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New Research on the Polychromy of an Archaic Grave Stele and Finial in the Form of a Sphinx in the Collection of The Metropolitan Museum of Art, New York

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Abstract

This contribution presents a detailed account of the history of research on the polychromy of an Attic Archaic grave stele in the collection of The Metropolitan Museum of Art (The Met) in New York, including its provenance, conservation and restoration since its initial acquisition by The Met in 1911. New interdisciplinary research on its extensive polychromy allows the identification of a variety of pigments including two varieties of blue, Egyptian blue and azurite, red made from cinnabar as well as red and yellow ocher, and carbon-based black. New evidence on how the paint was applied and the richness of the complex painted decoration enables a better appreciation of this elaborate funerary monument, which was created in the third quarter of the 6th cent. B.C. This research is part of a larger project that contributed to the ‹Chroma: Ancient Sculpture in Color› exhibition in the Greek and Roman Galleries at The Met that was on view from July 2022 through March 2023.

Keywords: Archaic Greek sculpture, polychromy, Sphinx, funerary stele, Attica, painting techniques, pigments, non-invasive spectroscopic techniques, micro-invasive techniques, multiband imaging

Introduction

This paper presents new research into the original colour and decoration of an Archaic grave stele with a sphinx finial (MMA accession number 11.185), which is one of the most extensively painted monuments in the Greek and Roman collections at The Met[1]. These investigations are part of ongoing research that explores sculptural polychromy in The Met's collection.

Building on The Met's long history of studying, documenting, and displaying works of art that preserve their original surface treatments, the research presented in this article stems from a collaboration between four departments in the museum: Greek and Roman Art, Objects Conservation, Scientific Research, and Imaging. The technical methods include 3D scanning, multiband imaging, microscopic examination, and scientific characterization. Our work aims to better understand the material qualities of the polychromy, the manner in which colour enhanced the physical characteristics of the sculpture, and how colour conveyed meaning in specific contexts, specifically ancient funerary contexts in Attica during the 6th cent. B.C.

1 The authors wish to thank the hosts and organizers of the Round Table, in particular Stephan Zink and Frederik Grosser, for the opportunity to present at the symposium, as well as Vinzenz Brinkmann and Ulrike Koch-Brinkmann for numerous conversations about the sculpture.

This research coincided with The Met's development of an exhibition on the polychromy of ancient Greek and Roman sculpture in collaboration with Professor Vinzenz Brinkmann, Head of the Department of Antiquities at the Liebieghaus Skulpturensammlung in Frankfurt/Main, which was on display from July 2022 through March 2023. The ‹*Chroma*: Ancient Sculpture in Color› exhibition highlighted the role of science and scholarship in identifying and interpreting surface treatments on ancient sculpture and explored the function of colour in communicating aesthetic and symbolic meaning within ancient Greek and Roman cultural contexts. The exhibition included a new reconstruction of The Met's sphinx finial created by Brinkmann and his team working in collaboration with our team at The Met. The *Chroma* exhibition also presented a number of Brinkmann's existing reconstructions.

The Stele

The marble funerary stele, which features a youth and a young girl on its central shaft, served as a focal point of the exhibition and our current analytical work (Fig. 1). The stele is the most complete Archaic-period grave monument of its type and it joins with fragments in Berlin and Athens[2]. Standing nearly 14 feet (4.27 m) high, the monument once marked the grave of a youth in Attica[3] and is dated on stylistic grounds to around 530 B.C.[4]. It is comprised of four distinct sections of a grey-white marble with a medium-grain size that likely comes from the quarries at Lakkoi on Paros[5].

The shaft depicts a nude boy standing in profile, holding a pomegranate in his left hand with an aryballos suspended from his wrist. His hair is arranged in a double row of spiral curls over his forehead and hangs in waves down his back, where it ends in another double row of spiral curves at the nape of his neck. A small child, who probably represents his younger sister, stands behind him wearing a long, belted chiton, and a short mantle (epiblema) draped over her shoulders and arms[6]. Also portrayed in profile, she wears a fillet on her head and holds a flower in her left hand. A marble capital, in the form of two double volutes that form the shape of a lyre, rests on the shaft and is crowned by the sphinx, which is delicately carved in the round[7].

The slender relief rests on a projecting rectangular base that preserves parts of an inscription that was painted in red, as indicated by traces extant on some of the letters. Although not preserved completely, enough of the inscription is known to understand that both parents of the deceased erected the monument. Scholars have suggested a variety of readings for the inscription[8] and in 1951, with the addition of the two joining fragments, a new translation was put forward: «To the dead Philo and Me […] the father erected (this) monument, and together the dear mother […][9]». This reading suggests that the monument may have been set up to memorialize both the youth and the young girl standing next to him, although, owing to the incomplete state of the inscription, un-

2 In 1901, the Staatliche Museen in Berlin acquired part of the head of the girl, her right shoulder, and the raised left hand holding a flower in four fragments (Staatliche Museum, Berlin Sk 1531). Two adjoining fragments found in the collections of the National Museum in Athens were discovered in 1966 and 1967 (Athens NAM 4518, NAM 4551). Richter 1974, 1. 3. The casts of these fragments have been incorporated into the shaft of The Met's relief.

3 Blümel 1940, A7 pls. 16–18. The fragment from Berlin is said to be from Anavyssos in southern Attica. Richter 1944a, 72; Jeffery 1962, 147. According to J. Marshall, the parts acquired by The Met are said to be from Kataphygi in Attica, southeast of Hymettos. Marshall suggested that some of the especially worn parts of the stele were reused to line later ancient tombs (Richter 1974, 4 f.). For the provenance of the stele and its extensive bibliography, see its object page on the museum's website: <https://www.metmuseum.org/art/collection/search/256974> (09.08.2024).

4 In particular, the girl's head in Berlin (inv. Sk 1531) and the Peplos Kore in Athens (inv. 679 Acropolis Museum, Athens).

5 Lazzarini – Marconi 2014, 74.

6 Recent research presented by Seth Estrin (MMA Fellows Colloquium, May 20, 2021) questions the identity of the child and suggests that the figure may represent a young boy rather than a girl.

7 Fragments were acquired by The Met in 1911 (shaft, acroterion, part of the base), 1921 (right shoulder and upper arm of youth), 1936, 1938 (body and head of sphinx, and additional fragments of the wings and legs), and 1951 (two additional joining fragments of the inscription).

8 At first, the monument was thought to have been set up by Megakles, an enemy of Peisistratus and a member of the famous Alkmeonid family. The excellent preservation of the majority of the fragments suggests that the monument was not long standing before it was broken up; this was linked historically with the exile of the Alkmeonids between 541 and 537 B.C. Subsequently, it was suggested to read «to dear Me[gakles], on his death, his father with his dear mother set [me] up as a monument.» In this case, Megakles becomes the name of the youth, not the father.

9 Richter 1974, 3 after Richter with Guarducci 1961, 159–165.


1 Grave stele of a youth and little girl with a finial in the form of a sphinx (overall and detail of capital and sphinx). Greek, Attic, Archaic period, c. 530 B.C. Marble. The Metropolitan Museum of Art, New York, Frederick C. Hewitt Fund, 1911; Rogers Fund, 1921; Munsey Fund, 1936, Anonymous Gift, 1951 (11185a-c, d, f, g, x)

certainty remains about the identity (or identities?) of the deceased, and it seems more probable to us that the monument commemorates a single individual.

The colour preserved on the monument has long been of interest to scholars, conservators, and scientists at The Met, and was extensively documented in the early 20th century. Two years after The Met acquired the shaft, capital, and a part of the base in 1911, E. Robinson[10] published his observations in the 1913 Metropolitan Museum of Art Bulletin, describing the red background behind the figures, the traces of red and black used to define the subjects' eyes and

10 E. Robinson was the Museum's Director, having joined The Met in 1906 as Assistant Director, and succeeding Sir C. Purdon Clarke in 1910. As curator and Director of the MFA (from 1895–1905/6), he had long been interested in polychromy on Greek sculpture and had published on the topic, including the 1892 article ‹Greeks: Did They Paint Their Sculptures?›.

eyebrows, and the designs extant on the front face of the capital that consisted of «a combination of scrolls and ‹palmettes,› the former making two pair of volutes, with the palmettes introduced between them, a large one at the bottom, and smaller ones at the sides and top. The only bit of pigment remaining on the pattern is a bright red on the band which connects the upper volutes. The moulding on the bottom also shows traces of a painted ornament, in black and red. […] The plinth of the upper member [i. e., that of the capital which supports the sphinx which had not yet been acquired by the museum] is also decorated in colour on its front and sides, a narrow border of red surrounding each face, with a rosette of red, black, and white in the middle of each side. The [border] design on the front, if there was one, is no longer visible[11]».

A reconstruction drawing that illustrates the painted design on the capital was first published by G. Richter and L. Hall in 1944, shortly after the sphinx was acquired by the museum and reunited with the other three elements[12]. An earlier reconstruction had a slightly different treatment of the spirals beneath the central volute. A plaster cast reconstruction was then executed under the direction of Richter indicating the colours; it is now on long-term loan at the Munich Cast Museum (Museum für Abgüsse klassischer Bildwerke).

In 1912, two freehand plaster copies of the fragment in Berlin by the German artist O. Herzog were purchased by The Met and one of them was used in the reconstruction of the monument. Actual casts of the Berlin fragment were not made, so as not to endanger the polychromy preserved on it[13]. Outlines of the remaining missing portions were drawn on the plaster in two reconstructed versions. In 1922, the fragment of the youth's shoulder was inserted into the stele. In 1942, the entire stele was taken apart and reassembled. The upper part of the shaft was lowered so that the Berlin copy was brought into contact with the fracture of the stone below in an area near the back of the shaft. Being a free-hand copy, the Berlin fragment follows, but does not accurately fit, the adjacent stone. The 1942 restoration reduced the height of the stele by 3 ¾ in., and gives a better sense of the true height, since no gaps remain. In the 1942 reconstruction, the second Herzog copy of the Berlin fragment was used. Two fragments of the inscription were added after their acquisition in 1951 and casts of two more fragments of the youth, including the right hand and buttocks, were incorporated after their discovery in the National Museum in Athens in the later 1960s. In an article in 1980, S. Karouzou, who identified the fragment of the right hand and buttocks, proposed that the youth was holding a wreath of myrtle in his hand, which would have been indicated with paint[14].

A colour photograph of the stele, as it was experienced for decades in the Greek galleries with the additions of the 1951 inscription fragments, and of the casts of the Athens fragments was published in the Museum's 1987 guide, ‹Greece and Rome›[15]. In preparation for the newly renovated Archaic and Classical Greek galleries that opened to the public in 1999, the stele was carefully conserved by R. Meyer and Ch. Faltermeier in 1993. Their treatment refined the appearance of the plaster surfaces with the smooth original surfaces connected by smooth plaster fills and damaged areas with rough surfaces to indicate the lost areas[16]. The red background of the shaft, the traces of red in the figures' hair, and the black outlining the youths' eyes and eyebrows are still visible today, as are the ghost-like outlines of the painted designs on the capital[17].

The sphinx was acquired and mounted on the capital in 1938, and these two elements (acroterion and sphinx) were set up separately at eye level, since it was considered too precarious to place the originals on the reconstructed stele (Fig. 1)[18]. Having them displayed in a lower position also allows visitors to see their extensive remains of polychromy more closely. To the naked eye today, the intricate designs that were painted on the sphinx now appear darkened

11 Robinson 1913, 96.

12 The 1944 (Richter 1944b) publication of this study lists red, black, blue, and green as the preserved colours on the monument, but we have not yet been able to identify green pigment. The green identified by Richter and Hall was likely degraded azurite that was originally blue.

13 Scholl 2020, 66–69, fig. 43.

14 Karouzou 1976, 9–22, pls. 1–4. We were not able to identify any traces of the wreath hypothesized by Karouzou on the fragments preserved at The Met.

15 Mertens 1987, 30 f.

16 The sphinx was acquired by The Met in 1936 and 1938. See Richter 1940, 178–180, figs. 1–4. The upper side of the acroterion, which had been acquired in 1911 through J. Marshall, with the shaft and part of the base, preserved four paws: of these three were complete, and one in part. The sphinx preserved parts of one paw and the fragments fit exactly (Richter 1974, 3).

17 Robinson notes that the edges of the eyelids are traced in black, and the eyebrow is lined in black; red was painted for the background and the hair of both figures. Robinson states that he believed the red was originally likely mixed with another colour for the hair, as it was «scarcely to be conceived» that the artists would use the same colour to highlight a hair's colour against the background of a similar colour (Robinson 1913, 94. 96). This assessment fits with current scholarship on Archaic sculpture where dark brown layers are identified above the red, as well as yellow ochre or blue. See Brinkmann 2007, 33.

18 Richter 1940, 178–80, figs. 1–4.

and faded. Nonetheless, close examination reveals many details of the original incised and painted decoration on the creature's wings, the decorative patterning on the breast of its leonine body, and features of the human head, with its eyes, dark eyebrows, red lips, hair, intricate diadem, and necklace. Incisions create an outline within the wing on the front. Painted patterns enhance the three-dimensionality of the sculpture with colour. The back of the sphinx illustrates this aspect well, particularly with the hair. In the front, colour greatly enhances the design of the feathers on the breast, as well as the intricate meander pattern of the diadem that crowns her forehead.

In their 1944 study, Richter and Hall identified the colour red on the «hair, diadem, necklace, some of the alternate breast feathers and flight feathers, the end of the pisiform bone and the border of the abacus. There are traces of red on the remainder of the alternate feathers and on the irises of the eyes. Traces of blue are on alternate flight feathers, except one or two, and were also found on alternate breast feathers to indicate that they too were painted blue. There are traces of blue on the tuft of the tail. Abundant black paint outlines the flight feathers, and faint traces of black appear on the eyebrows[19]». In their visual analysis, which included magnification and likely UV and raking light, Richter and Hall did not find any other colour traces, but in their published rendering, they suggest that red was arbitrarily applied to the lips and black to the pupils of the eyes. They also state that «it is obvious that there is a meander on the red diadem, but the surface is much encrusted and the exact pattern, as well as any colour traces that might be on it, is obscured[20]». Our current project, which aims to identify the painting and binding materials on the sphinx, has been able to build on the seminal work of Richter and Hall, leading to a refinement of their assessment and significant new information.

Scientific Analysis of the Pigments

The polychromy was analysed by a combination of non-invasive and minimally invasive techniques that, together with the digital microscopy examination and multiband imaging[21], provided information on the surviving pigments and guided the reconstruction of the original chromatic scheme.

A first campaign of non-invasive analyses included point X-ray fluorescence spectroscopy (XRF)[22], scanning XRF (sXRF)[23] and portable Raman analysis[24], which was followed by the collection of representative micro-samples. The samples were studied by polarized light microscopy (PLM)[25], scanning electron micros-

19 Richter – Hall 1944, 239.
20 Richter – Hall 1944, 239. Although not specifically mentioned, it is likely that Richter and Hall used UV lighting as one technique for examination, since J. J. Rorimer had been experimenting with it as early as the 1920s at The Met. Richter and Hall's reconstruction of the polychromy on a limestone Archaic sphinx in The Met's collection provides an interesting comparison, dated to ca. 560 B.C.: «Red is abundant on the narrow-raised bands outlining the breast and the wing coverts. A blob of red is preserved at the centre of most of the feathers of the wing coverts. On the breast no colour is preserved, except that a red spot occupies the centre of each feather of the top row. On the flight feathers abundant red occurs as a heavy central stripe on the primaries. Traces of black are found only on the flight feathers (which are fully coloured in the reconstruction) and there are faint traces of black on the secondaries. Both are outlined in reserve» (Richter – Hall 1944, 240).
21 Digital microscopy images were taken in situ using a Keyence digital microscope VHX-6000 with a VH-ZST dual objective 20–200× zoom lens. Multiband Imaging was carried out with a modified Canon D60 camera (IR/UV filters removed) with a Coastal Opt UV-Vis-IR 60 mm macro lens. Lens filters used were: IDAS-UIBAR for Visible (VIS) images, IDAS-UIBAR + a Kodak 2E Wratten or Schott 418 filters for UV-induced visible luminescence (UVL), X-Nite BP1 + X-Nite 330 filter for ultraviolet-reflectance (UVR), and X-Nite 830 filter for infrared-reflectance (IRR) and visible-induced infrared luminescence (VIL) images. UVR, IRR and VIL monochrome images were created in Adobe Camera RAW with the black and white function. False colour images (IRRFC and UVRFC) were generated in Adobe Photoshop. A three-channel LED fixture was used for illumination for VIS, UVL, UVR and IRR and red LED strip lights for VIL.
22 Point XRF measurements were collected with a Bruker Tracer III-SD using Ti/Al/Cu filtered Rh radiation at 40 kV, 30 µA for 60 seconds live-time acquisition.
23 Scanning XRF was performed with a Bruker Elio XGLab using an unfiltered Rh radiation at 40 kV, 80 µA, a dwell time of 1 s and a step size of 1 mm.
24 Portable Raman spectroscopy was conducted using a Bruker Bravo handheld Raman spectrometer equipped with a charge-coupled device (CCD) detector. Two lasers emitting light at 785 nm and 852 nm were used as the excitation sources. The output laser power was ≈ 50 mW for both lasers, while the number of scans and integration time were adjusted according to the Raman response of the different areas.
25 PLM was realized with a Zeiss Axioplan 2 polarized light microscope.

copy (SEM) coupled with energy dispersive spectroscopy (EDS)[26], micro-Raman spectroscopy[27], and micro-X-ray diffraction (µXRD)[28]. The location of the surface analyses was guided by the results of the UV-induced visible luminescence (UVL) and visible-induced infrared luminescence (VIL) examination, and by digital microscopy, while micro-sampling also profited from the results obtained by XRF and Raman analyses[29].

Results

Point XRF analysis was performed on areas with visible traces of pigments, as well as where VIL indicated the presence of vestiges of Egyptian blue. Analysed areas include the shaft's background and the youth's hair and aryballos, the sphinx's wing, chest, head and hair, diadem, legs and tail end, as well as the capital (see Table 1).

All the XRF spectra show the presence of the characteristic and dominant X-ray lines of calcium (Ca) and strontium (Sr) from the marble, and by lines of sulfur (S), titanium (Ti), manganese (Mn), iron (Fe) and lead (Pb) of varying intensity. In some cases, strong characteristic X-ray lines of copper (Cu) and mercury (Hg) were also detected (Table 1).

Point XRF analysis allowed for the identification of two types of Cu-based blue pigments, one of which is Egyptian blue, and at least two types of red pigments, a Fe-containing red and a Hg-containing red.

Blue Pigments

The detection of Cu confirmed the use of Egyptian blue in details of the wing feathers, as shown by the characteristic luminescence recorded under VIL imaging (Figs. 2 b. c; 9 a). VIL exhibited the typical luminescence of Egyptian blue in sections near the edge of the wings that were previously thought to have been unpainted (Fig. 2 c)[30]. Faint luminescence of a few particles can also be seen on the back of the object in a corresponding area.

The other Cu-based blue was found in areas of the youth's aryballos, the sphinx's chest, the wing feathers, the diadem and the end of the tail. PLM, micro-Raman spectroscopy and SEM-EDS analyses of a minute sample of loose pigment particles identified them as azurite (Figs. 3 a; 9 b). The azurite particles display a bright blue colour in PLM, although a few greenish-blue grains, most likely weathered azurite, were also identified in the mixtures. The particles are rather angular in shape, and their size ranges from a few microns to about 100 µm. Fine-grained gypsum particles are present on the azurite particles and dispersed in the loose sample. The abundance and distribution of gypsum in the sample indicate that it was probably intentionally added to the paint mixture, although it is not possible to rule out the possibility that its presence is the result of secondary deposition. Other accessory phases are calcite and fine-grained silicates, such as quartz and feldspars, rare Fe oxides/oxyhydroxides and chromite.

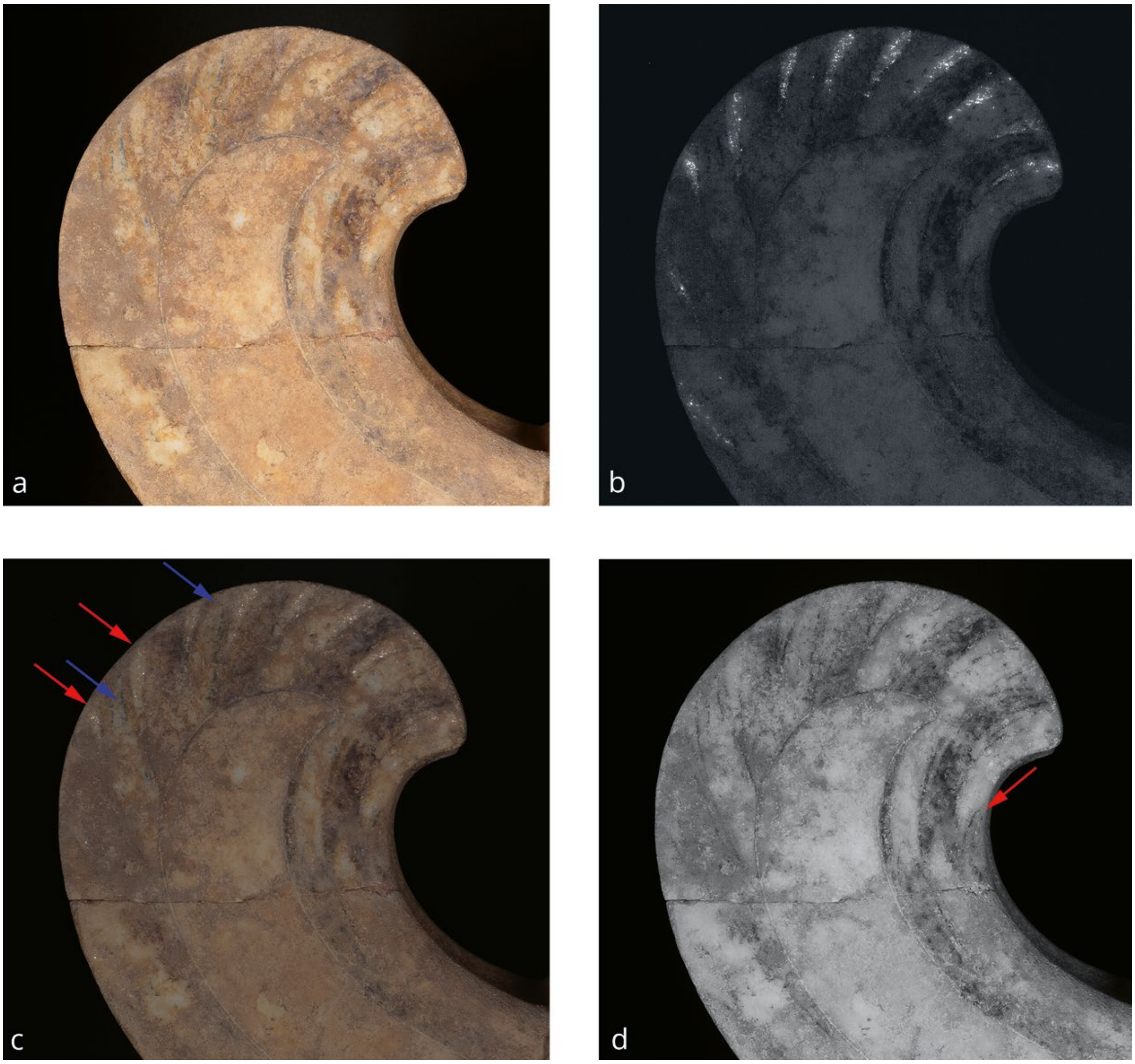
26 SEM-EDS analyses were performed with a FE-SEM Zeiss Σigma HD, equipped with an Oxford Instrument X-MaxN 80 SDD detector. Backscattered electron (BSE) images, energy-dispersive spectrometry (EDS) analysis, and X-ray mapping were carried out with an accelerating voltage of 20 kV in high vacuum.

27 Raman analysis was performed using a Bruker Senterra Raman spectrometer equipped with a 50× microscope objective and a charge-coupled device (CCD) detector. A Spectra Physics Cyan solid-state laser and a continuous wave diode laser emitting at 488 nm and 785 nm, respectively, were used as the excitation sources, while two holographic gratings (1800 and 1200 rulings/mm) provided a spectral resolution of 3–5 cm^{-1}. The output laser power, number of scans, and integration time were adjusted according to the Raman response of the different samples.

28 µXRD was performed with a Bruker D8 Advance using Cu Kα radiation at 40 kV and 40 mA, equipped with a Göbel mirror, a 1 mm UBC collimator, and with a Eiger2 R 500K Hybrid Photon Counting detector working in in 1D mode. Continuous scans were collected between 20° and 70°, with a step size of 0.02° and a time step of 1 s. Micro-samples were mounted on a rotating low-background plate.

29 Digital microscopy images were taken in situ using a Keyence digital microscope VHX-6000 with a VH-ZST dual objective low power (20–200×) zoom lens mounted on tripod.

30 Egyptian blue at the edges of the feathers may have been used to depict the void between the azurite and cinnabar feathers, as seen against the blue sky as in the use of Egyptian blue on the strut of the Artemis from Pompeii (see Østergaard – Nielsen 2014, 132 fig. 11). In contrast, the strut between the tail and the body, as well as the space between the wings as seen from above, is painted a red colour since it depicts a void.

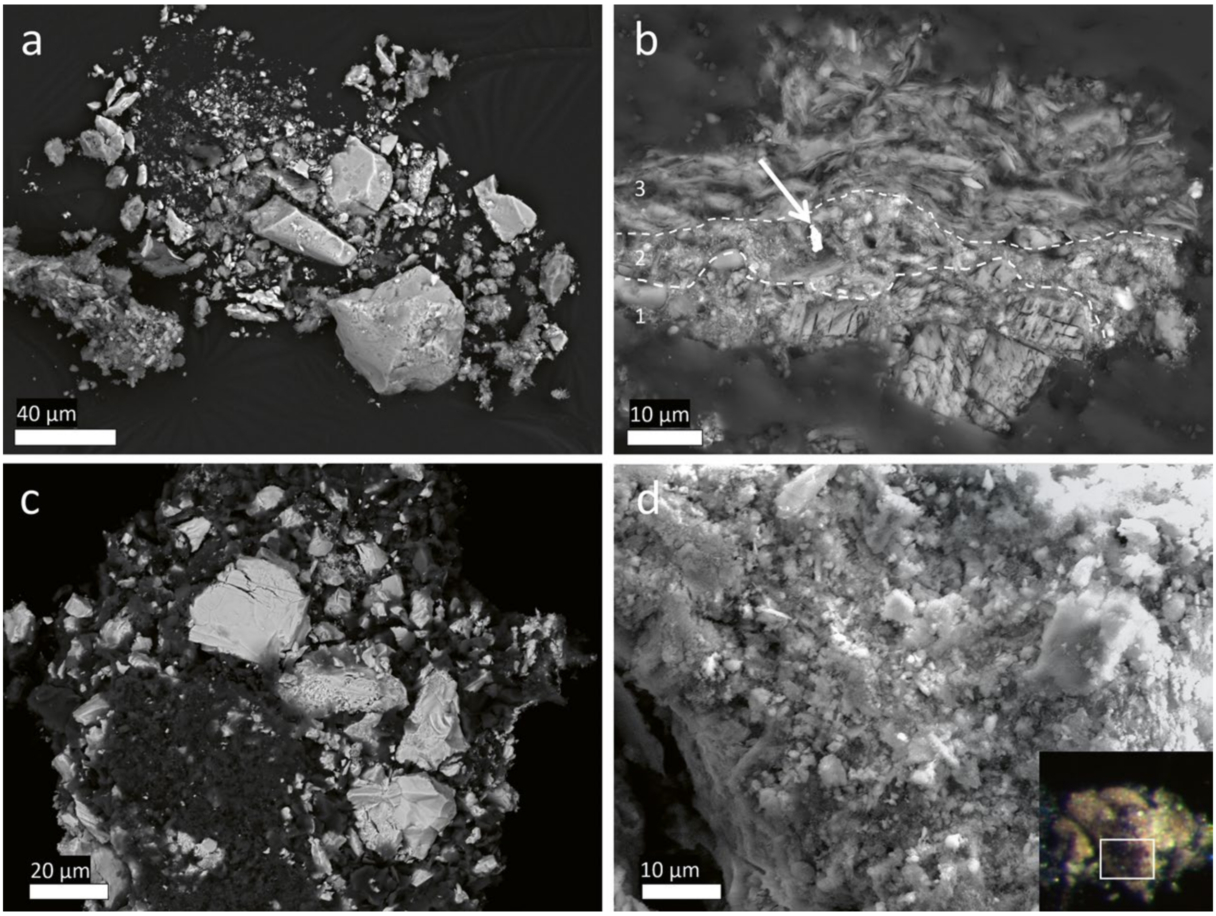


2 Detail of wing on front of sculpture. a) VIS; b) VIL exhibiting the characteristic luminescence of Egyptian Blue; c) Transparent VIS image stacked on VIL image, illustrating placement of the Egyptian blue along the outer edge of the wing in sections separate from the visible azurite or cinnabar feathers (red arrows: Egyptian blue, blue arrows: azurite); d) IRR provides additional detail of the carbon-based pigment lines that outline the feathers, many of which are obscured below accretions (red arrow: outlines of the tips of a lower row of feathers).

Red and Yellow Pigments

The detection of intense X-ray energy lines of Hg associated with weak lines of S by XRF indicates that the darkened red pigment consisted predominantly of cinnabar (HgS). This interpretation was confirmed by SEM-EDS, Raman and μXRD analyses of a few pigment particles collected from the proper right wing. Bright red particles of pigment consistent with this interpretation were imaged in these locations by digital microscopy, surrounded by darker particles of weathered cinnabar, most likely metacinnabar (Fig. 9 c)[31]. The presence of cinnabar was detected in the youth's aryballos and its straps, the sphinx's chest, wing, diadem, necklace, and eyes. An XRF line scan recorded across the proper left eye shows that cinnabar is concentrated in the eye's centre, suggesting that it was used either on its own or mixed with ocher to represent the iris and, possibly, the pupil. The analyses also suggest that cinnabar was not mixed with gypsum.

31 Nöller 2015.



3 a) Backscattered electron (BSE) image of azurite particles, surrounded by fine gypsum; b) BSE image showing the paint stratigraphy of the hair, Layer 1: marble substrate, Layer 2: hematite-rich ocher, gypsum and rare cinnabar particles (arrow), Layer 3: deposit of clay minerals with occasional Fe oxides/oxyhydroxides; c) BSE image of cinnabar particles surrounded by calcite; d) Secondary electron image of the carbon-based black pigment. The inset shows the area of the sample imaged by SEM.

An Fe-based pigment containing traces of Mn was found on the inscribed letters of the base and the shaft's background, the youth's eye and hair, the sphinx's hair and the carpal pad (Richter's pisiform bone) by XRF analysis. In other locations, such as the sphinx's face, the leonine body and the wings, the identification of Fe-based pigments by means of non-invasive techniques was hindered by a thick burial accretion and by the scarcity of preserved pigment. Digital microscopy proved essential in locating Fe-based pigment particles in highly disturbed surfaces, such as the sphinx's lips, where vestiges of the pigment were found deep in the groove that defines the lips.

Two cross sections from the sphinx's hair revealed that the pigment had been applied directly to the marble surface without a preparation layer (Fig. 3 b). Digital microscopy further indicates that all the pigments were applied directly to the calcite substrate. The red pigment consists of clusters of very fine Fe oxide platy particles (< 1 µm in size) associated with very fine silicates, most likely clay minerals, rare quartz and very rare pyrite, which indicates that this red pigment is a highly refined red ocher. Raman spectroscopy and µXRD identified the Fe oxide particles as hematite. Noticeable traces of arsenic (As) are associated with hematite particles (up to 1 wt%), as determined by EDS analysis[32].

Scattered clusters of platy Fe oxides particles containing traces of As, such as those seen in the cross section from the sphinx's hair, have been identified in a loose sample collected from the area between the

32 Kostomitsopoulou Marketoua et al. 2019.

wings, suggesting that red ocher was used for the decoration of this portion of the sphinx's body. Given the nature of this sample, it was not possible to determine whether red ocher was used together with other pigments or on its own.

A few particles of cinnabar are present in the ocher layer (Fig. 3 c) and have also been detected in the loose samples from both the sphinx's hair and front left leg. Although sparse cinnabar particles could be the result of either intentional addition or a contamination of the artist's tools, their recurrent presence associated with ochers suggest that cinnabar was deliberately added to modify the hue of these pigments. Similarly, traces of Ca and S were detected by EDS analysis in the sphinx's hair and wings, and gypsum was identified in ocher samples by µXRD. This result suggests that fine-grained gypsum was likely intentionally added to the ocher layers, although it cannot be excluded that gypsum may have been deposited as a secondary phase within the pigment layers.

The identification and characterization of yellow pigments on the sphinx was challenging and, for the most part, inconclusive. One micro-sample consisting of loose particles of yellow colour was removed from behind the diadem, where a rather homogeneous yellow layer is visible. Raman spectroscopy and SEM-EDS analysis revealed the presence of hematite and goethite, associated with very fine-grained aluminosilicates and traces of gypsum. This association of hematite, goethite and clay minerals has been interpreted as an intentional pigment consistent with a yellow ocher.

It is likely that various typologies of red and yellow ochers containing different types and relative ratios of Fe oxides/oxyhydroxides, cinnabar and, possibly, gypsum have been used in different parts of the stele, the capital and the sphinx finial, including both the face and the leonine body. At present, only the red used for the sphinx's hair has been properly characterized, while the other Fe-based pigment assemblages remain undetermined and await further analysis.

An accretion consisting predominantly of clay minerals and scattered particles of calcite, gypsum and Fe oxide/oxyhydroxides is present on top of the ocher layer.

Black and White Pigments

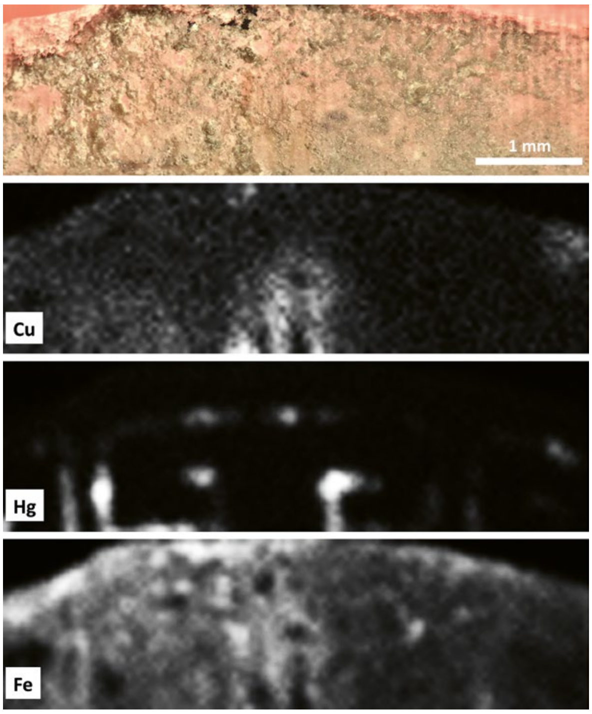
Black pigment can be seen in the wings, on the outlines of the flight feathers and in the separating areas painted with azurite and Egyptian blue, in the left eyebrow and highlighting the sphinx's genitals. Although this black pigment is easily mistaken for darkened cinnabar, particularly in the highly decorated wings, Raman analysis of two samples indicates that it is a carbon-based black. SEM analysis shows that the black pigment consists of small particles (< 5 µm in size) of irregular and variable shapes. None of the particles show morphologies clearly associated with chars, such as typical cellular structures of wood or vine blacks (Fig. 3 d)[33]. Although EDS analysis ruled out the use of bone/ivory black or coal, the exact typology of this carbon-based black remains unclear.

Only minimal vestiges of white areas are visible in a small portion of the left eye. A few particles were collected from this area and have been analysed by Raman, µXRD and SEM-EDS. Results indicate that these white, loose particles consist predominantly of fine, angular calcite grains, while no traces of other common white pigments, such as lead white, kaolin or gypsum, were found. Given that the sampled area shows signs of the mechanical removal of burial accretion, which possibly reflect an attempt to reveal the coloured iris, it is likely that the sampled calcite particles originate from the abraded marble substrate, rather than being an intentionally applied pigment.

Scanning XRF and Polychromy Scheme

Elemental maps were collected by sXRF on selected areas of the sphinx's diadem, wing, chest and the capital. Scanning XRF was performed in these areas to aid the reconstruction of the original polychromy scheme, particularly where it has been compromised by accretions or losses.

33 Winter 1983.



4 Scanning XRF of the Sphinx's diadem

The most informative elements are, for azurite and Egyptian blue, Cu and, for cinnabar, Hg. Although the distribution of Fe is indicative of the presence of Fe-containing pigments, mostly ochers, it does not always correspond directly to the presence of such pigments, as this element can be found in abundance in accretions and patinas.

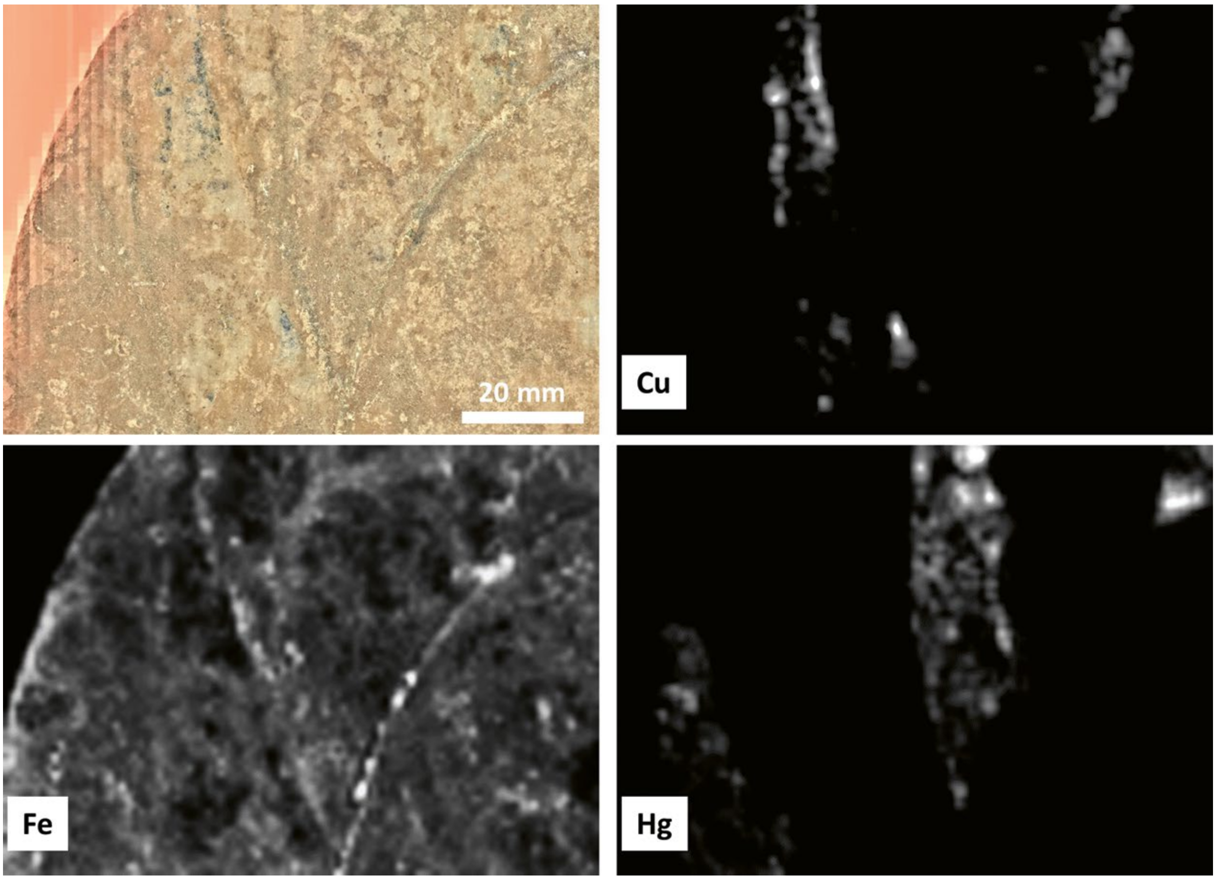
The distribution of Hg, Cu, and Fe on the analysed area of the diadem reveals a geometric design, one which is almost completely concealed by the presence of a thick accretion and the alteration of the stone (Fig. 4). Hg and Cu clearly identify the design of repeating red and blue meanders. Fe is distributed across the analysed area, and it is likely that a Fe-based pigment, possibly a yellow ocher, was used as a background to the meander design.

The combination of sXRF, VIL and minimally invasive analyses of the proper right wing reveal the original design of alternating red (Hg) and blue (Cu, azurite) feathers separated by black lines, against a lighter blue background (Cu, Egyptian blue) (Figs. 2 d; 5). Although Fe appears concentrated around some of the flight feathers, the original distribution of Fe-based pigments in the wing remains speculative and deserves further investigation (Fig. 5).

Hg, Cu, and Fe are also the most significant elements in the scale-shaped design of the breast feathers, indicating a red and blue pattern obtained with the use of cinnabar and azurite (Figs. 6. 7). A higher concentration of Fe around the chest feathers suggests that a Fe-based pigment, possibly a yellow ocher, was used to delineate and separate the scales. These lines are clearly visible in ultraviolet-reflected false colour (UVRFC) images (Fig. 6 d).

Scanning XRF failed in the task of mapping the little pigment remains on the capital. Conversely, multiband images revealed much of its detailed decoration, which was particularly clear in UVL (Fig. 8 b). Raking light images highlight the incised lines that were likely used to lay out the ornament on the capital (Fig. 8 a). Incised lines, as well as the faint image of the central rosette in relief, which resulted from differential weathering of areas protected by original polychrome, can be seen on the plinth at the top of the left side of the capital. This mirrors the visible remains of colour that can be seen on the right side in daylight.

Examination of the stele revealed the use of Fe-based pigments, most likely ochers, for the red of the background and the hair of the youth. Of particular interest was the aryballos that he holds, which has traces of cinnabar, Cu-based blue and carbon-based black pigments. Traces of its painted design of diagonal lines points to similar decoration on contemporary Archaic-period painted terracotta oil vessels. For example, coloured swirling crescents encircle the body of a terracotta aryballos in The Met's collection, which is signed by the painter and potter Nearchos (MMA accession number 26.49; Fig. 8 c. d). The straps that surround the vessel likely represent leather that is held together underneath by a metal rivet with a decorative finial. The vessel itself has a stopper fitted into its opening on top. Such vessels held the oil used by athletes to clean themselves for competition.



5 Scanning XRF of the Sphinx's proper right wing

Conclusion

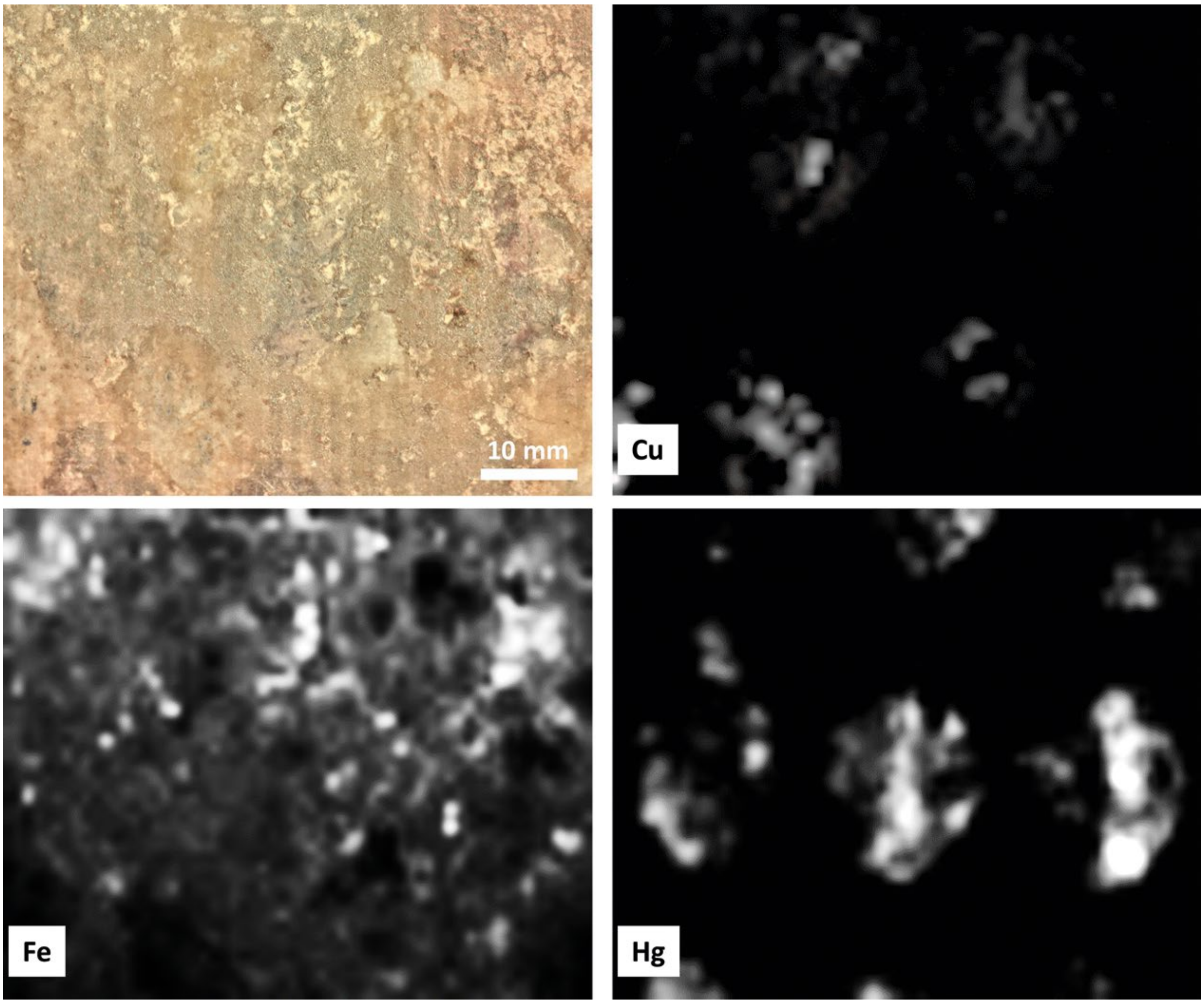
While the sphinx still holds numerous secrets, many of which we hope to discover in our ongoing investigations, the current state of knowledge allows us to consider the ways in which colour enhanced the physical characteristics of the monument and how colour may have conveyed meaning within a funerary context[34]. The palette of colours attested on the sphinx compare well to the polychromy employed in contemporary later 6th cent. B.C. works of art, such as the Peplos Kore in Athens and a contemporary limestone sphinx in the Ny Carlsberg Glyptotek (IN 1203), which was studied by the CPN Network and published in a preliminary report for the Tracking Colour project[35]. Unlike many contemporary works, however, green has yet to be identified on the sphinx or the capital.

In its original setting, the monument would have towered over a visitor to the tomb and been visible from a significant distance. The strong and striking colours accentuated the sphinx's looming figure while their vibrancy and patterning emphasized the beast's composite parts and salient features: the

34 The identity and variety of all the Fe-containing pigments are not yet fully understood. In addition, traces of Pb have been found by XRF in correspondence to pigment remains, as well as being associated with burial accretion. Analysis of samples did not identify any specific lead-containing compounds, however, either in the pigment layers or in the accretions. On the basis of our existing data, it is not possible to explain whether Pb is present as a secondary adventitious phase, as a yet-unidentified pigment, or occurs naturally in certain types of ochres (Marketou et al. 2019).

35 Sargent et al. 2009 document red ocher, yellow ocher, hematite, and blue, probably azurite. The polychromy preserved on another sphinx from the Athenian acropolis (inv. 632) also allows for close comparison to The Met's sphinx. See Schuchhardt 1940 and the catalogue entry in Brinkmann 2003, no. 70, fig. 70, 7. This sphinx is seated profile to the right, turning her head to the left to face the viewer. Her hair is arranged in waves (indicated by incisions) over her forehead and cascading over each shoulder to just below the bottom of the neckline.

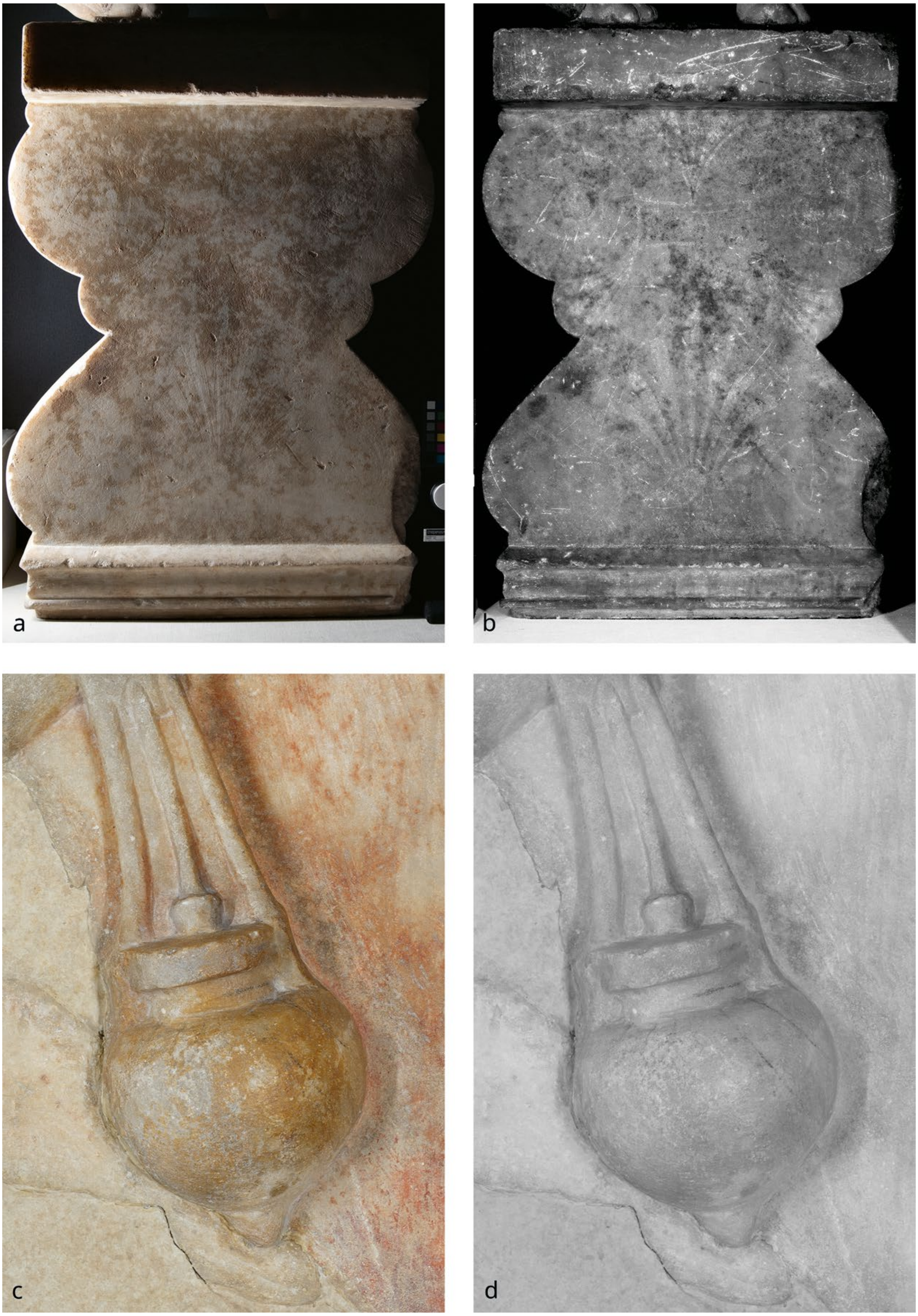
6 a. b) Detail of wing on reverse of sculpture; c. d) Detail of the right side, including breast of the Sphinx. a) VIS; b) UVL image illustrating the multiple lines used to define the detail of the staggered row of wing feathers. The bright fluorescence in the hair is due to a modern consolidant; c) VIS; d) UVRFC image illustrating the apparent remains of iron pigment that outlines the breast feathers, similar to the lines that detail the wing feathers in Fig. 7.



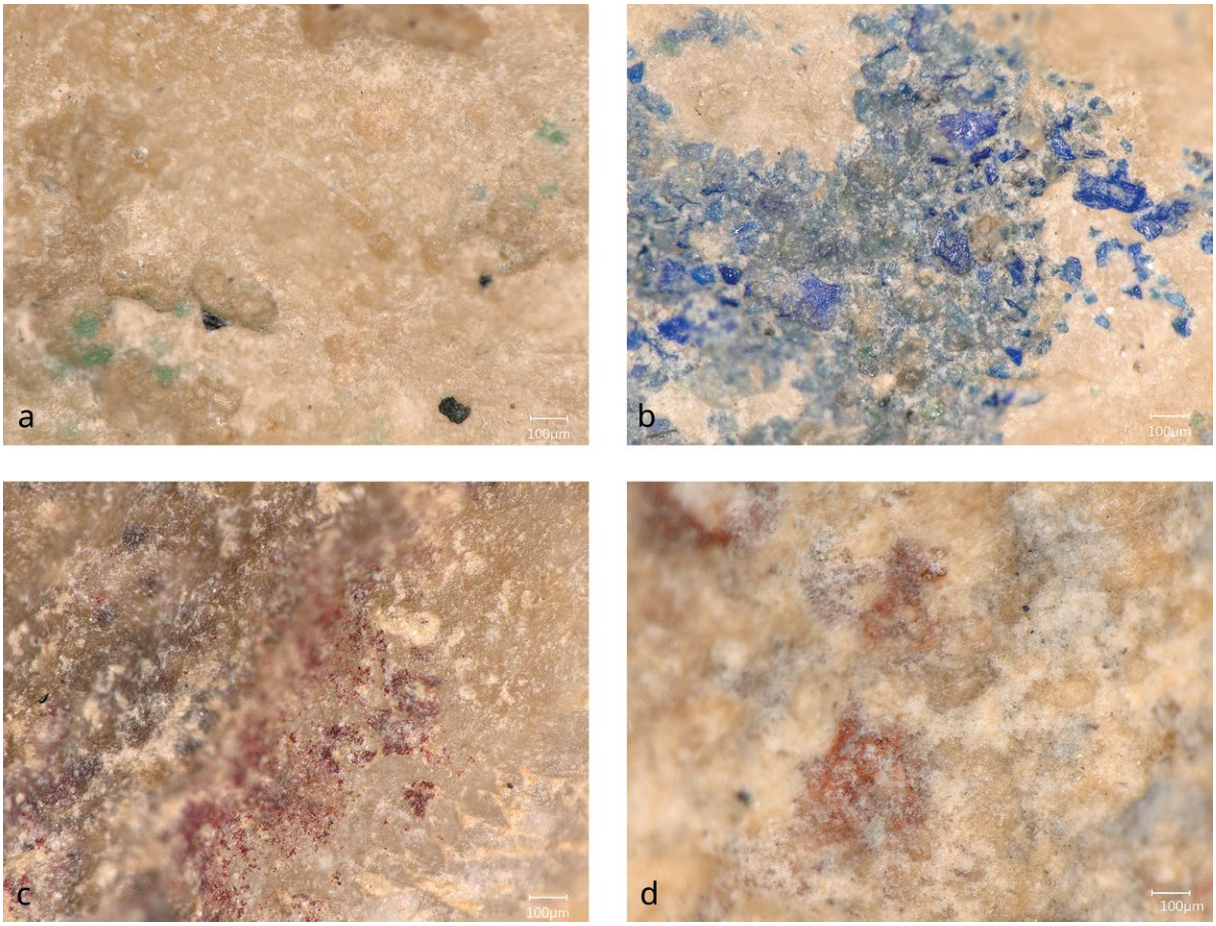
7 Scanning XRF of the Sphinx's chest

strong body of a lion, the vivid breast and dynamic wings of a bird, and the human features of the face and hair, crowned with an ornamental diadem and embellished with a slim necklace around her neck[36]. As the guardian of a grave, the sphinx's intricate polychromy underscored her fantastic and ferocious nature, and contrasted the relatively limited use of colour on the human figures depicted on the shaft below, wherein red served as the background and to accentuate hair and black defined the eyebrows and eyes[37]. We now understand, however, that the aryballos was decorated with bright red diagonal lines and, blue and black pigments, which adds further complexity to the role played by colour in the representations of the sphinx, the human figures, and their accoutrements. Finally, the vibrant colours and elaborate decoration employed on the sphinx and capital would have signalled the wealth and prestige of the family that was able to commission such an elaborate monument to their deceased relatives.

36 Kiilerich 2016, 5 suggests that specific hues on ancient sculpture were chosen for their salience.
37 We do not know yet whether the red of her eyes is an undercoat or was intentionally painted to indicate her mythical and monstrous nature, as is apparent from the use of iron rich inlays of either red (hematite) or black (metallic iron, or magnetite) in the eyes of the Geometric bronze centaur battling a man in The Met's collection (MMA 17.190.2072).



8 a. b) Palmettes and volutes on capital; c. d) Detail of aryballos on stele. a) Raking light image; b) UVL image rendered in black and white with detail enhanced in Photoshop; c) Visible light; d) Infrared-reflected image



9 In situ digital images of the front of the monument. All images taken at 200× magnification and stacked in Photoshop. a) Detail of wing including particles of Egyptian blue, in area pictured in VIL, image 2b; b) Detail of wings showing heterogeneous size mix of azurite particles; c) Detail of diadem showing fine particles of cinnabar; d) Detail of Fe-based pigment on background of shaft adjacent to aryballos

Location	Colour	XRF*	PLM/SEM-EDS	Raman	µXRD	Pigments
Youth's aryballos, sphinx's diadem, eyes, neck, wing, chest	Red	S, Ca, Ti, Mn, Fe, Cu, Hg, Pb, Sr	Angular particles of cinnabar 1–10 µm large, surrounded by fine calcium carbonate. Darkening concentrated at the outer portion of the HgS particles.	Cinnabar (253, 283, 344 cm^{-1})	Cinnabar, calcite, quartz	Cinnabar
Shaft background, youth's hair, sphinx's hair, eyes, wing, leonine body	Red	S, Ca, Ti, Mn, Fe, Cu, Zn, Sr, Pb, Hg	Aggregates of small platy hematite crystals < 1 µm, associated to fine clay minerals and rare quartz. Gypsum and calcite are also present. Few cinnabar particles. Hematite contains As. Ocher is very refined.	Hematite (225, 292, 410, 496 cm^{-1})	Hematite, gypsum, calcite, quartz	Red ocher, gypsum, cinnabar, most likely in different proportions
Back of diadem	Yellow	–	Particles of Fe-oxides, together with very fine-grained aluminosilicates and traces of gypsum	Hematite (225, 294, 411, 496 cm^{-1}) Goethite (244, 295, 388, 549, 1008 cm^{-1})	–	Yellow ocher, gypsum
Youth's aryballos, sphinx's wing and chest feathers	Blue	S, Ca, Ti, Mn, Fe, Cu, Zn, Pb, Sr	Angular particles of azurite 1-50 µm large, surrounded by fine gypsum particles.	Azurite (140, 180, 250, 401, 545, 765, 835, 940, 1095, 1420, 1578 cm^{-1})	–	Azurite, gypsum
Sphinx's wing	Blue	S, Ca, Ti, Mn, Fe, Cu, Zn, Pb, Sr	–	–	–	Egyptian blue+, possibly gypsum
Sphinx's wing, eyebrows, genitals	Black	S, Ca, Ti, Fe, Cu, Zn, Sr	Small particles < 5 µm in size, with variable shape. No morphologies clearly associated with char. No P detected by EDS.	Carbon-based black (1378, 1599 cm^{-1})	–	Carbon-based black, gypsum

Table 1 Summary of the results of non-invasive and minimally invasive analyses of pigments. * Traces of Cu and Zn may also originate from the instrument.– + Identified by VIL.

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