coating with large particle inclusions was applied to the bottom of the leg, sides of the foot, and the upper part of the toe and it overlaps the modern layer discussed above (fig. 73).



Figure 73 ancient outline of the foot (red arrows above), rough beige coating

5.2.2.b Restorations and Over-paint

There are four areas of modern imitative restoration and four campaigns of over-paint on the coffin. The restorations are; (1) parts of the feather patterning on the head and an area between the lappets immediately below the neck including the upper portion of the PL lappet, (2) the PL side of the head, the headband, and lower edge of the cheek, (3) alterations to the mummy figures on the sides (4) apparent restorations made of the over-layer of polychrome on the foot that have failed or been removed.

The four campaigns of over-paint are; (a) an extensive red paint over the failed the ancient red paint, (b) the black color of lappets and grey over some of the pale blue bands around the lappets, (c) imitative over-painting of compensation materials and ancient paint at the juncture between the foot-block and the bottom sides of the leg, and (d) an ill-defined area of black paint on the PL side of the head.

The first campaign of restoration is distinguished from the ancient paint by observable differences in the color and surface qualities, and by the greater opacity of the substrate in x-ray images (fig. 74). The surfaces are hard and smooth with sharp break edges.

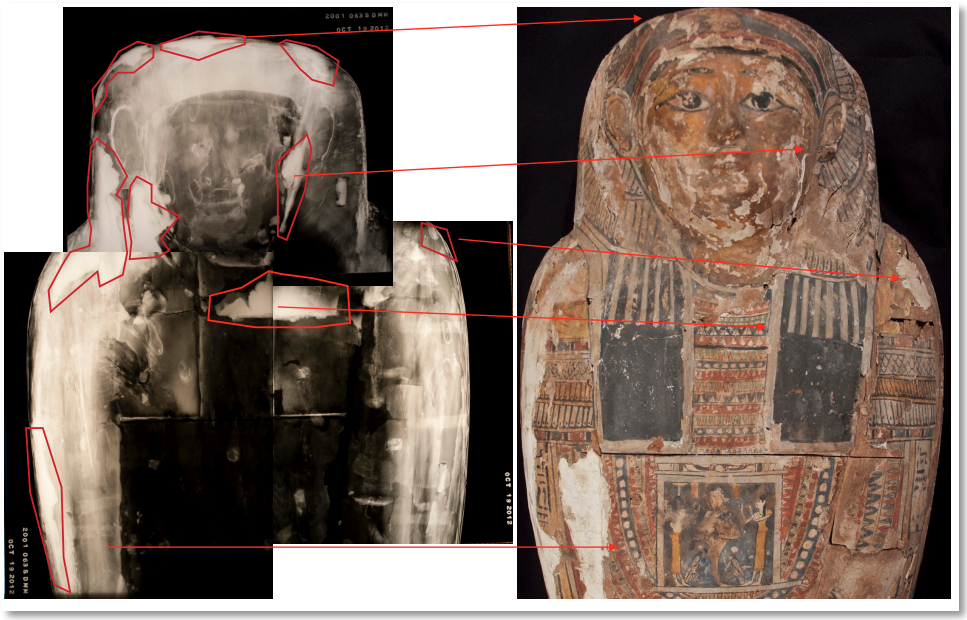


Figure 74 X-ray imaging of the greater opacity of the imitative restorations (l)

The material overlaps, and is integrated into, the ancient paint layer and the decorative pattern. The imitation of feathering on the headdress is a thinly applied paint with an intentionally mottled surface, unlike the ancient paint (fig. 75). Also VIL identification of Egyptian Blue is absent in the restoration that is present in the analogous areas if ancient pale blue. The restoration of vertical black stripes on the PL lappet tapers to the exposed wood along the top edge and is integrated into the black over-paint of the lower portion of the lappet.

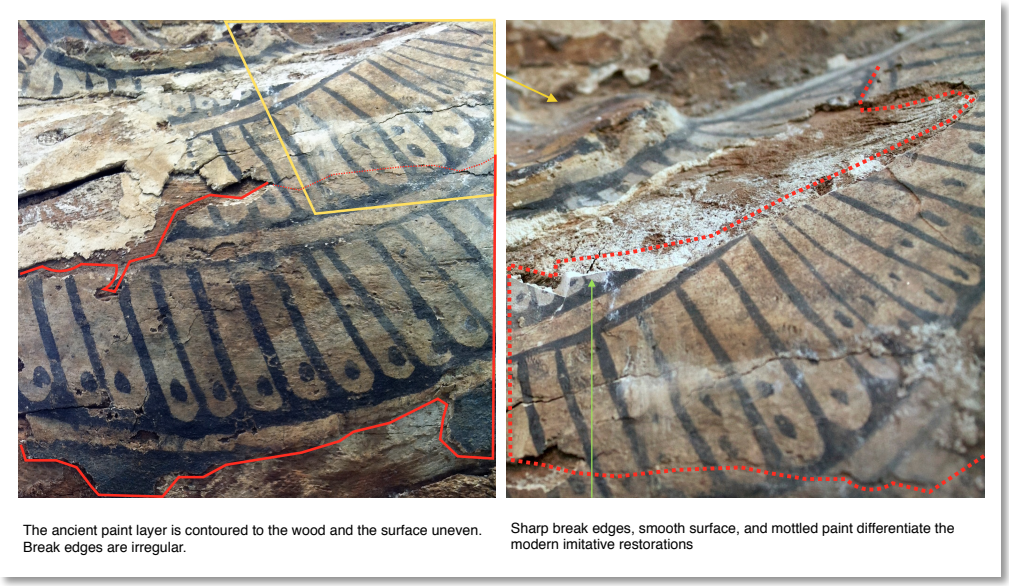


Figure 75 The ancient paint surface (l) and restoration surface (r) are outlined in red.

There is a restoration on the PL side of the head (2) extending from the chin to the top of the headband, and a section of the face that incorporates the PL part of the eye and a small area of the cheek. These are visibly distinguished from the ancient paint layer by brush strokes and inconsistency in color and surface qualities (fig. 76). This restoration is integrated into a section of the feather pattern restoration at the top of the associated with the first category of restoration. Material is now lost from the gap between the face-block and the body. The chronology of these interventions is not clearly evident.

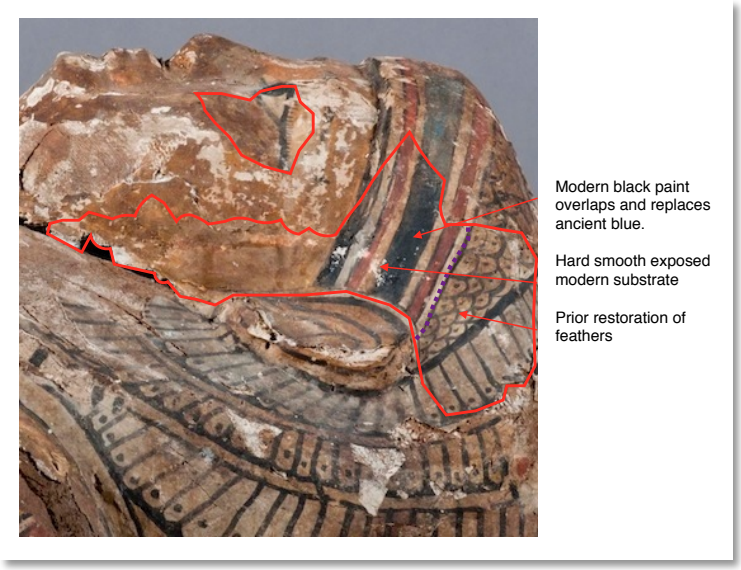


Figure 76 Restoration PL face

The third campaign (3) of interventions introduced a non-original and incongruous third reclining figure in the middle of three bands of figures on the PR side that is readily identified in UV observation and imaging (fig. 77). The upper torso of the lower front PL figure is also a restoration, and the red on the headband appears to have been repainted as a part of this campaign. The red paint was applied and black linear elements applied over in each of these examples.



Figure 77 Modern added figure PR (l) Restoration and over painted black lines PL (r)

The over-layer on the foot-block extends onto the leg and it appears it was used to create imitative restorations (4) on the PL leg and the PL side of the head, and possibly the PR side mid torso (fig.78). Although these have failed or been removed the two small remnant fragments strongly resemble the foot-block over-layer in the color and texture of the gesso layer. The red

paint is stable and has a slightly orange tint, which distinguishes it from all other reds on the sarcophagus. The use of the foot-block material as an imitative restoration on other parts of the object supports the assertion that the foot-block is a modern addition.



Fragments of the foot over-layer of polychrome on the leg (two left images), the PR side of the torso, PR side of the head.

Figure 78 Locations of the failed restoration associated with the foot-block over-paint layer

The extensive application of red paint over the failed ancient red (a) has been described in the pigment analysis section (4.2.2). This paint has been applied directly over the ancient red overlapping the original lines. In addition a fragment of the surface layer on the PL side of the lower torso that is entirely covered with the red over-paint has blue, green and white areas as well as red. The clean break edges of this piece suggest a larger area was covered in this red over-paint (fig.43). There is no evidence of this paint layer on the foot-block.

The lappets are over-painted black and different solvencies of the paint suggest at least two interventions. The pale blue band along the outside edge of the PR lappet to the shoulder is damaged and partially over-painted-painted grey (fig. 56). The presence of a deteriorated blue layer underneath the black suggests the lappets were blue in antiquity. The black paint over the lower areas of the lappets is thick and has a smooth surface that is unlike other paints on the object. At the top of the PR lappet the paint is soluble in the organic solvent acetone, and elsewhere only soluble in water suggesting a combination of interventions rather than a unified effort. Also of interest is the unique presence of rodent teeth marks on the lappets. The preferential attraction to this area suggests the presence of a material in the binder or coating that is unique to the object.

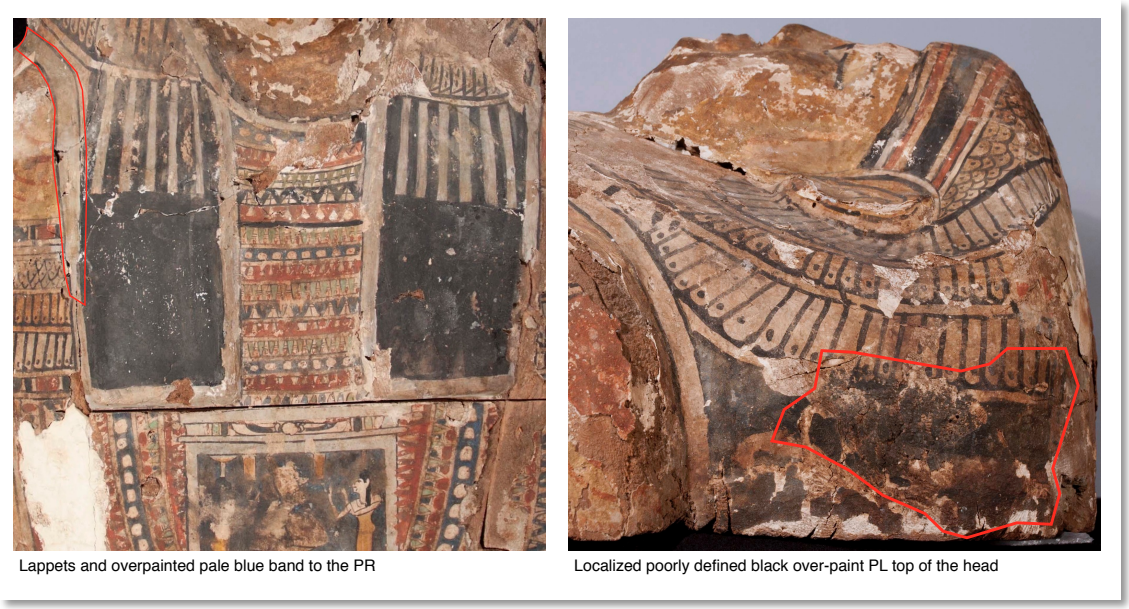


Figure 79 Black and gray over-paint

A thin poorly defined application of black paint is applied directly onto the wood and over remaining fragments of the ancient paint layer on the PL side of the head (fig. 79). This application is anomalous on the object.

5.2.2.c Coatings

Three modern coatings have been distinguished, an extensive coating over the head and body, a localized transparent application on the lappets, and a polymer that has deteriorated and the fractions have emerged from the surface as exudates. Although residual plaster on the top of the head is noticeably darker than other surfaces no additional coating material has been identified in that area. Also there is an identified saturated or oily-looking stain in the PL top of the foot that extends onto the leg of the sarcophagus. The stain is roughly round and approximately 9.0cm in diameter.

The extensive application of animal glue, identified using GCMS, is present on the head and body and on the bottom of the foot block. Drips and tide lines of this material are clearly evident in UV images of the head, PR side, and the front surface (fig. 80). The directionality

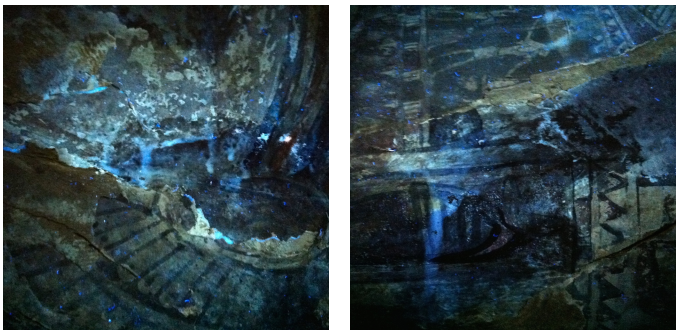


Figure 80 UV PL face (l) and PL side (r)

suggests the substance was poured then brushed or wiped over the front of the object while it was in a horizontal orientation (fig.81).

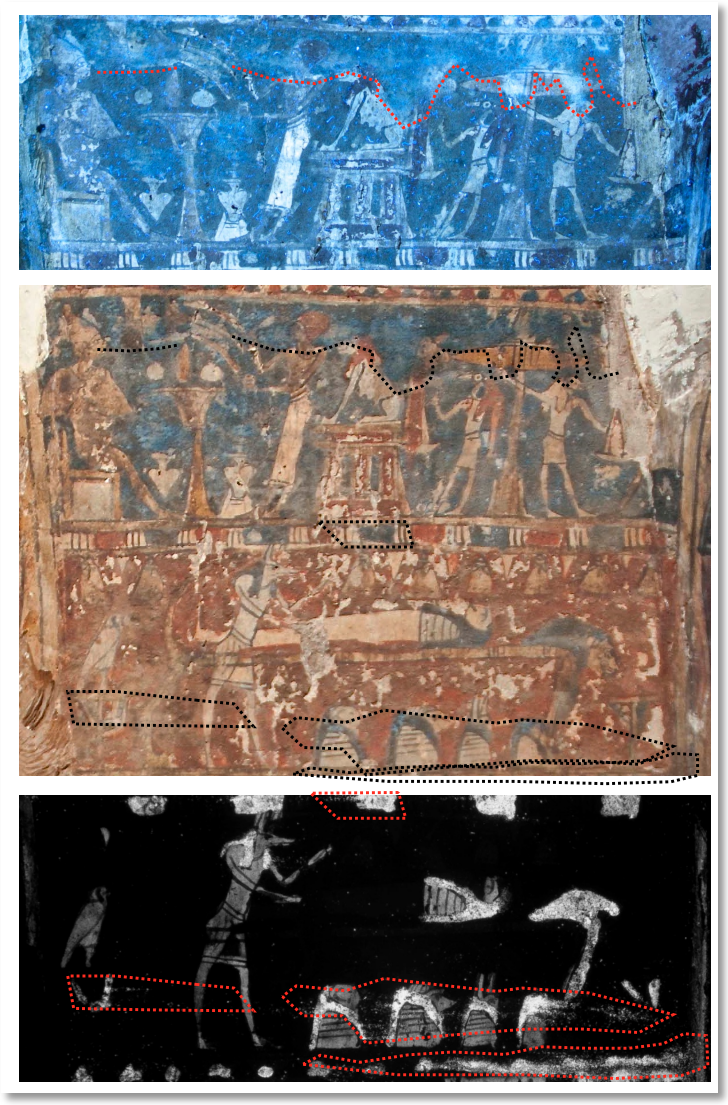


Figure 81 Long wave UV imaging (above) shows thicker areas of the coating and the tide lines. VIL imaging (below) captures images of Egyptian blue particles that have been mobilized by the coating.

A shiny transparent substance has been applied to the lappets in vertical parallel strokes that are clearly is visible in UV (365 nm). Fine brown synthetic fibers, possibly brush hairs, are adhered in the material (fig.82). These fibers are unique on the object.

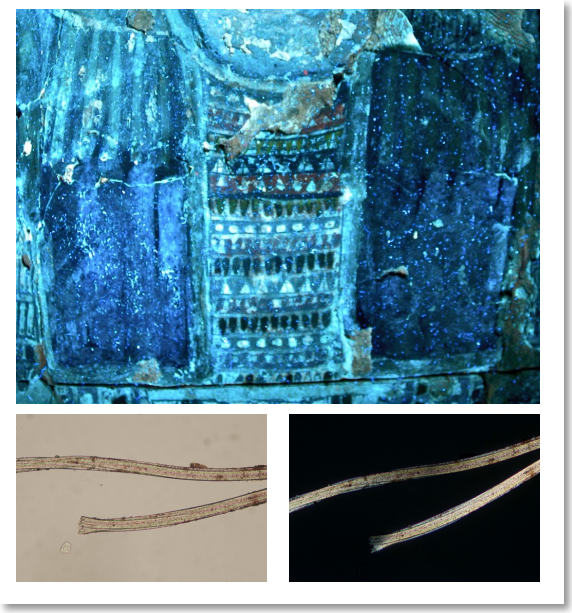


Figure 82 Lappets UV induced fluorescence and photomicrographs of brush fibers

The other coating or applied material became evident as an emergence of exudates on the surface of the vignettes and on the PR and PL shoulders (fig. 83). This substance has been indentified using FTIR and GCMS analyses as a phthalate plasticizer, which is a component of a modern materials and the separation of this fraction indicates deterioration of that material (appendix IV).

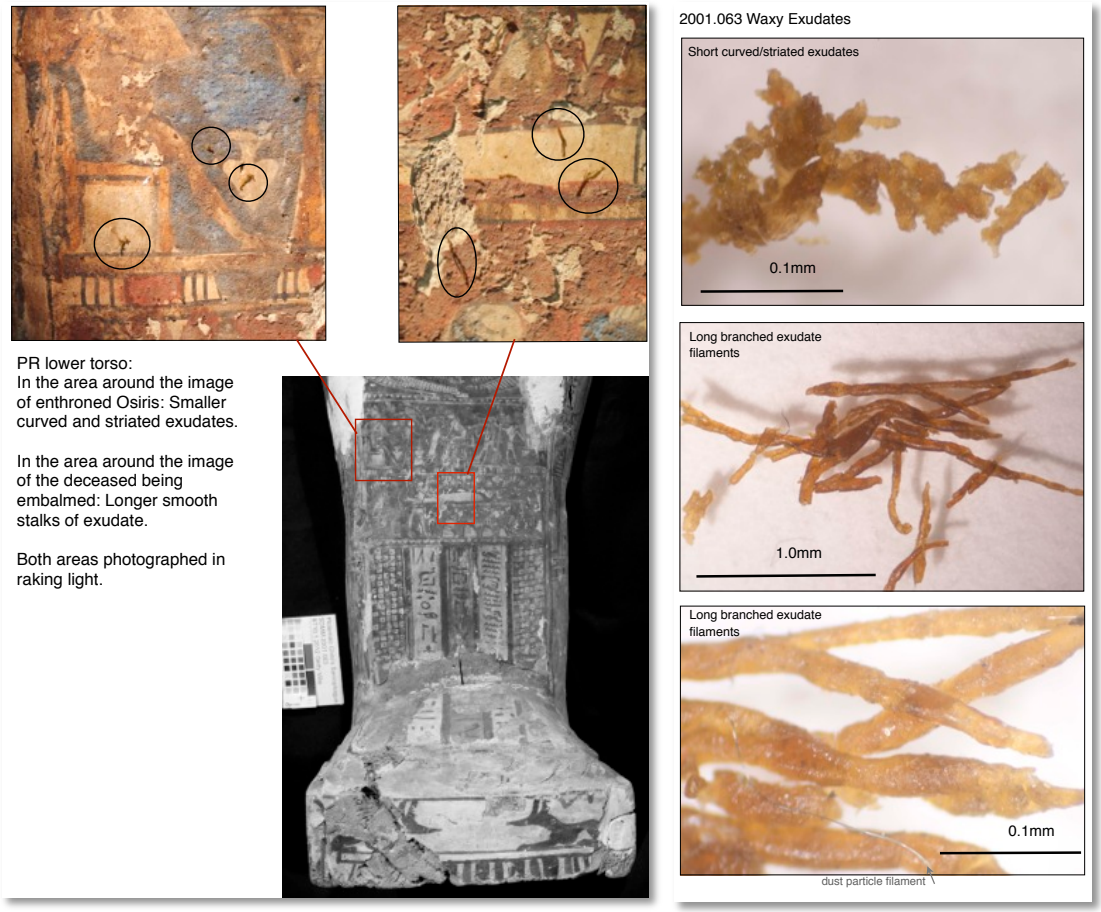
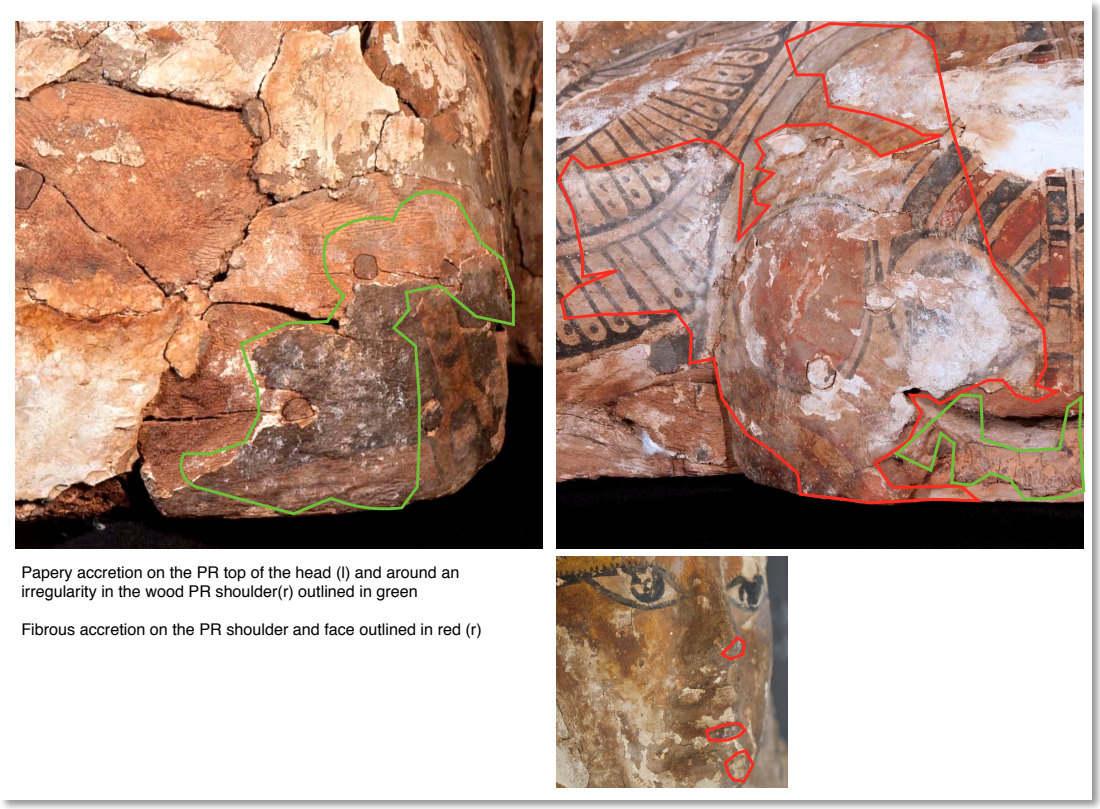


Figure 83 Locations (l) and appearance under magnification (r) of the waxy exudates

5.2.2.5 Accretions

There are two modern surface accretions: a thick white fibrous material concentrated on the PR shoulder and a fine white paper residue on the PR top edge of head (fig.84). A brown granular accretion on the PR side was described in the section on ancient accretions although it has not been definitively identified as ancient.

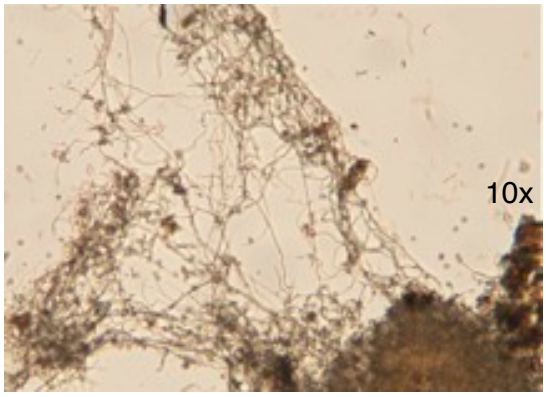


Papery accretion on the PR top of the head (l) and around an irregularity in the wood PR shoulder(r) outlined in green

Fibrous accretion on the PR shoulder and face outlined in red (r)

Figure 84 a fine accretion PR top of head (l) and fibrous accretion PR neck, shoulder and face (r)

The thick fibrous accretion on the PR shoulder is associated with an extensive area of discoloration and weakness of the paint layer. There are also small (<1.0cm) patches of this material on the lower lip and chin. The material resembles synthetic insulation fibers both macroscopically and in microscopic dispersion samples (fig. 85). The binding medium of the



Slide 24
White papery accretion on top of the head at the back edge.
Fine twisted fibers with irregular thicknesses, and tapered ends. The larger fibers are branched. Small transparent irregular spheres are present and are also isotropic. There are transparent red-brown particles consistent with hematite as well as a single blue particle consistent with Egyptian blue. A transparent coating material is attached to the fibers and particles.

Figure 85 fibrous materials on the PR shoulder and face

accretion is soluble in acetone indicating it is a modern polymeric material. The paint layer on the shoulder is very fragile and the surface is matte and mottled. Areas of the paint and gesso layer are lost possibly as a result of water damage as well as the accretion. The irregularity of the area, the damage, and the type of accretion suggest an accident.

There is a sparse residue of white paper fiber loosely attached to the PR top of the head and over an irregularity in the wood of the PR shoulder in a band approximately 8.0 cm wide and 30.0 cm along the edge. The uniformity of the material and the contained area suggests it is the result of an abandoned effort to consolidate the paint layer. There is no evidence of an associated consolidant and it caused no observable impact or alteration to the surface. The material is easily removed with a soft brush.

5.3 Modern Interventions Summary and Conclusions

Distinguishing these materials contributes evidence, if not complete explanations, of multiple modern interventions to the structure and surface, and begins to create a chronology of interventions to the coffin, and identifying these materials, and the order of their application is vital to developing an effective conservation strategy for the object.

An assessment of modern interventions contributes directly to the assertion that the foot-block is a modern intervention. The removal of material from the base structure, the components of the foot-block and their orientation, the methods and materials used to secure the structure and to connect it to the body, are all evidence of modern interventions. The absence of red over-paint and of the coating found on the head and torso, separate the foot-block from those interventions. Additionally the presence of the outer polychrome layer as a restoration on the body reinforces the thesis that the addition of the foot-block was part of an effort to redefine the object as a complete, and presumably more marketable, artifact.

6. Conclusion

The large and rich store of ancient Egyptian funerary objects, sarcophagi, coffins, and mummies that have survived to the present in museum collections seems to proclaim that these objects were intended to last for eternity. The sacred iconography and hieroglyphics confer a gravitas that suggests these object have always been revered and protected. However, tomb robbing was common in antiquity and is documented in ancient literature. Many coffins had already been stripped of gold details and gilded features, such as the faces, centuries before they were excavated.

Wood was not abundant in ancient Egypt, and as a result sarcophagi were most often pieced together rather than carved as a single whole, and it was a common practice to re-use elements from other sarcophagi in this process. Egyptian iconography persisted over three millennia, but the paint medium allowed changes in gender or style to be applied on top of older imagery. Egyptologist Dr. Kathlyn Cooney is compiling an increasing body of evidence and scholarship on the extent of historical reuse of sarcophagi, as well as historical and social factors that contributed to reuse. The fascination with Egyptian artifacts in the modern era has resulted in reuse, reconstructions, and many other interventions to create seemingly whole or visually cohesive objects.

Analysis of this child coffin has identified distinctive features that, taken together, make a compelling argument that this object incorporates both ancient and modern reuse. The ancient reuse was undertaken to meet the demands of the funerary industry, and the modern reuse to meet the demands of the antiquities market.

A significant piece of evidence in this thesis is the observation by scholars that the carving and facial expression date the face to an earlier period than the Ptolemaic, possibly the 25th or 26th dynasty. The material evidence for this argument includes the characteristic polychrome on the face, the way in which the face block is attached and integrated into object,

and the localized insect damage to the wood in the face-block. In addition the face is distinguished the presence, identified in VIL imaging, of Egyptian blue dispersed in the gesso layer.

The granular substrate that is ubiquitous over the rest of the object is absent on the face, the orpiment used to make the yellow paint is distinguished microscopically by the presence of red particles, and the face has an obscuring coating that is unique on the object as a whole. The face-block does not conform to the base structure, but instead tapers back from the sides creating a void. To secure it in place, a combination of solutions were engaged; a carved wood wedge and fill material on the PR, a wood inset on the top of the head, and a thick "plaster" fill on the PL. The face-block has a concentration of insect tunnels and related loss of material not present in the surrounding wood. And lastly the presence of an even dispersion of fluorescing Egyptian blue particles over the face indicate another distinctive aspect of the materials and preparation of the paint layer.

The foot-block was added within the recent century to meet the demands of the antiquities market. It is distinguished from the head and torso by aspects of the materials, the way in which the foot-block is constructed, the method of attachment to the base structure, and the surface treatments.

The foot-block is a complex assemblage of multiple pieces that are ancient but unrelated, and these include a section removed from the side of different wooden sarcophagi. These pieces are attached together with a modern adhesive and with modern metal screws. The cuts and joins of all parts of the foot-block are rough and imprecise, in distinct contrast to the construction of the head and torso. Three unused dowel holes along the bottom edge of the coffin leg indicate that there was a different foot attached to the base structure at a prior time.

Aspects of the surface and paint layers of the foot-block corroborate a thesis positing the modern reuse of ancient parts. Paint is only present on the large block that makes the front of the foot-block. There are two paint layers on the top of the foot and the toe, but there is no remaining

paint on the sides, and the extensive red over-paint on the torso and head are absent from the foot-block. The under-layer of paint is ancient, yet is distinguished by the presence of the bright orange red pigment realgar, which is unique on the object.

The outer polychrome layer has only red and black details and no indication of characteristically ancient pigments. The gesso layer has a distinct appearance and is a rougher consistency, however, it is not diagnostically distinct from the ancient layer. There are residues of this layer on the torso and head, indicating that this material was applied as a compensation and restoration material when the over-layer of polychrome was applied to the foot-block.

The goals of analysis are to gain detailed knowledge of the materials used, the methods of manufacture, the changes to the object, and the potential for future change, and may include distinguishing the authentic or original from components that are not. These distinctions may be essential to identifying breakage or loss to the original materials, and can contribute to a new understanding of the manufacture of an object, its history, and its use.

Analysis of the child coffin has generated knowledge about every aspect of its construction and manufacture, as well as the ancient and modern history of the object. Furthermore, analysis has provided a base of knowledge with which to compare this object to other Egyptian artifacts and to related scholarship. This information has provided the knowledge with which to determine and undertake essential conservation interventions, and to develop a more comprehensive treatment proposal. Finally, this work has created a base from which to continue and deepen research into these ancient materials and practices.

END

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Appendix I. Conservation Treatment Proposal

Conservation Treatment Proposal San Diego Museum of Man
2350 El Prado Balboa Park San Diego CA 92101 619 239 2749

Name of conservator: Casey Mallinckrodt Date: July 21, 2012
Contact information: Cmallinckrodt@mac.com or cmallinckrodt@ucla.edu
917 796 2857

Company or school affiliation: UCLA/Getty Masters Program in the Conservation of Archeological and Ethnographic Materials

If this is a school project, name of instructor or advisor:
Dr. David A. Scott
Professor Ellen Pearlstein

Instructor/Advisor contact information:
"David A. Scott" <dascott@ucla.edu>
Ellen Pearlstein epearl@ucla.edu

Artifact(s) associated with this proposal
Egyptian/Ptolemaic Childs Sarcophagus Lid
SDMM Accession number 2001.063. (old number 2001-63-6)

Please describe the treatment methods that you propose for the artifact:

The goals of the project are to carry out a technical study of the object, develop a conservation treatment strategy and to undertake priority interventions. Documentation will be completed in photographic and written form, including the results and interpretation of analysis. Regular reports with photographs will be provided to SDMM for use and publication. The final report will include a conservation treatment proposal and handling guidelines as well as documentation that can be used by the museum for education and outreach. Because of the need to bring the object to the Getty Villa, it will be secured and packed for transportation beforehand in San Diego. The design for the crating will be developed as part of this project and the staff of SDMM will build it.

Focused analysis and research on several topics will be included in this project: security and transportation of the fragile polychrome object, determination of the components and the methods of its construction, identification of the wood, identification of the paints, binders, and "gesso" layer, identification of previous interventions, increasing knowledge of the provenance of the object, and determination of the optimal display conditions and handling practices.

Several non-invasive techniques will be used to evaluate the materials and manufacture, to identify pigments/colorants and binders and the gesso like substrate, and to identify prior interventions. Observation unaided, under low magnification, and in raking light as well as

photography in visible light will be used to understand the object and its condition and to thoroughly document the condition.

Photo imaging of ultra violet light induced fluorescence will be used to aid in identifying the materials used in manufacture and possible subsequent interventions such as adhesives or paint campaigns. Infrared reflectance spectroscopy will be used to aid in identifying under-painting, prior paint campaigns or other inconsistencies in the surface or materials. XRF (X-ray fluorescence spectroscopy) will be used to aid in identifying elemental components of the paint and "gesso" layer and other components of the object as analysis and observation indicate. X-radiographs will be taken to aid in determining the construction, materials, and the condition of the wood structure. UVVisNIR spectroscopy may be used to aid in identifying binders in the paint or "gesso" and the presence of dyes. Evaluation of the wood will include observation under low magnification to identify the characteristic structures of the wood.

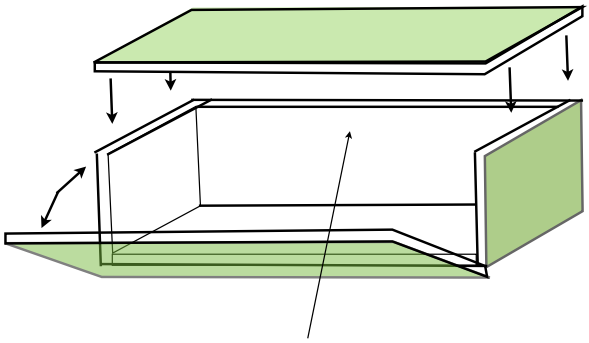
Some invasive analytic techniques may be used if warranted by the results of non invasive testing, and on approval of SDMM executive leadership, collections manager and curator. These include but are not limited to the following: samples of the pigments may be taken to carry out XRD (x-ray diffraction) and FTIR (Fourier transform infrared spectroscopy) analysis to identify chemical compounds. In this case samples will be viewed using polarized light microscopy for further identification of pigments and binders. Thin sections of wood may be made for microscopic analysis to determine paint layers and to identify the wood or woods used in manufacture as well as parts of the object that may not be original. Carbon 14 (C14) dating may be used to date the gesso layer. Dendrochronological analysis (tree ring dating) may be carried out.

The treatment proposal will be determined by analysis of the collected data. Treatments proposed may include reattachment of a detached fragment in the possession of SDMM, and adjustment of the plaster fills. A strategy for accomplishing these, or other priority interventions, will be addressed in the condition report and carried out if approved by SDMM executive leadership, curator and collections manager, and there is adequate time.

Approved by: Date:

Appendix II. **Crate Design**

Crate *draft* August 8 2012
Dimensions are approximate scale: ~1" = 1'

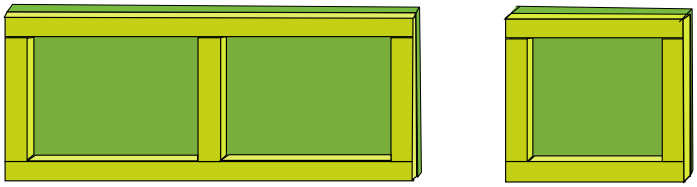


CRATE:
General Design:
Removable top and fold-down front panel.

Alternatively the front panel may be screwed in.

Pallet slides into the crate: it is built with recessed support pieces to allow it to be handled.

Cushions _ secured to the inner side of the lid, apply gentle pressure when lid is secured: soft Tyvek with polyester batting: Possibly teflon on contact surfaces.

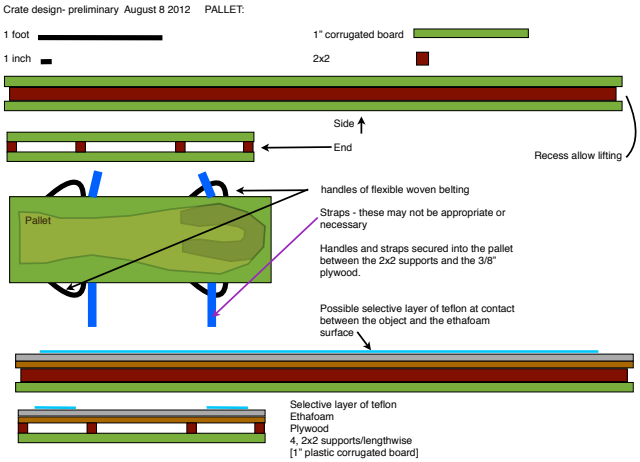


Side Panels

wood 1"x 2" support on the corrugated walls of the crate.

1" Corrugated plastic board

Materials: Luan Plywood may be adequate for the sides and top. The base requires a sturdier material: 1" corrugated plastic board (?)





Support

Appendix III. Museum Record

2001.063.0006 ~ Sarcophagus *03/28/2012*

Collection			
Other#		**Category**	8: Communication Artifact
Old#	2001-63-6	**Subcategory**	Ceremonial Artifact
Accession#	2001.063	**Othername**	
Received as	Gift	**Accession date**	05/03/2005
Cataloged by	Ramirez, Sandra	**Catalog date**	05/31/2006
Source	Paul, Martin and Maria		
Creditline			
Home loc	Lab 6 Balcony		

Description

Ptolemaic Period, c. 305-30 B.C.

Extremely rare wooden anthropoid sarcophagus for a child perhaps of royal birth. This may have been the only example of this type of ancient Egyptian sarcophagus in private hands. There is approximately six other children's wooden sarcophagi in only four museums world-wide. Although there are several mummies of children in various collections and a few cartonnage cases made for children, there are precious few fragments let alone complete wooden cases which have survived. Normally children did not receive the usual care, embalming, wrapping, and placing into a wooden sarcophagus which an adult would receive. Usually a child if they were even embalmed would at best be placed in a crude slab-sided box with no decoration and only occasionally a crude hieratic, demotic, Greek, or Latin inscription of his or her name. Usually a child was simply placed in a simple depression in the sand, placed in simple communal tomb or shaft, or simply floated down the Nile River. The first thing one cannot help but notice is the diminutive size of the case. It is well constructed from very thick cedar planks unexpectedly heavy. The cherub-like face with it's very expressive eyes. The child's head is covered by a special wig which is comprised of a winged solar disc at the forehead with the wings gently framing the face with blue and red stripes and black lappets comprising the rest of the wig. The ears are delicately carved and painted and showing a great attention to detail. At one time the face had been gilded and traces of it remain. There is a large depiction of a beaded broad collar in red, green, blue, black, and yellow. In the center of the collar below the ends of the wig is the depiction of a naos shrine topped by a winged solar disc. Inside the shrine is a depiction of the goddesses Isis (right) and Nephthys (left) worshipping Osiris. Also present is a pair of perched falcons. Below this scene and across the chest is the depiction of the sky-goddess Nut, with her protective wings embracing the child's mummy. As a sky-goddess she would fit in with the Horus and solar identification. Below her is a beautiful illustration depicting Anubis preparing the body of the young child laying upon a couch carved in the shape of a lion. Below this brier rests a set of four canopic jars topped with the carve stoppers depicting the heads of the Four Sons of Horus. They are left to right; Qebehsenuef, Hapy, Duamutef, and Imsety. Below this scene and running down the middle are three colums of hieroglyphs bordered on either side by a curious checkerboard pattern in blue, red, and white. This extends on down on top of the foot box and at the front of box is depicted a pair of recumbent Anubis. Along the sides are depictions again of The Four Sons of Horus, this time in their mummiform pose and beneath them is a depiction of what appears to be a solar disc in red set upon a yellow background with red wavy lines extending vertically in the scene. Since only royalty would be reunited with the sun at the time of death, it can be assumed that this case, with all of it's divine solar messages so clearly and unusually stated would have been meant for a child of royal birth.

Date	Ptolemaic Period, c. 305-30 BC			**Status date**	05/31/2006
Year Range	0 - 0			**Status by**	Ramirez, Sandra
Condition	Not rated			**Status**	OK
Height	129.000 cm	**Width**	18.000 cm	**Dim Notes**	
Length	50.000 cm	**Depth**	0.000 cm		
Diameter	0.000 cm	**Circum**	0.000 cm		
Weight	0.000 gr	**Count**	1		
Collector				**Coll date**	/ /
Site				**Site#**	
Pl origin	Ancient Egypt				
Event					
Material					
Found					
Used					
Made					

Page 1

Appendix IV. Iconography

The imagery on the sarcophagus is derived from the Egyptian myth of the death and resurrection of the god Osiris. Osiris was killed and dismembered by his brother Seth. His sister, and future wife, Isis, reassembled and revived his body. They then conceived a son, the god Horus (Ikram and Dodson 1998; Taylor 2001).

The study of the purpose, meaning and importance of funerary iconography is a complex field of scholarship, and it is not the goal of this thesis to argue for a particular interpretation of the iconography on *this* sarcophagus. But a simplified explanation is that the iconography served to aid the deceased through the process of rebirth as a god. John H. Taylor (2001) has described the coffin as a sacred environment that could be considered "an eternal house," "a miniature tomb," "a substitute body," and an idealized manifestation of the deceased in the god form they would achieve in resurrection (Taylor 2001). Each component of iconography played a role in facilitating the successful passage of the deceased to divinity. Osiris was the first mummy, and the embalming and wrapping of the deceased is a reenactment of the embalming and wrapping of Osiris. The relevant processes and spells are contained in the Egyptian Book of the Dead (ref).

The iconography and text are applied symmetrically within a linear scheme laid out in black. On this sarcophagus, the figure wears a black wig with a red and blue headband on the forehead and a blue band across back of the head. At the center of the headband are the remains of what appears to have been a sun disk. During the Ptolemaic period the faces of the deceased were often gilded or painted a golden color to depict the deceased reborn as the sun god, or they were painted green, which is the color of Osiris's face. Many extant sarcophagi faces are gilded (Ikram and Dodson 1998) or, as is the case with this object, painted with the bright yellow pigment orpiment to give the appearance of gold. A discolored coating layer, believed to be ancient, now largely obscures the orpiment on the face. Orpiment constituted a less costly method of achieving a gold-colored face rather than using real gold . Analysis has confirmed that there is no gold on this object, contrary to the original SDMM report.

On the sarcophagus, the deceased is depicted wearing a vulture headdress characteristic of female deities (Cooney 2012; Corcoran 2012). A talon is visible on the proper right (hereafter PR) topmost part of the head, and the feathering on the remaining ancient paint layer is readable. The black paint on the lappets covers a layer of Egyptian blue that is partially lost on both lappets, and, additionally, there is a residue of iron oxide red paint under the black paint close to the vertical black and white elements. Black is associated with males, yet the nature and application of the paint and associated restorations more strongly suggest that blue was the color applied in antiquity, and that the black is part of a modern restoration (Cooney 2012).

Centered immediately below the lappets is a framed image, which depicts a pectoral in the shape of a shrine, containing a conventional image of Osiris flanked by Isis and Nephthys, as well as two Ba birds (Corcoran 2012). Ba birds embody the soul of the deceased and are usually depicted as birds with human faces and hands. This scene was common on coffins in the third intermediate period but *not* the Ptolemaic period (Corcoran 2013). Two noteworthy details are the unusual inclusion of the Ba birds and the absence of the goddesses' names from the yellow rectangular name-plaques above their heads. This appears to have been an oversight by the artist.

A wide necklace, referred to as a broad-collar, begins along the bottom of the lappets and extends to the lower torso. This low, somewhat anomalous position is characteristic of the Ptolemaic period (Ikram and Dodson).

There are three framed vignettes centered on the lower torso. Immediately below the collar is the figure of the sky goddess Nut, kneeling at the center with wings extending to either side, indicating her protection of the deceased in preparation for the soul's rebirth (Corcoran 2013). The four registers of feathers are, from the top: pale blue, yellow/golden, an unknown color now deteriorated to mottled brown, and pale blue. Of note here is the absence of the pale blue on the proper left (hereafter PL) upper register, which appears to have been an oversight by the artist.

The vignette below the four registers of feathers depicts *Spell 125* from the Book of the

Dead. Here, the deceased is in the underworld, or Duat, and enters at the viewer's right, although due to loss of the surface only the legs remain intact. Progressing from right to left, falcon-headed Horus holds a set of scales, itself a "T" shaped form on which the heart is weighed against the feather of truth. This is an attribute of M'aat, the goddess of cosmic order (Ikram and Dodson 1998,). The creature seated on a shrine in the middle of the scene is Ahmit (also known as Ammit). Part crocodile, part hippopotamus, and part lion, Ahmit consumes the heart of the deceased if it is too "heavy." Typically, Ahmit is on the far right of such a scene. To the left of Ahmit is the deceased, who has now successfully passed this test and stands before Osiris, who is seated to the far left. On the table between are offerings to Osiris that were made on behalf of the deceased, including lotus flowers. The deceased here is depicted as an adult male, and Osiris is depicted as a seated mummy.

The vignette below this depicts the deceased, or Osiris, being embalmed by Anubis on a lion-headed bier. This scene is one of the most commonly depicted during the Roman-Egyptian period (Corcoran). There is a falcon on a stand to the left of the image as well as four canopic jars at the bottom of the frame. The falcon may represent the Ba, or soul of Horus (Corcoran). The canopic jars hold and protect the organs removed during the embalming. Each has the head of one of the four sons of Horus, and each is associated with a specific organ: (a) Hapy, the baboon head, is associated with the lungs; (b) Daumutef, the jackal head, is associated with the stomach; (c) Imsety, the human head, is associated with the liver; and Qebehssenuef, the falcon head, is associated with the intestines. Below this three vignettes are three vertical text panels flanked by rectangular areas painted with a grid of small blue, red, and white squares in a grid painted in black.

On each of the shoulders is a red circle, depicting the sun being guided by a hawk head in profile. Immediately below this toward the foot, is a band with three registers of feathers in which two pale blue registers flank a central yellow one.

Along both sides, between the feather band at the shoulder and the foot-block, the four sons of Horus are represented in recumbent, mummified forms, arrayed on a "wood grain" background of red undulating lines and circles on a yellow ground.

Each of the sons of Horus is, or should be, paired with a text band. In this case, there are six figures in stacked pairs and toward (or in front of) each is a vertical band of text. The exception to this is a third figure in the middle-PR that is a modern restoration. This figure is out of alignment, it is different in style and surface texture, and it supplants the text panel for what has become the middle figure.

Seven of the recumbent mummy's heads are lost along with loss areas of the ancient paint. The placement of these gods is *not* symmetrical from the right to left sides. On the PL Qebehssenuef (the falcon head) is in the top register near the edge. Immediately below is Imsety (the human head), and to the front of Imsety is Daumutef (jackal head). The shoulders and face of this figure are a modern repainting, and Daumutef is repeated in the front position of the bottom register. On the PR side, the upper-most figure along the edge is Daumutef. In the middle register we can see Imsety at the edge, with Daumutef to the front, and the text panel is replaced by the aforementioned restoration. Neither figure in the bottom register is discernible.

The yellow background with red undulating lines and circles is meant to imitate wood-grain. There is documented use of this pattern during different periods, including the Roman (Svoboda 2012). It was used, for example, in temples to create false doors as well as on funerary objects as a surface paint (Ikram and Dodson 1994, 217).

The over-layer of paint largely obscures the remaining ancient paint layer on the foot-block. No iconography is visible on the small exposed areas although the outline of a foot is visible on the PR top of the foot-block. This decorative device has been found on similar objects from this time period (Traditti 2013).

The bottom of the foot-block was carved to create the effect of a low pedestal, and the alternating vertical paint marks along the bottom edge are intended to suggest the cavetto at the

roof of a shrine (Corcoran 2013). Immediately above this cavetto are two reclining jackals, facing one another. The jackals are known as Wepwawets, and they run ahead of the sun god, opening the pathway to the sun. *Wep* translates as "to open" and *Wawet* "the road". In this configuration, they are leading the newly deceased, who has transformed into a sun god, on the journey to eternity. The distinction between Anubis and the Wepwawet figure is not absolute, and their figurative placement, recumbent on a shrine, may more formally identify them as Anubis (Corcoran 2013).

All of the text panels, with the exception of the center panel on the lower leg, are black hieroglyphs on a pale blue background. The center panel background is white coated with a darkened mottled material, which may have originally imparted a tone or sheen.

Overall, the text is garbled, as if copied or transcribed without understanding (Cooney 2012). For example, the center front panel has conflated the appropriate standard offering "hetep dj nswt" with a different and misplaced introductory phrase "djed medw jn," meaning "words to be said by" or "quote." This phrase should normally be placed in front the speaker, in this case the recumbent mummies along the sides, and it should be followed by "I am your son, your protection" along with the name of the god who is speaking. The text panel in front of the falcon-headed god, Qebehssenuef, on the PL, only partially depicts the hieroglyphics for this phrase and the name of the god (Corcoran 2013).

Appendix V. Analytic Methods

Non-destructive forensic imaging techniques

VIL Visible-induced Infrared Luminescence imaging

This forensic imaging technique is used to identify Egyptian blue. The Cu^{++} ion in the Egyptian blue emits a diagnostic luminescence in the infrared region of the electromagnetic spectrum around 950 nm when it is stimulated with visible light between 400-700nm (Verri).

A Mini Crimescope® (Spex) was used to illuminate the object at between 500 and 600 nanometers. Photographs were taken with a Nikon D90 digital camera with UV and IR spectrum sensitivity and a Nikkor 16-70mm lens with a PECA 908 (#87C) filter to capture between 800 and 900nm (Kakoulli 2012).

IR Infrared Reflectance Imaging
IR (above 700 nm) energy is more penetrating than UV or visible light and has been used to identify highly absorbent carbon materials under the surface layer, notably under-drawings. IR imaging is often used in conservation to highlight carbon-based materials found in under-drawing.
IR images were captured with a Nikon D90 with UV and IR spectrum sensitivity and a Nikkor 16-70mm lens with a PECA914 (89B) filter.

UV Ultraviolet-induced Visible Fluorescence
Some materials exhibit a characteristic fluoresce in the visible light range of the electromagnetic spectrum (400-700 nm) when they are exposed to long-wave ultraviolet light in the 300 to 400 nm range. Coatings, resins and adhesives
Observation and imaging was done to identify qualitative differences in surface materials using a hand held UV light source (365nm), and with a Mini Crimescope® (Spex) to illuminate the object in the 300-400 nm wavelength range of the electromagnetic spectrum. A Nikon D90 and a Cannon Rebel IOS T4 were both used during the project.

X-ray X-radiography
X-ray imaging can identify structural components including individual wood elements and dowels, and metals. Jeffrey Maish, associate conservator at the Getty Villa, performed the x-radiography.
X-radiography contributed to this analysis by elimination of the radio-opaque materials gold and lead. In the current SDMM object description, gold is reported to be present on the face but it is not evident in the x-rays. Lead paints were used during the Ptolemaic period and are opaque in x-rays. There is no opacity in areas of this object that would correlate with these predicted radio-opaque materials.

Non-destructive analysis
p-XRF or ED-XRF Portable Energy Dispersive X-ray Fluorescence Spectrometry
XRF analysis is used to identify inorganic elements by inducing and measuring signature x-radiation energy. The analysis was carried out using a Bruker Tracer III unit with a rhodium analyzer, which detects elements between sodium to Uranium, 11 to 92 on the periodic table of elements.

Approximately seventy pXRF analyses were carried out to acquire. Rhodium analyzers have been found to falsely indicate presence of strontium when calcium is a major element in a sample. In this case the calcite ground is present over all parts of this object and strontium peaks are attributed to this. (Walton; Muros). Iron is identified in all spectra.

Destructive analysis
XRD Powder X-ray Diffraction
X-rays generate characteristic diffraction patterns of crystalline structures to identify compounds as well as elements. A Regaku R-Axis Spider X-Ray machine to collect Debye-Scherrer rings of samples collected from all colors. Samples were placed on a glass spindle with Apiezon grease. The base line was corrected and MDI/Jade v8.2 software was used to compare the spectra with

ICDD data (International Center for Diffraction Data). David A. Scott and Vanessa Muros carried out the XRD analysis.

PLM Polarized Light Microscopy
Plane and cross-polarized light observation can identify organic and inorganic materials by a number of known qualities and measurements. Ninety-nine dispersion samples and fifteen cross section samples where prepared.
Olympus BH-2 Microscope.

FTIR Fourier Transform Infrared Spectrometry
Infrared absorption patterns indentify molecular bonds to generate characteristic spectra.
Herant Khanjian, scientist at the Getty Conservation Institute carried out micro-FTIR analysis of two materials, the exudates and the green pigment. Analysis of paint and gesso samples has been carried out by the author using a Nicolet *is* FTIR spectrometer with a diamond ATR.

GC-MS Gas Chromatography Mass Spectrometry
Identifies organic compounds such as resin and waxes by separating and identifying the components. Joy Mazurek, scientist at the Getty Conservation Institute carried out GCMS analysis of several samples.

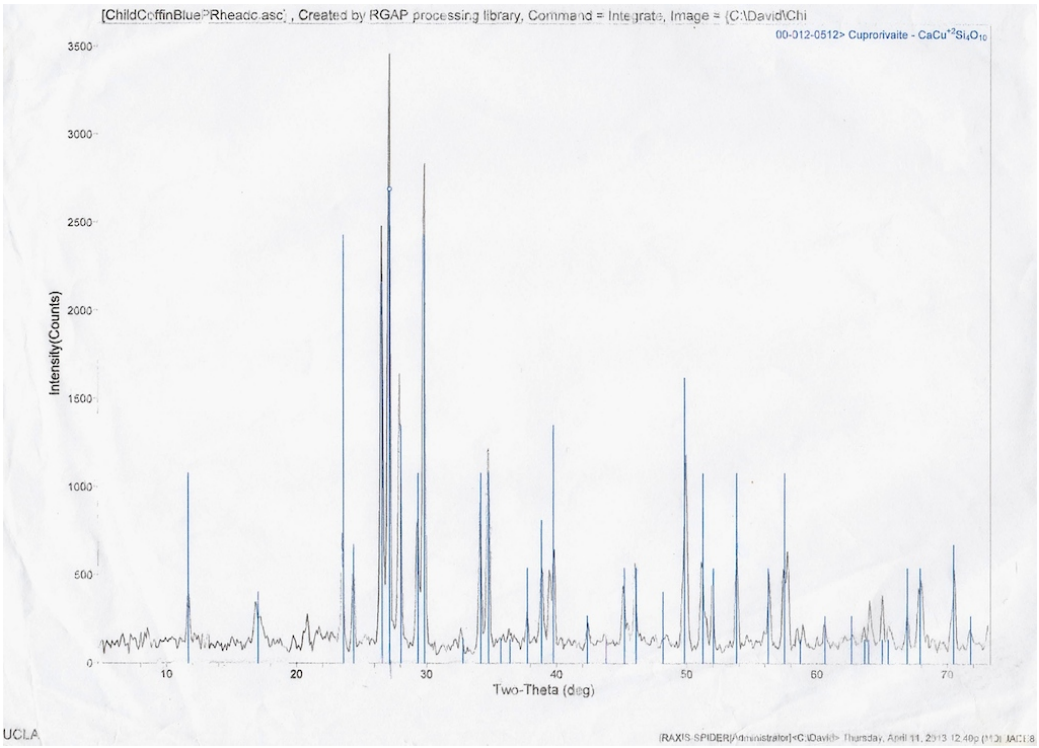
Appendix VI. **XRF Analysis** abbreviated summary
Bruker Tracer III, with rhodium analyzer

	Ca	Ti	Fe	Cu	As	kV µA	Vacuum	Filter
						40kV 1.9µA		
Blue S	p		s	m				
Headband	m		p	M		"	n	n
Chest	M	t	p	P		"	"	"
foot	M		s	p		"	"	"
Lappet over blue	m		M	m		"	"	"
Green								
chest	m		p	m	t	"	"	"
chest 2 p	M		P			"	"	"
Red								
Leg	m	t	M			"	"	"
Foot	M		m			"	"	"
Yellow								
face PL nose	m				M	"	"	"
Pectoral, figure	p		s		M	"	"	"
Lower torso, wing	m		s		M	"	"	"
Black	m		p					
Lappet, no blue	m		M			"	"	"
Grey								
PR Torso, over-paint	M	m	m			40kV 12.	y	"

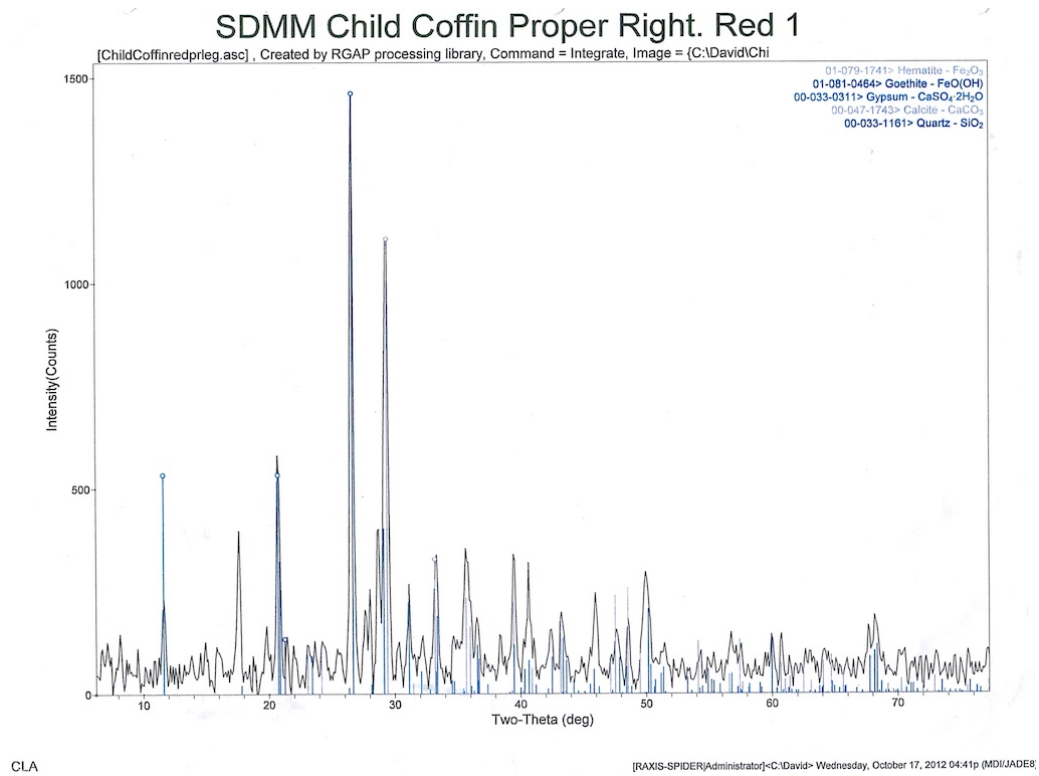
Child Sarcophagus XRF 2012-2013
CMallinckrodt

Color	Location	File Name	Al	Mg	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	Ni	Cu	Zn	As	Br	Sr	Rh	Date	filter	Vac	Counts	KV	ma
	PR	PRsidetopmiddlefigure																								
		Restoration																								
Red	Middle figure			?	?					M	T		M		T	T	S	S	M	X	10.16	Red	n			
																										0.2
Red	PR Leg	XRFsite_Red								M	T		M	?	T	T	P/S	P/S	M	X		red	n		40	~2K
Red	PLLeg	PLEdgeLeg			T		T		T	M	T		M		T		T	T	P	X	10.13	n	y		40	1.9
Red	Top of Foot	FootTop_Red	T		T		T		T?	M	T?		M		T		T?		S	X	10.13	n	y		40	1.94
Red	PRShoulder	sarcPRShouldermatte_5_25	t		small	tr	present	present	trace	Major	small		major	t?						x	5.25	n	y	8806/6797		
Yellow	PRLeg	XRDsampleyellow		t?						Major	T		M		T	T	t		major	X	10.16	red	n		40	20
Yellow	PR Pec/feather	PRSideYellowpecfeather	?t				T?		T?	M			M		T	t	M k+l	M	M	X		red	n		40	0.8
Yellow	PR_Side	PRSideYellow		T			T			M			M		T?	T	T	T?	M	X		red	n		40	0.8
Yellow	PR side	Mid			T?		T?	T?	T?	M			M	T?	T	S			M	X		red	n		40	.80 5
Yellow	PL Nose	FacePLofNose_Yellow	t?		T		sm	sm	tr	M	tr	t?	M	t?	t?	t??	M		P	x	10.12	n	y	7531/58	40	.80 6
	PR face above	2001-063_PRFaceYellow																								
Yellow	PLFigure on C	PLFigureChest			T		T	T?	T?	P/M			P		T		M		S	x	10.13	N	Y		40	.80 7
Yellow/Orange	Top of foot	Underlayer Topfoot_feb24			t		t	sm	t	Major	t		major	t	t		Major		present	x	3_24	?	?	7262/56	40	1.9
Yellow	PLPectoral	2001_063SDMM_PLPectoral	t/		t		sm	sm	t	Major	tr		present	tr	tr		Major		present	x		N	N	9080/68	40	1.9
Yellow	Plchestfigure	2001_063SDMM_PLFigure_ChestImage.....			tr		sm	sm	t	Major	tr		Pre	sm	sm		Major		Small/p	x		n	n	11,327/	50	1.9
Yellow	Plshoulder brig	2001_062SDMM_PLShoulderBright_			sm/tr		v small	trace	tr	major	trace		Major	tr?			tr		Small	x		n	n	9573/7	40	1.9
Yellow/Orange	Top of foot	sarc_topfoot_5_25....	tr?		sm	v sm	sm	Present	v sm	Major	sm		major				Major				5.25	n	y	8234/6506		
Yellow	PL FIGURE	#PLLowTOrsoWing			t	t	sm/tr	small/p	t	major	r		small/p	sm/t	sm/tr		Major		smal							
Blue	Chest_Image	Chest_Image_Blue			S		T/S		T?	M	T	T??	P		M		T		S	X	10.12	n	Y		40	1.94
Blue	Front of foot u	FootFront_Blueundelayer			T		T			M	T	T	P	T	P			T	P	X	10.13	N	Y		40	1.9
Blue	Front of foot u	FootFrontBlue_vacnofilter			t		t		ng	M	ng	ng	Minor		T			ng	minor	x	11.11	n	y		40	1.9
Blue		PLheadbandblue			S		S		T	P	T/S?		P	T	M		T		S	X	10.12				40	1.9
Blue	Toe	2011_063_FootFront_Blueunder			sm		sm	sm		M	T		P	T	M			tr	present	x	?	n	n	7029/55	40	1.9
COLOR	LOCATION	FILE NAME	Al	Mg	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	Ni	Cu	Zn	As	Br	Sr							
Blue/Pale		PLpectoralpaleblue			S		S			M	T		S	T?	S				S	x						
Black Text on	PLLeg	2001_63SDMM_Plreg_txt....	t?		v sm		sm	sm	t?	Major	trace		Sm	tr	small			tr	present	x		n	n	8147/62	40	1.9
Green																										
(Xray indicate	Upper Center	GreenCtrChestNoBlue			T?		P			M	S/T		P/M	T	T		T		S	X	10.12	n	y		40	1.94
Green		Green_CtrChestBlue_labrat	T		tr		T/P			M	T		P	T	P		T		P	X	10.12	n	y		40	1.94
Green May 2	PL Green #3	# 3 PL			tr		Sm? (Rh?)			M	t		sm		M		t		sm							
Green May 2	Low Middle	center			tr		Sm? (Rh?)			M	t		sm		Present		t		sm							
NewGreen	restoration	SarcNewGreen_5_25..	t?		vs	vs	Major	present	t?	Major	Pre		major								5.26	n	y	8990/6824		
White*	PR Head/pale	PRHeadwhite_labrat			T		T		?T (hidd	M	T		Minor	?T	Minor			T	Minor	X	11.11	none	n		40	1.9
White #2	PR Head/pale	PRHeadwhite_labrat_2 NOTE: This is vac no			T		T		T		Neg		Minor		Minor				Minor	X	11.11	none	y		40	1.9
White	PR side white	PRWhiteMiddle_vacnofilt			T		T		T	Ca	ng		Minor	T	Minor				Minor	X	11.11	none	y		40	1.9
White	PR side white	Prwhitemiddle_vacbluefilt					ng	?ng or f	ng?	M	ng		minor		minor					X	11.11	blue	y		15	12
White	Foot Front	FootFrontWhite_nofilternova	ng		T		T		ng	Major	ng		Minor	T			t		Sr	X	11.11	non	y		40	1.9
White	PR front leg	FrontPlegRwhite_vacbluefilt					t	t		major	ng		minor		minor					x	11.11	blue	y		15	12
GreyFIll	Prhead	GreyfillPRHead_vacnofilt	t?		sm		present		t	Major	t	sm	Major	t	t				minor	x	11.11	none	y	6996/54	40	1.9
Grey fill	PR foot blok	2001_063_greyfillPRatFootBlock			trace		small		t	major	trace	Trace	Major	t	t	t			sm/tr	x		n	?	6385/51	40	1.9
GreyPRShldrH	SarcGreyPRsh	oulderatHead_5_25		ts	t/s	t	sm	present	sm	Major			Major								5.26	n	y	8557/6641		
COLOR	LOCATION	FILE NAME	Al	Mg	Si	P	S	Cl	K	Ca	Ti	Mn	Fe	Ni	Cu	Zn	As	Br	Sr							
Black	Foot	2011_063SDMM_FootFront	t		v sm		sm	pr	t	Major	t		present	sm/t					Present	x	?oct?			8003/61	40	1.9
Black	PLHeadband	2001_063SDMM_PLHeadba	t		t	t?	small pr	sm/pr	tr	Major	sm	sm/t	major	t	t	t	t		sma	x	?	n	y	6847/54	40	1.9
Black	PR lappet upp	Sarc+Priappetupperstripes	t?		sm		small pr	small pt	t	Major	Present		Present							x	5.25	none	y	10,465/	15	12
Black	PR Lappet	Prlappet_vacnofilt_2			minor				ng	major	tr	minor	major		ng					X	11.11	none	y		15	12
Black	PL Headband	2011_063SDMM_PLHeadba	t/		t		minor	Minor	t	Major	sm	t	major	t	t	t	t		sm	x	?	none	y	6847/54	40	1.9
Black	PLHeadOnWoo	PRHeadBlackonWood					t	t	sm	Major	t+		Present		t						6.2	red		1523/14	40	20
Black	Upper Chest R	UpperChest Resto					small	present		Major	small		Present	t?												
																					6.2	Blue		ok	ok	ok
Plaster	Plaster	sarcPlasterPR_5_25	t		t?	t	Major	small	t?	Major	t?		small								5.25	n	y	9121/7915		
Plaster	Mid torso PR	sarcPRmidPlaster_5_25..	t			t	Major			Major			v sm	t?						x	5.25	n	n	8617/6693		
Restoration	pr head	SarcPRHeadRestoration	t?		t	t?	Major	small	tr	Major	sm		present	major							5.25	n	y	8499/6625		

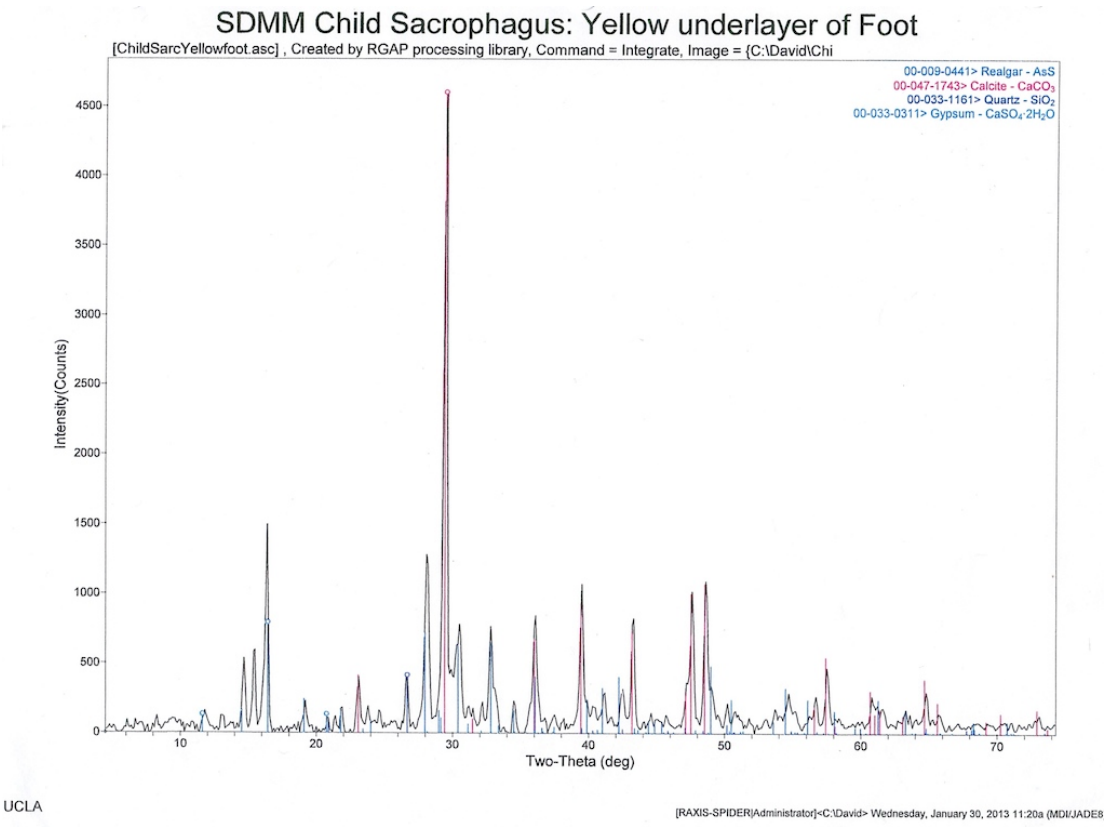
Appendix VII. **XRD Analysis**



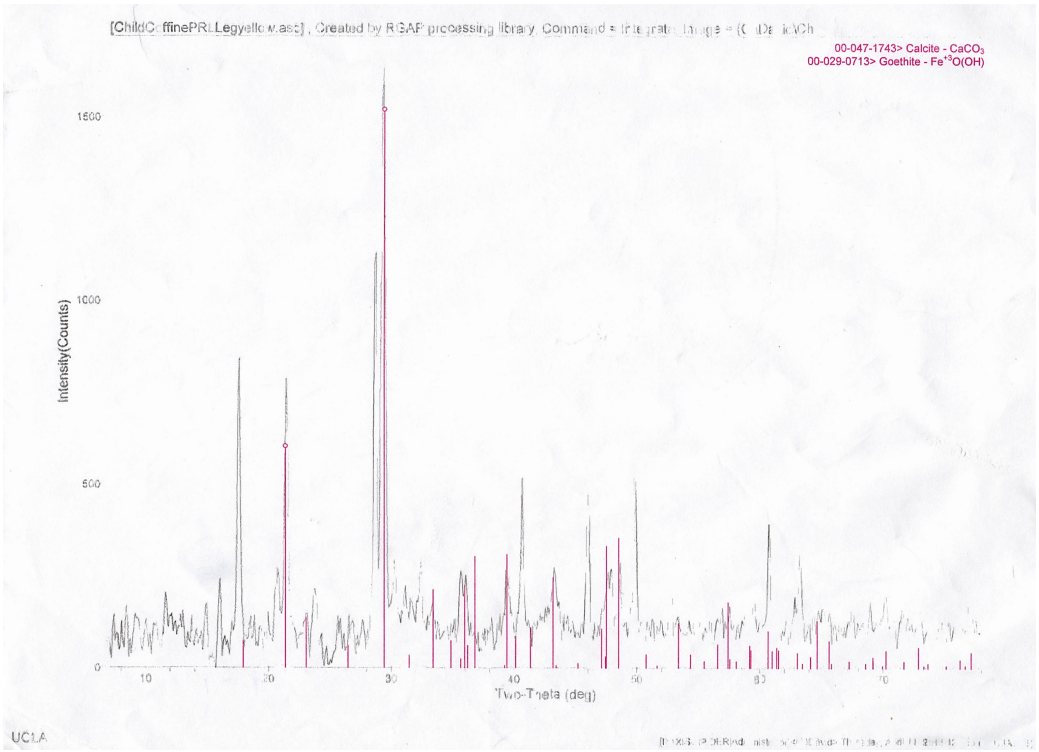
a. Blue sampled from the headband PR Cuprrorivaite is characteristic of Egyptian blue



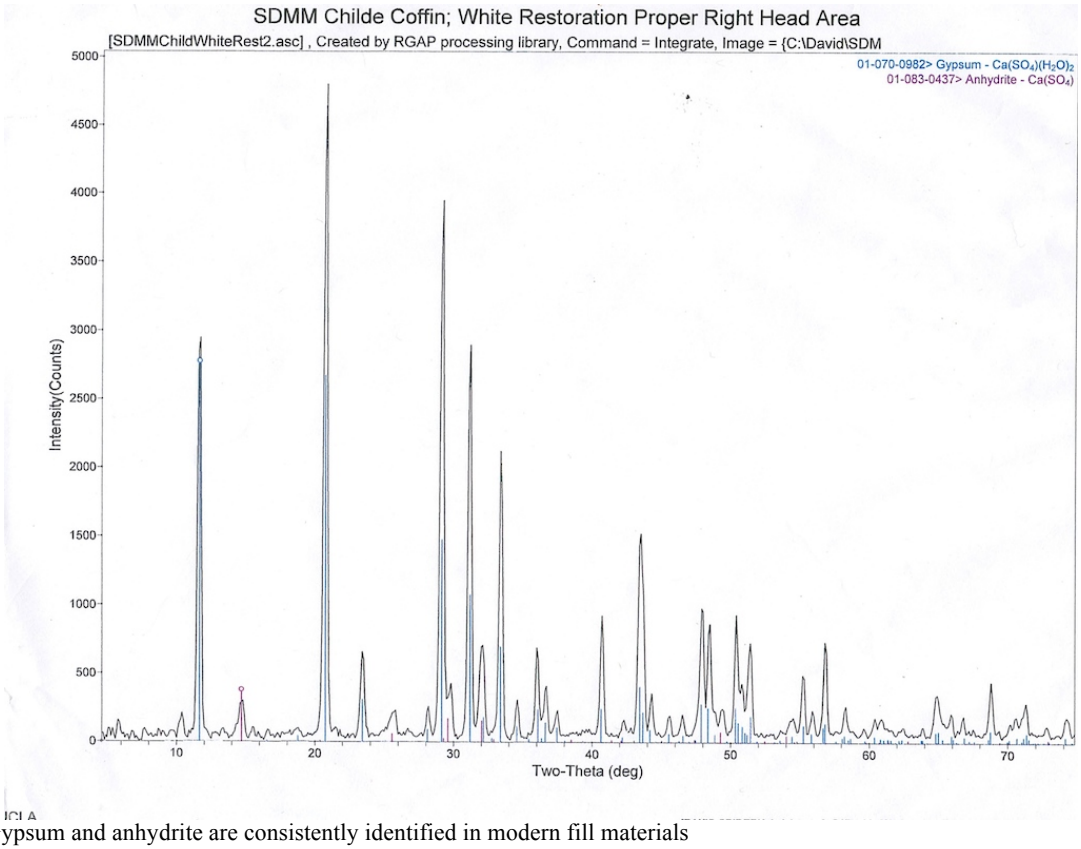
b. Hematite is consistent red ochre. Goethite is also identified in the yellow on the sides of the coffin. Quartz, calcite, and gypsum have been consistently identifies in the ancient gesso.



c. Realgar is found only on the under-layer of paint on the foot-block.



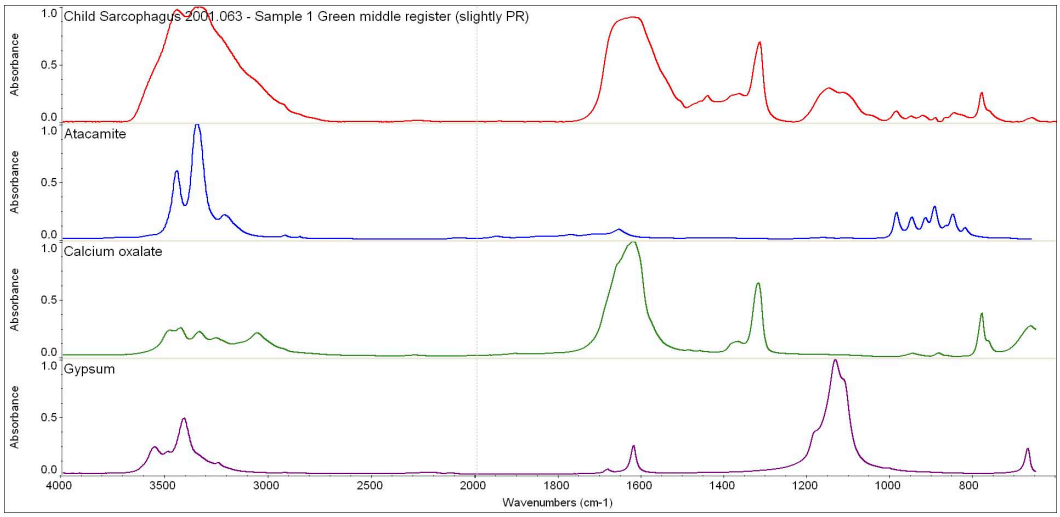
d. Goethite is the yellow paint on the sides of the coffin

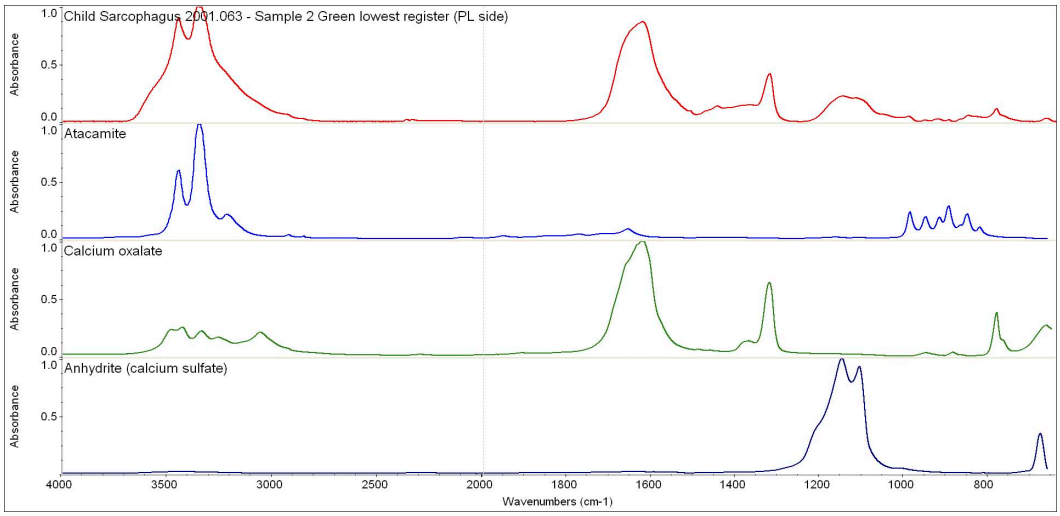


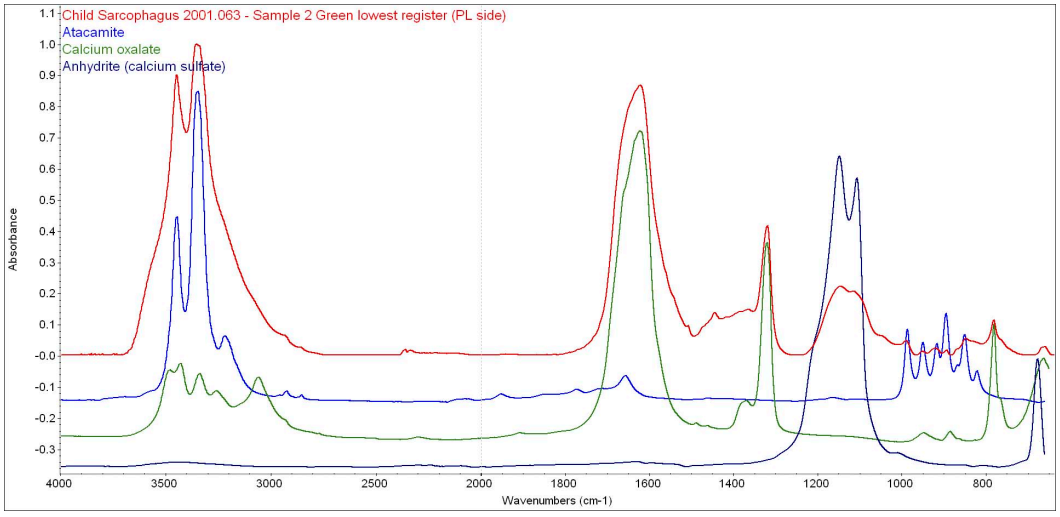
e. Gypsum and anhydrite are consistently identified in modern fill materials

Appendix VII. **FTIR Analysis**

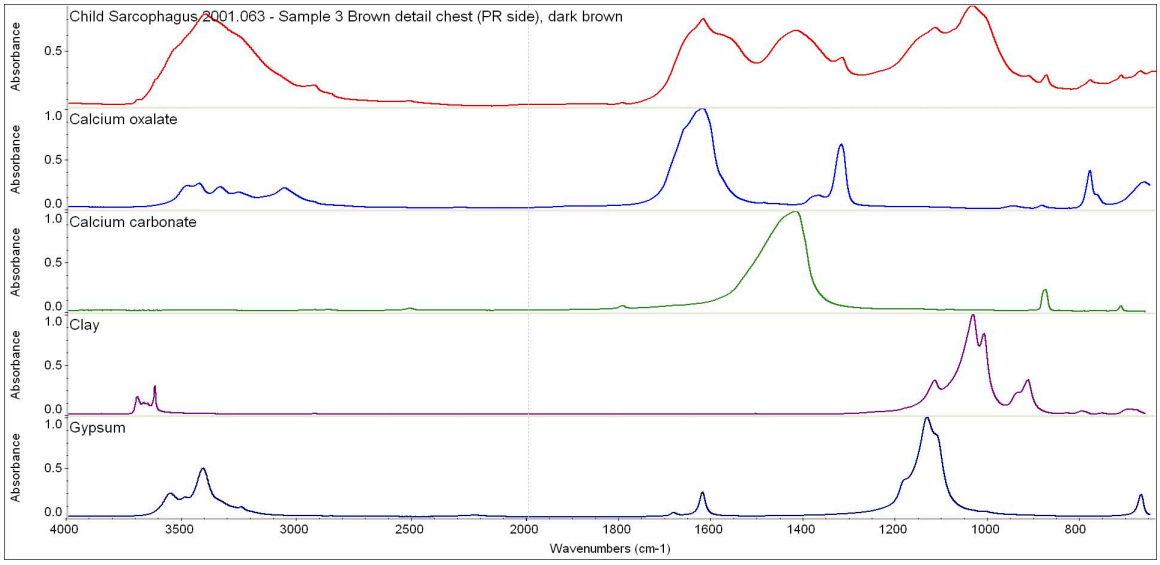
a. Analysis of green samples 1 (t) and 2 (m,l)



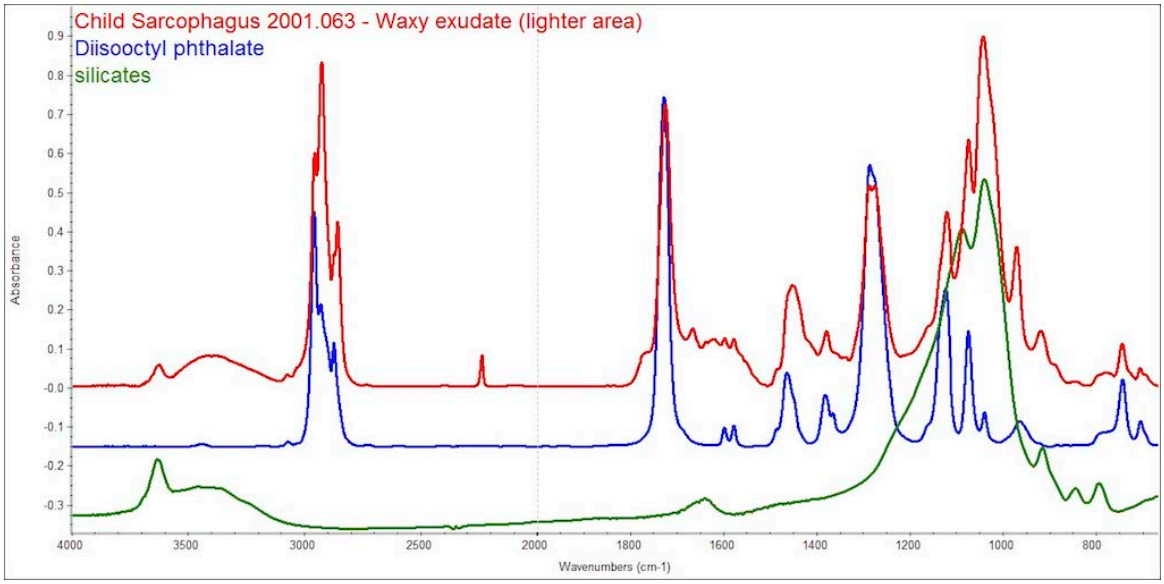




b. Brown deteriorated material

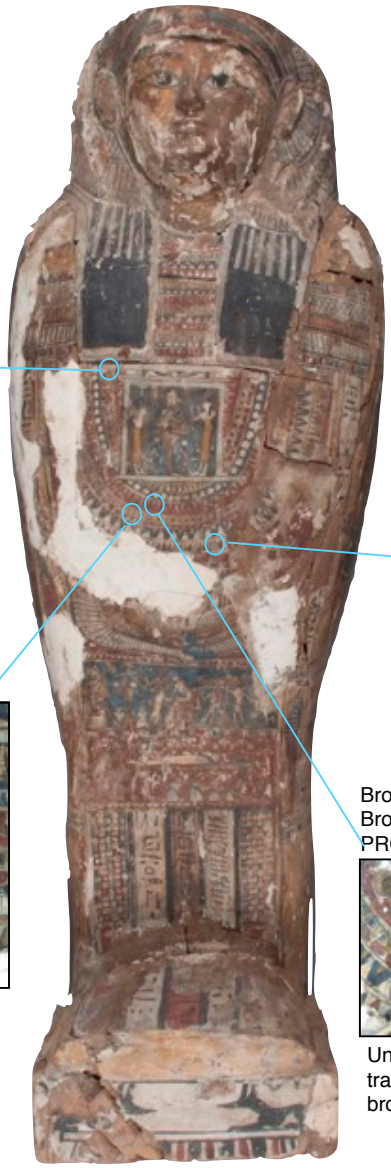


c. Exudates, PR side of the lower vignette



d. FTIR Sample locations

Casey Mallinckrodt cmallinckrodt@ucla.edu
Samples for FTIR/Herant Khanjian GCI 5.15. 2013
Child Sarcophagus San Diego Museum of Man 2001_063
1. Green. Green Middle Register (Slightly PR)
2. Green. Green Lowest Register Chest (PL)
3. 3. Brown. Single Register Center Chest Slightly PR
4. Green Cross section



Cross Section **#4**
1st Register near image
PR top element



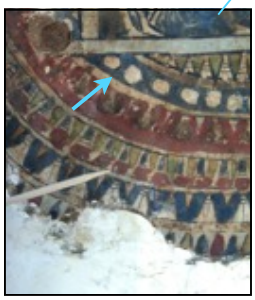
Possible green earth. May include or be a mix of Egyptian green, E. Blue, and orpiment.

Green_Pectoral **#2**
Green Lowest Register/
PL Side



Possibly deteriorated Malachite? This was David Scotts suggestion from PLM

Green_Pectoral **#1**
Green Middle Register/
PR Side



Appears to be similar to the green in the cross section (#4)

Brown_Pectoral **#3**
Brown Detail Chest/
PRCntr



Unknown semi translucent, resinous brown.

Appendix IX. **GC-MS Analysis Summary** The report *is attached as a supplementary document*

THE GETTY

CONSERVATION INSTITUTE

SCIENTIFIC PROGRAM: ORGANIC ANALYSIS LABORATORY

Object Descriptions:	Polychrome sarcophagus, Egypt 320 BC.
Prepared for:	Casey Mallinckrodt, UCLA/Getty Conservation of Ethnographic and Archaeological Materials
Scientist:	Joy Mazurek
Date:	May 13, 2013

ANALYSIS REPORT

Samples

Casey Mallinckrodt requested a technical examination of the organic material present in six samples. They were analyzed by gas chromatography with mass spectrometry (GC-MS). The three samples tested were: 1) 2001.063 11.19 waxy exudates center of leg; 2) Coating top of under layer of polychrome foot 2-28 4/1; 3) 2.4 sample resin PR shoulder; 4) Front foot upper layer 2001.063 4.2.13; 5) 2001.063 PR Top of Head Brown and Black; 6) 2.26 Gesso under layer foot

Techniques

The samples were analyzed for plant gums (carbohydrates), proteins (amino acids), and oils (fatty acids), waxes (hydrocarbons) and resins. Samples were first treated with chloroform for analysis of waxes, followed by MethPrep II for the analysis of oils (fatty acids) and resins, and subsequently prepared and analyzed for proteins (see descriptions of sample preparation at the end of the report). A separate sample was analyzed for carbohydrates. Appended to this report are copies of all pertinent reference information, such as gas chromatograms and GC-MS data evaluation forms. The identification of proteins by GC/MS is achieved by comparing the amino acids (building blocks of proteins) of each sample to those of standard reference materials, using the method of correlation coefficients. A perfect match is a correlation coefficient of 1.0, but for most samples an acceptable match is 0.93.

Analytical Results

The table below summarizes the analytical results. No resins (tree resins), oils (fats and drying oils) or waxes (beeswax, paraffin) were detected in any of the samples tested. Sample 1 (waxy exudates) is a modern material, mainly composed of a phthalate that closely matches n-Octyl

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phthalate; it also contains lesser amounts of N, N-octadecylamine, ethylhexyl maleate. Sample 2 (coating) contains 13% carbohydrates that match several different types of plant gums, however the plant gum most readily available in Egypt is Acacia sp. and is the likely source of gum (0.99 corr. coef.). Sample 3 (resin) contains animal glue. Sample 4 (front foot) contains 0.11% animal glue and 0.45% plant gum (probably Acacia sp. Gum). Sample 5 (PR top of Head black and brown) contains 0.37% animal glue and 0.7% carbohydrates (does not match plant gum). Sample 6 (Gesso) contains 0.75% animal glue and 1% plant gum with 5% glucose (starch perhaps).

Table 1. Summary of Analytical Results

Sample	Wax/Oil/Resin	Carbohydrates	Amino acids
1) Waxy Exudates	Main component is phthalate (n-Octyl phthalate). N, N-octadecylamine, ethylhexyl maleate	No Carbohydrates	No Proteins
2) Coating top of under layer polychrome foot	No Waxes, Oils or Resins	13% carbohydrates, matches many gums and Acacia gum (0.996 corr. coef)	No Proteins
3) Resin PR shoulder	No Waxes, Oils or Resins	3.8% carbohydrates, no match to plant gum	52% amino acids, matches animal glue (0.97 corr. coef.)
4) Front foot upper layer	No Waxes, Oils or Resins	0.45% carbohydrates, matches many gums and Acacia gum (0.994 corr. coef)	0.11% amino acids, matches animal glue (0.99 corr. coef.)
5) PR Top of Head Brown/Black	No Waxes, Oils or Resins	0.7% carbohydrates, no match to plant gum	0.37% amino acids, matches animal glue (0.97 corr. coef.)
6) Gesso under layer foot	No Waxes, Oils or Resins	6% Carbohydrates, matches plant gum (1%) with glucose (5%)	0.75% amino acids, matches animal glue (0.96 corr. coef.)

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Appendix X. Condition *Summary*

Ptolemaic Child's Sarcophagus San Diego Museum of Man 2001.063.0006

Culture
Ptolemaic period 350-30 BC, Northern Egypt

Dimensions
Length: 129.5cm (51")
Width at head: 32.5 cm (12 ¾")
Width at shoulder: 46.0cm (18")
Width at leg: 31.0cm (12 ¼ ")
Width of base: 33.0cm (13")
Height at face: 27.0 cm (10 5/8")
Height at chest (lappets): 21.75 cm (8 ½ ")
Height of Base: 24.0cm (9 ½ ") 28.5cm including the mortise projecting from the rim.
Thickness at back edge: between 6.25 and 7.2cm or 2 ½ and 2 5/8 inches
Weight: ~18 kg (40 lb)

Materials
Ancient
Wood, clay based compensation material, brown granular paste with plant fiber inclusions, textile (linen), binding medium, gesso, mineral pigments, Egyptian Blue pigment,
Modern
Metal hardware, polymer adhesive, paint, as yet unidentified coating materials, plaster, and plaster with additives

Owner
San Diego Museum of Man, gift from Martin and Maria Paul
Accession Number
2001.063

Date
October 1, 2012/October 26, 2013

Conservator
Casey Mallinckrodt, UCLA/Getty Conservation MA Program

Structure

The base structure is complete with some minor losses. The wood is largely robust with localized areas of deterioration from rot and prior insect infestation. There are areas of separation of joins between wood pieces and subsequent deformation or breakage of the surface layer. The interior surface is intact. There is insect damage from prior infestations.

This section describes changes to the object from deterioration or intervention and defines risks.

Losses

Some losses have been detailed above in the description of the structure and are summarized here.

- The PL side and front of the base structure at the bottom of the "leg" have been removed to accommodate the foot-block.
- The compensation materials and coatings have been lost and are actively deteriorating from the joint between the foot-block and the base structure. Metal hardware maintains the attachment.
- All but the bottom PR mortise have been lost or are broken off at the wood surface.
- Two contiguous shaped pieces of wood (2-H) and (3-H) were added in antiquity at the top the head. 2-H covers and compensates for void between face block and the base structure. Both cover and compensate for irregular and deteriorated wood. 3-H is cracked with the grain and the sections are mobile but secure.

On the PL side of the back edge of the head there are two naturally occurring losses in the wood. The loss on the PL is irregularly shaped deep. The second roughly rectangular loss is 2.0 cm to the right (as viewed) of the loss described above. It continues through the wood to the interior. Fill material in the PL gap is believed to be residue of ancient compensation materials that provided a substrate for the paint layer. Fragments of the paint layer are attached to the wood around these gaps

There is a loss associated with two parallel 2.0 cm saw cuts on the PR side of the head block approximately 3.0cm from the top of the head next to the wood wedge fill (4-H). The cuts

are on the horizontal axis of the object and continue behind the adjacent wood wedge. There are no associated marks on the wedge that would indicate they were made after construction.

The foot end of the long wood piece (7-T) attached to the PL side has a large splinter loss along the object edge (3.5 cm x 1.0 cm) and two cm of the end of the piece have been cut off with a chisel. There are associated chisel marks and accretions of a beige dried paste that was applied as a fill and an adhesive.

Cuts and Gouges

There are chisel marks on along the edge on both the PL and PR sides. These all roughly the same size and width suggesting they were made with the same tool. There are six chisel gouges near the cut on the PL discussed above. Three of these are angled and three perpendicular to the edge. One of the gouges extends under the remaining wood. Two are in the area previously covered by wood and a <1.0 cm wide piece of the wood surface has been lost between them.

There are two parallel chisel gouges higher on PL side. These bisect the uppermost reclining mummy figure. There are two chisel gouges on the PR side associated with a crack at the transition from the leg to the widening of the torso.

There is a straight horizontal cut across the torso that runs along the bottom edge of the lappets and extends from 3.0 cm the PR lap to 7.5 cm outside the PL lappet. The cause and date of the cut are unknown but the precision of the cut and absence of saw marks suggest it is modern.

Loose Elements

As noted above, the attached wood piece on the PR top of the head (2-H) is cracked with the grain, parallel to the edge of the object. The fragments remain attached with dowels but are loose.

There is a moving piece of wood on the PR side of the head at the shoulder. It appears to be part of a knot. There is white residue of fill material in the knot that has not been analyzed. The small piece of wood on the PL side of the foot-block, 14-F, is loose but attached.

Cracks and distortion

There are extensive small cracks and gaps that are the result of predicted deterioration of the ancient wood, and also that result from handling.

There is a crack on the upper chest from the outside edge of the PR lappet to the top interior edge of the PL lappet along the line where the neck and top of the garment meet. This follows the bottom edge of the face-block (1-F) and the upper edge of the panel on the chest (6-T).

Lifting of this panel (6-T) on the chest has resulted in cracks and losses of the paint layer that extend along the PR side, PL side and the bottom edge now obscured by white plaster compensation material. Cracks in this white material are evidence of continued movement of this panel and need to stabilize the artifact with a permanent secondary mount.

The wood pieces applied to the PL side are slightly misaligned from separation of the elements. A gap between the long segment 7-T on the PL side, and the base structure can be observed from the reverse of the object and in x-ray images. There is a step at join between segments 10-T and 11-T on the PL.

There is a diagonal crack on the PR side extending from a chisel mark at the edge approximately 38.0 cm or15 inches from the bottom of the foot-block in a ~45^0 angle toward the head. The crack transects the adjacent mummy figure, the text panel in front of the figure, and terminating in the figure of the forward mummy figure.

There is a blind crack at the bottom center of the base structure visible on the exterior and interior surfaces. The crack emanates from a shallow empty dowel hole that was cut off at an angle with the removed section of the bases structure.

Deterioration

An area of loss and deterioration on the PL side of the face-block that extends from the top of the head to the neck below the chin is visible in x-ray images. A radio-opaque modern fill

material below the ear obstructs this area but is consistent with a gap and a modern intervention that is visible on the surface.

Insect damage

There is evidence of prior infestation by four types of insect characterized by differences in the dimensions of the tunnels and exit holes. There is no evidence of an active infestation. The object underwent a pesticide treatment at the SDMM since accession but there is no record of the exact date or pesticide that was used. The presence of bromine in XRF analysis may be residue of this treatment although further analysis is required for an accurate identification.

X-ray images indicate that the largest of these tunnels are elongated and irregularly curved ovals and bands with a thin line of radio-opacity along the edges. A few of these areas appear to have material in them that is more radio opaque than the surrounding wood. These tunnels are concentrated in the head block with individual insect tunnels identifiable under the corner of the PR forehead, eye, and the side of nose and PL cheek and there is a significant directional concentration that emanates from a loss area parallel to the PL ear. These tunnels are notably are absent from the wood of the base structure that is in immediate contact. There is a small group of tunnels in the PR shoulder and two isolated examples along the PL side of the torso.

The x-ray image shows that the PL edge of the face block is irregular from deterioration and the thin radio-opaque edge of this loss, located within that concentration suggests these are the remains of insect tunnels. Observed macroscopically the polychrome is missing below the ear (toward the chest) and the distinct gap between the head block and the wood of the PL side is visible, but there is no evidence of deformity to the wood.

Frass had accumulated under the object when on display at SDMM concentrated on the PL side and the head along the edge at gaps between the base structure and the added elements. No insect body parts were present. Entymologist Carl Olson, at Arizona State University was consulted in the summer of 2012. He was not able to make a definitive identification based on the

frass but expressed the strong opinion that it was produced by crickets or German cockroaches, which are not damaging to wood and he suggested that the frass may have been loosened by occasional seismic tremors.

Insect exit holes that are consistent in size and orientation to those of powder post beetle larvae are visible on the interior and exterior surfaces concentrated in the middle of the upper and lower image panels, and dispersed over the surface of the torso.

Extensive Insect tunnels are clearly visible in fill material in a gap in the bottom middle front surface of the foot-block. These tunnels are half the diameter of the large tunnels in the head, and are randomly interlaced. The material is stable, and appears to have been consolidated.

None of the infecting species has been indentified definitively at this time.

Surface

Numerous modern interventions have significantly impacted the surface, and together with the inherent deterioration of two thousand year old materials have created a complex landscape with highly varied strengths and vulnerabilities. The surface is comprised of the ancient paint layer, over-layers of gesso and paint, over-paint, modern restorations and compensation materials, coatings, accretions, polymer exudates, staining, and dirt. This section describes areas of risk to the surface.

Interior Surface

There is no current risk to the interior from material deterioration or prior interventions. The interior surface was abraded slightly by the mount at contact points. There is some light accretion of plaster along the edge.

Exterior Surface

There is extensive loss of the ancient paint layer on all parts of the sarcophagus. There is active loss and the ancient paint surface is at high and immediate risk. The losses are the result of movement of the added wood components, impacts, fragility of the paint layer and loss of adhesion in the substrate. There are several areas of discoloration of the paint surface. Some of

these are tide lines or discoloration caused by the coatings, and some are the result of accumulated dirt and grime. Droplet stains on the PL side are discussed above in this section.

Deterioration of the brown grainy substrate layer has caused significant loss of adhesion of the paint layer to the wood surface. In areas where this material has been exposed by recent losses, the reduction of volume and cohesiveness is evident. The face does not have an observable substrate of this material.

The gesso layer on all areas except the face is very thin (<1.5mm) and it has also lost volume and strength. The combined effects of weakening in the substrate have resulted in a barely attached surface layer of paint.

The gesso layer on the face is appreciably thicker (>1.5 mm) and somewhat more robust although large areas of the surface layer have been lost. The modern coating on the face is obstructive of the ancient paint but may have had a consolidating effect.

The ancient paint layer is very weak and brittle. Areas that have been over-painted red to compensate for extensive failure of the ancient red are cracked and cupped. The most at risk areas of the brittle paint surface can be further described as either intact but not adhered, or as areas of unsupported paint layer. The unsupported paint includes lifted chips, tented chips, or paint bridges over eroded gesso. The ancient and modern surface layers are described in greater depth in the text of the thesis.

Several factors suggest there has been water damage to the PL side of the object. There are droplet stains along the PL side of the body from the feathered pattern on the side of the head to the lower torso. The uppermost text panel appears pale and some of the characters to have been repainted. The yellow paint at on the PL side near the foot is considerably more fragile than its counterpart on the PR side.

Parts of the face and the lower image panels have been heavily coated resulting in cracks and cupping of the paint and gesso. The uneven application of the coating to the face has resulted in distinct differences in the strength of the paint layer within very small areas. For example on

the PL side of the nose the surface is both highly powdery fragile and it is stiff and inflexible. The powdery area can be observed as darker in UV images.

In addition to cracking and cupping there are extensive chip losses to the paint in the lower image panels. This has been caused by the coating and by the red over-paint. There are insect exit holes concentrated in the center of the two lower image panels resulting in weakening and loss of the surface.

The types of red paint have been described in the thesis text. The ancient red is lost except for the outlines of the details where the binder would have concentrated while drying. The ancient red has been over-painted extensively and roughly with a red paint and this over-paint, as noted in the above paragraph, has caused lifting and cupping. It is also applied over blue and green ancient paint.

On the PR shoulder near the edge there is a cluster of white blooms visible in UV light. These range in size from 1.0 to 2.0 cm. On the band of gray over-paint that extends along the angle of the shoulder to the head there is an area 2.7 cm long of fine dark yellow-brown spots.

On the PL side of the head, observed in UV light, there are black specs dispersed over the feather pattering and there is a soft edged vertical black band that extends from the upper half of the ear to approximately 2 to 3 cm above the edge. This bisects the messy black over-paint described in the section on prior interventions, but this material is not observed in visible light.

There is saturated stain at the attachment of the foot-block to the base structure. It is approximately 20.0 cm in diameter and extends onto both components.

Several areas of white bloom on the PL side of the face on above the PR eye were tested and found to be chloride salts. Sustained high humidity might cause the migration of salts from the substrate into the wood and ancient paint layers, but this is not a current concern.

Compensation materials

Overlap of compensation materials over the ancient paint layer poses an immediate risk to the obscured paint. This material has not was applied over the edges of the ancient paint

removal in these areas will pose a risk of further loss to the ancient paint layer. There are four types of compensation material on the torso and head, and there is active loss to all of them posing the risk of further loss of the ancient paint layer. The polymer components of the pink and gray plasters on the torso pose the risk of deterioration and migration into the wood and ancient paint layer.

Two types of modern coatings have been identified. On coating is an extensive application of animal glue. The other is an unknown resin identified by the emergence of exudates on the object surface. The dates and chronology of their application is unknown

Accretions

The emergence of the plasticizer and copolymer as exudates is likely to accelerate as the deterioration of the polymer that was applied to the surface continues to deteriorate. Further research is required to determine the effects of these two phases on the wood and ancient paint, and what conditions would reduce any impacts to the object.

The accretion on the PL shoulder, lips and chin, and the discoloration on the shoulder associated with this are visually disruptive. The material is loosely bound together, but it is firmly adhered to the paint layer. Solvency tests have demonstrated that the binder for this material is soluble in acetone.

There is a dark brown accretion of soil, pebbles, and dust at the base of the neck that is adhered to and obstructing the paint layer. This has been examined under low magnification and includes fine particles of the face paint layer but there are no observable chips.

Appendix XI. **Treatment Proposal** *Summary*

The treatment goals for this object are stabilization, both short and long term, and visual cohesiveness. Essential stabilization has taken place. The proposed future treatment has two phases. The initially phase will continue the stabilization of the surface areas, and extend removable adjustments of the white plaster.

The second phase would involve a comprehensive assessment of the relationship between surface loss and structural movement, and will consider the viability of the restorations and over-paint.

Any interventions undertaken or proposed are guided by a primary goal of sustaining the object, emphasizing minimal intervention, preventative conservation, and the use of materials that have meet conservation standards as archival. Treatments of ancient materials are intended to be durable, without requiring removal or retreatment, but also reversible or re-treatable without causing loss or damage to the ancient materials. There is no proposed removal of ancient material, or of existing painted restorations. Were a proposal to advocate the removal of material the need to do would be justified to explain how it is either actively or potentially causing harm to the ancient materials. All aspects of this project endeavor to adhere to the ethics and standards of the American Institute of Conservators.

Treatment Proposal Summary

There are two proposed treatment phases. The initially phase will continue the stabilization of brittle surface areas, and interventions to reverse the cupping on the face and the image panels. AYAF will be used.

The cracked and cupping paint will be relaxed and secured into place with Isinglass (sturgeon glue). In this process glue is applied on the underside of individual lifted chips, which are then gradually rolled onto the surface. In concentrated areas of low cupping thin directional Japanese tissue paper will be applied over the area, brushed with fish glue and allowed to dry completely. To remove the paper, the entire application is brushed with de-ionized water and gently pulled off just as the surface glue solubilizes but before the water penetrates the paint layer.

Toned Japanese tissue paper masks, or other masking system, would be created for the loss areas of the face. Masking the white plaster fills on the torso has successfully reduced the visual impact of those areas but has also redirected the viewers attention to losses on the face.

This phase will involve removing the white plaster fill materials. This is a staged process involving the following procedures.

- Removal of the existing paper fills

- The mechanical removal, or reduction, of plaster that is overlapping the ancient paint surface
- Removal of plaster with acetone soluble pink and gray layers
- Removal of plaster that currently has a structural role. These are the long panels attached to both the PR (5-T) and PL (7-t) sides and the panel on the chest (#6). This process could put the object and paint layer at greater risk and cause considerable damage. For this reason it needs to be done incrementally, and it must be possible to stop the treatment and restore the object to the most secure configuration.
- Reduction of white plaster residue from the wood surface.

The gallery conditions should be monitored for temperature and relative humidity. The object should be monitored for changes. Emergence of exudates should be documented and the potential for damage from these materials researched.

The second phase would involve a comprehensive assessment of the relationship between surface loss and structural movement. This will be facilitated by information about the structure resulting from the removal of the large white plaster areas as discussed above.

Movement of the structural components and fragility of the surface materials are the two greatest risks to the continuity of the object. The paint and substrate layers can be consolidated. There is a need to assess the movement and consider the best long-term method of preserving the ancient materials.

The second phase will also consider the impact of areas of over-paint that is obscuring ancient paint, and of the restorations.

Appendix XII. Treatment Report *Summary*

Interventions have taken place to allow the object to be transported, to be safely handled and to address active deterioration and high-risk conditions.

Two site visits were made to determine the risk to the object during transportation from San Diego to Malibu in September 2012. The decision made to support and consolidate fragile surface areas at the SDMM prior to moving the object, and a crate was designed to safely transport the object. It included a secure permanent mount that would allow the object to be handled during analysis with minimal impact.

The surface was supported with folded or rolled threads of Japanese tissue paper without an adhesive wherever a physical support would be adequate, for example under slightly lifted and bridged paint, and in gaps resulting from loss of the gesso layer. By securing these areas for transportation a more considered long-term solution could be devised and carried out in the Getty Villa conservation lab if needed.

AYAF polyvinyl acetate resin in acetone was chosen if adhesion or consolidation was needed because it is soluble in organic solvents that would not damage the water-based paint layer. AYAF provides strong adhesion but retains some flexibility, has good aging properties and is easy to handle. The goal was minimal intervention to assure stability to travel. The treatment was done in a small poorly lit storage area immediately off the exhibition space, requiring that the intervention be efficient and manageable. Conservation ethics (CITE) direct treatments to be reversible or re-treatable. Although this adhesive could not be entirely removed he intervention was undertaken out of the necessity to secure the paint layer from further damage.

The support and crate were designed with Ken Bordwell, exhibitions preparatory at the SDMM. Ken built the crate and among his improvements were the addition of a lightweight Coroplast® cover, hinged on a long side, that would serve as a dust and light protection for the object. This proved to be an invaluable addition for the intended protection, but it also served as the support for a microclimate to control the relative humidity during season variations, especially, drops associated with the Santa Anna winds in southern California. Conditioned silica gel was placed with the sarcophagus inside the Coroplast® cover and it was enclosed in polyethylene sheet.

During the months that the sarcophagus was at the UCLA Student Conservation Lab at the Getty Villa some selected interventions were undertaken. The approval of the museum leadership was acquired before taking action. The extreme vulnerability of the surface was the primary concern. Exploration of methods to be used in future treatment was a secondary goal, and surface modifications to create more visual cohesiveness was a third goal.

The surface was selectively consolidated and losses were re-attached primarily using AYAF. A 5% solution was used for consolidation and a 15% or 20% solution used to adhere. This material was very successful in the preparatory consolidation carried out in San Diego in September of 2012, and it was desirable to limit the number of new materials added to the already complex surface.

In areas where the paint layer was lifted from the surface both the substrate and the paint chip were first consolidated. The paint layer was then humidified to relax the paint layer onto the wood surface before adhering it to the wood. A small slightly damp polyethylene sponge wrapped in slightly permeable material Goretex® was placed adjacent to but not initially touching the chip. As the paint layer relaxed the wrapped sponge was moved to press it gently to the surface.

The extreme fragility of the paint on the PL side of the nose required an alternative method of intervention. An ultrasonic mister was used to apply Klucel G® (hydroxypropyl cellulose) in ethanol at a concentration of slightly less than 1.0%.

The treatment proposal calls for the removal, or reduction, of the compensation materials and accretions. Removal techniques were tested on small areas to establish methods for future treatment, and to evaluate the potential risk to the object from the treatment. These interventions are described in detail in the attached document.

Removal of the extensive plaster fills was tested on the PR and PL shoulders and a larger area of plaster was removed from the center area around the small double layer of polychrome. This was done to better preserve the double layer of ancient polychrome and it provided the opportunity to explore the removal of larger sections of plaster, the removal of the pink and gray plaster materials, and to better understand the wood structures in this area.

The pink plaster “blob” on the PL front of the foot was removed. This was unsightly, potentially damaging to the wood, and provided the opportunity to remove a somewhat larger area of the plaster with a polymer component. The material was removed mechanically with a #11 scalpel to the extent possible. Arbocel® poultices of acetone where applied to the remaining accreted material to dissolve the wick out the resin phase, and allowed to dry. After one or two treatments it was possible to remove the remaining plaster with a somewhat stiff brush.

Mechanical methods of removing the white accretion on the PR shoulder and face were explored and used to selectively reduce the accretions on the face. A #15 scalpel was effective in cutting away most of the accretion. It is firmly attached to the paint layer and the use of solvents would have risked propelling the adhesive into the paint layer and discoloring it. Alternative methods of removing this material need to be explored.

Toned Japanese tissue paper masks were applied to large areas of white plaster including the area on the chest described above paragraph, and a moving plaster element on the top of the head. The paper was toned with water soluble gouache paints and applied to the edges of the plaster areas with AYAF. These can be removed very easily and quickly using acetone to re-solubilize the adhesive.

The small doubly polychrome layer in the center of the torso was treated to reduce risk to the material. The modern plaster abutting and partially overlapping this area of double polychrome was reduced. A removable protecting support of Japanese tissue paper was adhered in place with acryloid B-72 to stabilize the area from movement.

The plaster compensation material on the front center of the lower torso was partially removed to explore the condition of the substrate the effectiveness of mechanical removal. Toned tissue paper masks were applied over area.

Materials

All conservation materials are available from Talas.com

Acryloid B-72	Methylmethacrylate copolymer Rohm Haas
Arbocel®	Cellulose fiber J.Rettenmaier & Sohne Rosenberg, Germany
AYAF Adhesive	Thermoplastic polyvinyl acetate resin Union Carbide
Glass micro-balloons	3M
Gortex	Polytetrafloroethylene (PTFE)
Gouche paint (toned tissue paper)	Windsor Newton
Isinglass	Sturgeon Glue
Japanese Tissue Paper	
Klucel G®	Hydroxypropyl cellulose
MQuant™ MerckMillipore colorometric spot test strips	merkmillipore.com

XIII. **Poster**

First Vatican Coffin Conference, Vatican Museum, Rome Italy June 19-22, 2013

Pigment Analysis of a Ptolemaic Sarcophagus Lid
as an Aid to Identifying Re-purposed Components

Catherine Mallinckrodt UCLA/Getty Program in the Conservation of Archaeological and Ethnographic Materials MA 2014

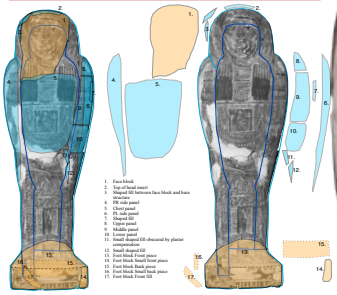
The Getty Conservation Institute

UCLA

ABSTRACT

There is significant evidence of ancient reuse of structural components in Egyptian sarcophagi and coffins. Since the rediscovery of ancient Egyptian tombs in the 18th century, waves of "Egyptomania" have motivated repurposing and joining of unrelated components to meet the demands of the antiquities market.

The technical analysis of a Ptolemaic sarcophagus lid was undertaken as a master's degree thesis in conservation. Pigment identification was explored as an aid in distinguishing both ancient and modern repurposing of structural components.





EVIDENCE OF REUSE

The **Face-Block**: Ancient Reuse

- Egyptologists consulted for the project suggest ancient reuse of the face block based upon style.
- Application of the face paint is unique on the object:
  - A thick obscuring coating over the paint
  - Absence of the brown granular gesso substrate present on all other parts of the object
- X-ray imaging and direct observation show the face block does not contour to the base structure. Wood and plaster fills were used to integrate it into the whole.
- X-ray imaging shows significantly more insect damage than in the adjacent components

The **Foot-Block** Modern Reuse

- Visually discordant size and decorative elements
- Presence of two gesso and paint layers is unique on the object
- The under-layer of polychrome is ancient
- Residues of the over-layer of polychrome are evident on other areas on exposed wood and extending over the ancient paint layer.
- The components are pieced and joined with a poly vinyl acetate emulsion and attached with this adhesive and modern metal screws
- The back section has been cut from another sarcophagus
- The sarcophagus leg has been partially cut off and the foot block is roughly fit to the loss
- Residue of multiple campaigns of failed compensation materials at the join to the leg

INTERVENTIONS

- Modern restorations comprise approximately 6% of the surface.
- Visually disruptive areas of plaster compensation are present over approximately 15% of the surface.
- Anhydrite, a component of modern gypsum plaster, is identified by XRD and PLM in all samples. Restorations and compensation materials and are visually distinct viewed in UV light. Both extend over exposed wood and some areas of the ancient paint layer.
- GC/MS (Gas Chromatography/Mass Spectrometry) identified a modern protein-based animal glue coating over most of the surface, and phtalate plasticizer exudates from an unidentified modern coating.

ANALYTIC METHODS

Non-destructive analysis

μ-XRF Portable X-ray Fluorescence Spectrometry

Destructive analysis

XRD Debye-Scherrer Powder X-ray Diffraction
PLM Polarized Light Microscopy
FTIR Fourier Transform Infrared Spectrometry

Non-destructive forensic imaging techniques

VILS Visible Induced Infrared fluorescence diagnostic fluorescence of Egyptian blue in the 800-900nm range of the infrared stimulated with visible light in the 500-600nm range
IR Infrared reflectance imaging
UV Ultraviolet Induced Visible Fluorescence (365nm)
X-ray X-radiography

Abbreviations are used in the chart to indicate effective analytic methods. Bold letters indicate greater effectiveness.

Approximately seventy pXRF analyses were carried out to acquire consistent results for all distinct color areas. Dispersion samples for microscopic analysis were made of each color including black. Cross-section samples were made as needed. Fragmentary losses of the paint surface were used whenever possible to minimize sampling.



Insect tunnels concentrated in the face block are absent from adjacent areas of wood.



Face block, profile



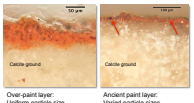
(L) Egyptian Blue imaged with VILS. Fluorescence of a deteriorated Egyptian blue layer on the PL lappet, now obscured with black paint is framed in red.



Egyptian Blue Particles PLM 200x

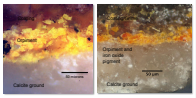


Green sample location framed in red. The arrow indicates discoloration characteristic of the green design elements.



Over-paint layer: Uniform particle size

Ancient paint layer: Varied particle sizes

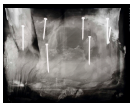


Face: PL side

Top of foot: under-layer of polychrome



Thin application of orpiment creates the pale yellow background of the feather patterns. (R)



X-ray image identifies modern metal hardware attachment of the foot block to the leg.



Figures in black on foot



White layer on calcite ground



Deteriorated organic colorant

RESULTS

The colors and pigments used on the lid, and methods of application are consistent with documentation of the Ptolemaic period. The palette of the ancient polychrome is blue, pale blue, green, red, yellow, pale yellow, black and white. Pale blue and the yellow on the under layer of the foot are the only mixed colors. The pale yellow background to feather patterns is the result of a thinner application. All of the ancient colors are mixed with a water-soluble binder.

BLUE

Egyptian blue is the sole source of all the blue coloration on the object. Mixed with calcite it has been applied as a paint to create pale blue hue. Dark and pale blue are present on the head, face-block, torso and the under-layer of foot-block in similar mixtures and applications. Identification of Egyptian blue on the foot block affirms that this structural component is ancient.

COLOR	LOCATION	MAJOR PIGMENT	IDENTIFICATION	METHOD	COMMENT
Blue	Head/Face-block	Egyptian Blue	Cuprorivaite/Calcium Copper Tetrasilicate crystals, $CaCuSi_4O_{10}$, Glass, Residual Quartz	VILS, XRF, XRD, PLM	All methods provide strong evidence
	Torso				
	Foot-block, under-layer				
Pale Blue	Head/Face-block	Egyptian Blue	Cuprorivaite/Calcium Copper Tetrasilicate crystals, $CaCuSi_4O_{10}$, Glass, Residual Quartz	VILS, XRF, PLM	XRD: Calcite overwhelms other materials
	Torso	Calcite	Calcite, $CaCO_3$		
	Foot-Block, under-layer				

GREEN

Green is present only on the torso as small details of the necklace design including a modern application of green in a restoration in the top register of the necklace decoration. XRD and FTIR analysis have identified the presence of a copper chloride hydroxide, atacamite or paratacamite as the green pigment. This may be a deterioration product of malachite known to have been used as a pigment in ancient Egypt. XRF identified the corresponding elements: Cu,Cl, and trace Zn.

Green Torso Only	Necklace details	Possible identification: Deteriorated malachite	Atacamite, $Cu_2(OH)_3Cl$ Paratacamite, $Cu_2(OH)_3Cl$ / $(Cu,Zn)_2(OH)_3Cl$ / Malachite, $Cu(CO_3)(OH)_2$	XRD, FTIR, PLM, (VBF)	XRF: Complex areas and small target spot problematic
	Restoration	[Green earth] modern	Complex	XRF, PLM	Associated with modern RL and graphite underdrawing. PLM: Medium sized vivid green particles

RED

Red is present on all parts of the object in four readily apparent applications: an ancient and largely lost application on the head and torso, a layer over and extending beyond the ancient layer, on the ancient under-layer on the foot, and on the outer polychrome layer of the foot. All reds are identified as the iron oxide pigment red ochre or hematite, and are in water-soluble binders. Microscopic observation of cross section and dispersion samples show differences in the particle size between the more varied and granular ancient layer and the smaller more uniform particles of the red over-paint.

Red	Head	Red Ochre,	Iron Oxide	XRF, PLM	XRF: consistent strong iron peak
	Torso	Hematite	Hematite Fe_2O_3	XRF, XRD, PLM	XRD torso: hematite
	Foot-block, under		Quartz SiO_2	XRF, PLM	PLM particles consistent with hematite and red ochre
	Foot-block, over			XRF, PLM	

YELLOW

Three yellow pigments were identified. The face, details on the chest, and the background of yellow feathers are colored with arsenic sulfide or orpiment. A thick brown coatingon the face obscures the color and the substrate lacks the brown grainy substrate present on all other parts of the object. The yellow details in the necklace design and image panels are an even dull dark yellow. The lighter yellow background color of the wings is the result of a very thin coating of pigment. XRD analysis of the orange on the upper surface of the foot block identified arsenic sulfide, realgar, which is unique on the object. XRF analysis also indicates the presence of iron, possibly indicating a mixture with iron based pigment but this is not corroborated by XRD or PLM analysis and requires further investigation.

Yellow/orange	Face	Orpiment	Arsenic Sulfide As_2S_3	XRF, PLM	XRF: major As peak, sulfur present
	Torso: Image Details, necklace elements	Orpiment	Arsenic Sulfide As_2S_3	XRF, PLM	Similar color and surface XRF: major As peak, sulfur present
	Torso: feather background color	Orpiment	Arsenic Sulfide As_2S_3	XRF, PLM	XRF: major As peak, sulfur present
	Torso: sides	Goethite	Iron Oxide Hydroxide $Fe^{III}O(OH)$	XRF, XRD, PLM	
	Foot-block	Realgar [Goethite]	Arsenic Sulfide As_4S_4	XRF, XRD, PLM	XRF: major As peak, sulfur present, iron present XRD: realgar
			Iron Oxide Hydroxide $\alpha Fe^{III}O(OH)$		

Black was applied to the head and torso as outlines and framing of images and details, and as text. Applications of black associated with restorations are velvety and very dark in IR reflectance imaging. On the foot-block figures are solid black and there are no fine linear elements. Particles consistent with carbon black are evident in microscopic observation of dispersion samples from the foot, torso, lappets, and head. Differences of particle size and shape are inadequate to be diagnostic of different sources or manufacture.

Black paint on lappets is thick and obscures a deteriorated Egyptian blue layer imaged using VILS. XRF indicates manganese is present in the black on the lappets and an area of restoration on the head. XRD analysis identified magnetite, which correlates to modern pigment, possibly Mars black.

Black	Head/Face-block	Carbon black	Carbon C	PLM	
	Torso				
	Foot-block: under				
	Foot-block: over				
	Lappets:	Carbon black, Mars Black	Carbon, C Magnetite Fe_3O_4	XRF, XRD, PLM	Appearance, association with restoration

WHITE

White on the torso is visible as details and areas of background. Two distinct layers were visible in PLM examination of a cross section from a distinct white pigment. XRD analysis identifies calcite in both samples and PLM dispersion samples are indistinguishable. A single layer of white ground creates the overall background color of the outer polychrome layer of the foot.

White	Torso	Calcite	Calcite, $CaCO_3$	XRF, XRD, PLM
	Foot-block	Calcite	Calcite, $CaCO_3$	XRF, XRD, PLM

BROWN/UNKNOWN

A deteriorated organic coloring or toning material is present on the ancient surface of the torso associated with figures and decorative bands and elements. There is no evidence of this surface treatment on either polychrome layer of the foot-block. The use and appearance corresponds to deteriorated resin or varnish.

Brown	organic material	Calcite, chalk $CaCO_3$	FTIR, PLM	Single sample from necklace decoration was analyzed.
	Calcite, (chalk), gypsum, quartz	Gypsum, Calcium sulfate $CaSO_4.2H_2O$ Quartz, SiO_2		

GREY

Grey paint is present on the PL side along the lappet in an area of restoration. XRF analysis identified titanium, which corresponds to components of modern pigments.

Grey	PR Torso only	Unidentified mixture	Titanium	XRF	Appearance, association with restoration, solubility in organic solvent

Note: X-radiography provided diagnostic information indicating the absence of gold as the face colorant contradicting the museum record. Lead white was used during the Ptolemaic period and by modern restorers but is absent from x-ray images.

CONCLUSIONS

Pigment analysis has contributed key information to a comprehensive understanding of this object, and specifically to identifying reuse of structural components.

The presence of Egyptian blue on the under-layer of the foot-block polychrome provides a terminus post quem that establishes it as ancient, and it is the most decisive information about reuse.

The distinction of arsenic sulfide pigments orpiment and realgar by location and method of application support the evidence of reuse of the face-block and the foot-block.

The identification of titanium and magnetite, which are associated with modern paints contributes definitive evidence of modern interventions.

All analysis has contributed to an overall understanding of the object and the history of manufacture, reuse and interventions.

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