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Polychromy in Roman Egypt: a study of a limestone sculpture of the Egyptian god Horus

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SUMMARY This contribution presents recent work on a Roman period limestone sculpture depicting the ancient Egyptian god Horus (British Museum EA 51100). In ancient Egypt, the god Horus was the divine representation of the living king and was commonly represented as a man with the head of a falcon. The iconography and style of depictions of Horus and other traditional Egyptian deities were influenced by Hellenistic and, later, Roman traditions of representation, often combining trappings of power in ways that are striking to modern observers. Sculpture EA 51100 demonstrates just such a combination of Egyptian, Hellenistic and Roman iconography and style. Given the lack of provenance and direct parallels for the object, scientific analysis offered a way to determine its authenticity and the cultural context for its production.

The sculpture retains extensive evidence of its original polychromy. The properties and spatial distribution of these pigment remains were investigated by technical (multispectral) imaging, applying visible-reflected, infrared-reflected, UV-induced luminescence and visible-induced luminescence techniques. The last of these revealed the presence of an additional pigment, Egyptian blue, which was not clearly visible to the naked eye. Further study of the surviving pigments, using Fourier transform infrared and Raman spectroscopy, revealed that pigments within the well-defined painting traditions of Egyptian art were employed side-by-side with a pigment, green earth, which is virtually unknown in dynastic Egypt, but is ubiquitous in Roman art. The analysis confirmed the authenticity of the pigments and thus the sculpture itself.

Introduction

The sculpture (EA 51100: 1912,0608.109)

The painted limestone sculpture of the Egyptian god Horus is 54.5 cm high and its base is 31.8 cm wide with a depth of 25.6 cm, Figure 1. Cracked at the waist, the object was repaired prior to 1996 and again in 2011, when the plaster makeup was improved. Visible traces of original red, yellow, green and black pigment are extant, suggesting that the sculpture was once brightly painted.

The god is represented sitting casually on a high-backed chair, the sides of which are detailed in red and black pigments, Figure 2. One sandal-clad foot forward, his knees are apart and draped in a green garment. From the waist down, he could be any senior Olympian deity or a Roman emperor aspiring to divine status.[1] He wears a shirt of feathered mail armour that ends just above his elbows. A knotted belt encircles the waist, dropping to the hips in contrast to the more typical position at the natural waist. A blue-green cloak, pushed back over the shoulders, is fastened by a round plate fibula. His yellow arms, now broken off, would have held weapons or other symbols of power. From the waist up, his costume belongs to Roman soldiers, military deities or emperors.

In contrast, the falcon head belongs to the Egyptian god Horus and is rendered in naturalistic style with the bird's distinctive facial markings articulated by the carving and traces of black pigment. The eyes and ears are, however, anthropomorphic and, unlike a 'real' falcon, the eyes are frontal and their incised and painted pupils tilt the gaze upward. In an imaginative turn, the feathers of the falcon double as the scales of a mail shirt. A crown (probably of metal) was once fitted to a hole in the top of the head (Figure 3); this was probably the combined white and red crown representing the king's rule

Figure 1. Roman period limestone sculpture of the Egyptian god Horus (EA 51100: 1912,0608.109)

Figure 2. Roman period limestone sculpture of the Egyptian god Horus, side view, with traces of black and red pigment visible on the chair (EA 51100: 1912,0608.109)

Figure 3. Hole in the top of the head placed for the insertion of a crown, probably in another material

over Upper and Lower Egypt.[2] This combination of typically imperial Roman and royal Egyptian iconography has tempted scholars to refer to this sculpture and similar representations as 'Horus as emperor' [1; cat. 196 and 197, 2; cat. 250–253].

Roman period depictions of the falcon-headed Horus have been found in a variety of materials throughout the empire, from Egypt to Oxfordshire.[3] Usually dressed in Roman military costume, falcon-headed Horus is sometimes depicted on horseback, but more often standing, while seated figures are rare [3]. Although smaller figures may have been dedicatory, larger stone and metal sculptures such as EA 51100 and EA 36062 (Figure 4) were probably objects of public or private devotion.

Acquisition and display

The findspot and circumstances of the sculpture's discovery in Egypt are unknown, but its association with the dealer Mohammed Mohassib (1843–1928) will draw the suspicion of Egyptologists. Mohassib regularly sold objects to the British Museum and to other international institutions. Among the British Museum's purchases were some notorious forgeries [4], but the great majority of objects in his Luxor shop were authentic, originating from the nearby East Bank temple complexes of Luxor Temple and Karnak, the West Bank funerary temples and tombs [5], or farther afield. By the 1880s, his Luxor shop was a usual stop for European and North American collectors [6]. Among his annual visitors was E.A.W. Budge, Keeper of Egyptian and Assyrian Antiquities at the British Museum (1894–1924), and the two maintained an active correspondence.[4] Over the course of 30 years, Mohassib sold around 1300 objects to the British Museum and EA 51100 was among 110 objects approved for purchase by the Trustees on 8 June 1912, for a total price of £681.10s [7].

The sculpture elicited little notice among the newly acquired objects, which ranged in date from the pre-dynastic to the 'Coptic' period and were commended by Budge for "filling gaps in the collection" [7]. By 1922, the sculpture was on

Table 1. Summary of the results of Raman and FTIR analyses of samples taken from sculpture EA 51100 (1912,0608.109). The images and sample locations can be seen in Figures 5 and 6

Image No.	Sample No.	Description	Raman results	FTIR results
I	1	Green from 'sword'	Carbon, gypsum and goethite	Gypsum and celadonite
II	2	Green from 'sword' lower	Gypsum	Gypsum, calcite and celadonite
III	3	Yellow on upper proper left arm	Goethite	Gypsum, calcite and ochre
IV	4	Red from cloak behind proper left arm	Hematite	Gypsum, calcite and ochre
V	5	Green from cloak on proper left shoulder	Egyptian blue, goethite and hematite	Egyptian blue, gypsum and ochre
VI	6	Black from cloak on proper left shoulder	Amorphous carbon	Gypsum and calcite
VII	7	Black from feather	Gypsum	Gypsum, calcite and ochre
VIII	8	Red stripe on proper left side of throne	Gypsum and hematite	Gypsum, calcite and ochre
	9	Black stripe on proper left side of throne	Gypsum, hematite and amorphous carbon	Gypsum, calcite and ochre
X	10	Yellow from proper right side below ear	Goethite	Gypsum, calcite and ochre
XI	11	Black behind proper left ear	Gypsum and amorphous carbon	Gypsum and calcite
XIII	12	Red feather at neck	Goethite and hematite	Gypsum, calcite and ochre
XIV	13	Green/blue under proper left arm	Egyptian blue, goethite, hematite and gypsum	Egyptian blue, gypsum, calcite and ochre
XV	14	Green on cloak over proper right leg	–	Gypsum, calcite and celadonite
XVI	15	Black around proper right eye	Gypsum, hematite and amorphous carbon	Gypsum and calcite

display in wall case 273 of the sixth Egyptian Room and given a pithy description: "seated figure of a Roman emperor(?), hawk-headed" [8]. The lack of attention is not surprising at a time when scholars sought to define (or invent) the neatly fixed categories 'Greek', 'Roman' and 'Egyptian', into which this hawk-headed sculpture simply did not fit.

Today, it is precisely this collision of cultural signifiers that excites interest. The object was on display at the British Museum until 1996, when the galleries were reconfigured to create the Great Court. Since that time, it has appeared in international exhibitions on Roman Egypt, for example those in Frankfurt [1; cat. 196] and Marseilles [2; cat. 252], appearing on the cover of the catalogue for the latter. An opportunity to study, authenticate and redisplay the object arose in 2011, when an ideally sized case in the Egyptian sculpture gallery was vacated when the Gayer-Anderson cat (EA 64391) travelled on loan. Following scientific analysis, the Horus sculpture was displayed from February 2012 until March 2013.

Scientific examination

The sequence of examination began with visual inspection under magnification followed by technical imaging to characterize the spatial distribution of the remaining traces of pigment. Based on the data from the visual examination and technical imaging, small samples of each area of interest were then taken and analysed using Fourier transform infrared (FTIR) and Raman spectroscopy; see the experimental appendix for full details of the techniques used.

Close inspection of the surviving polychromy on the sculpture under magnification revealed the presence of an extensive colour palette. Areas of interest were recorded in detailed images made with a 'USB microscope'; these are shown in Figures 5 and 6, identified using Roman numerals. The

Figure 4. Roman period copper-alloy figure of the Egyptian god Horus, standing and wearing a nemes headdress and military costume (EA 36062)

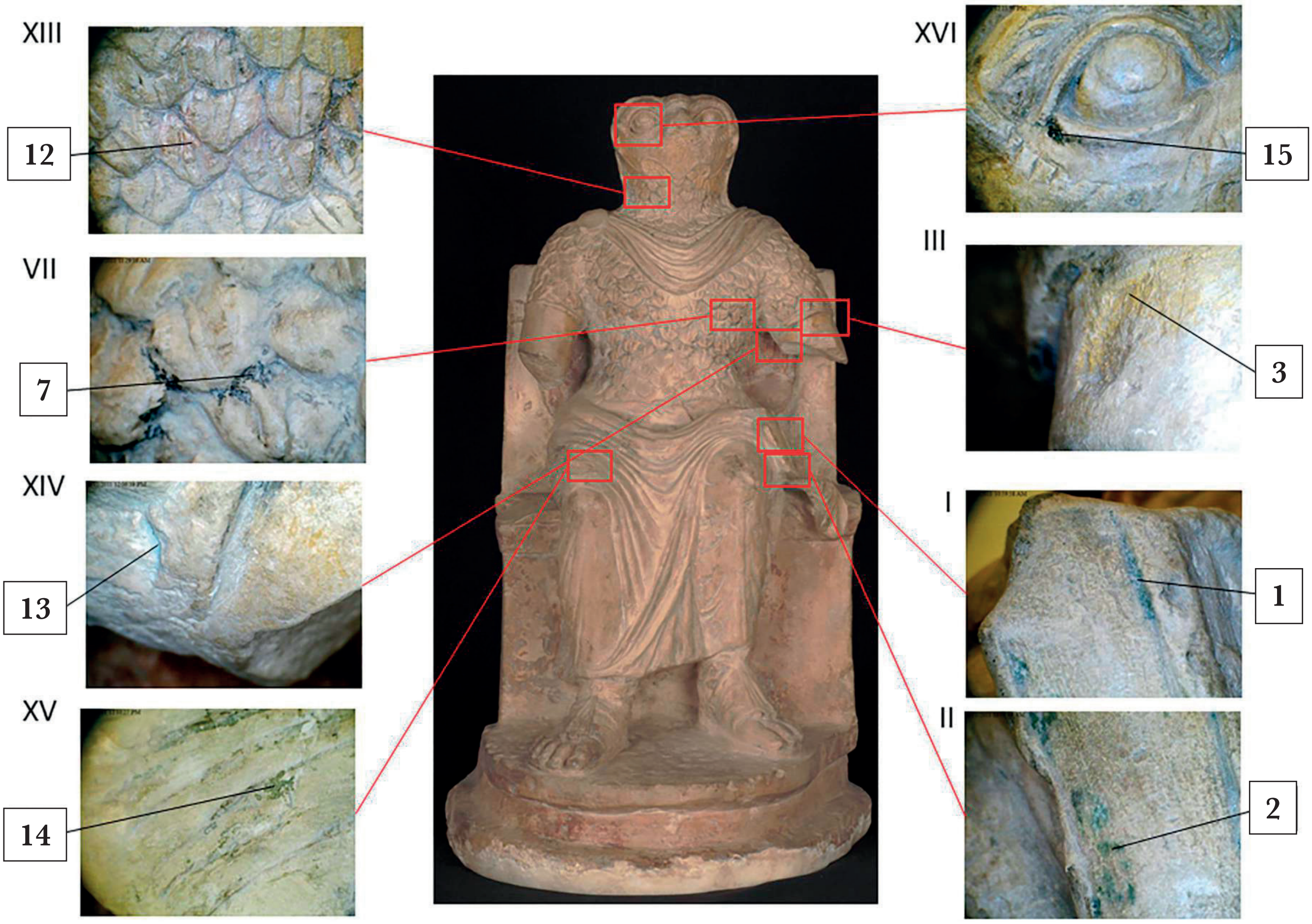

Figure 5. Detailed images of the traces of polychromy on the front of the sculpture (numbered with Roman numerals). Locations from which the samples listed in Table 1 were taken for analysis are also shown (indicated by Arabic numerals)

locations from which the samples listed in Table 1 were taken for analysis by FTIR and Raman spectroscopy (see below) are also shown on these figures, identified using Arabic numerals.

The detailed images show traces of black around the rim of the proper left eye (Figure 5 XVI), as well as along the edges of some of the feathers on the *lorica plumata* (Figure 5 VII), at the hairline behind the proper left ear (Figure 6 XI) and on the cloak over the proper left shoulder, Figure 6 VI. Black rectangles decorate the sides of the throne upon which the figure sits, Figure 6 VIII. The throne is additionally decorated with horizontal and vertical crossing stripes in a dull red colour (Figure 6 VIII), which are also observed along the back of the cloak on which the figure reclines (Figure 6 IV) and along the base of the sculpture. A few feathers at the base of the neck also appear to have a slight dull red colouration, Figure 5 XIII.

A bright yellow colour was observed on the upper arms of the figure (Figure 5 III), as well as on some of the feathers below the proper right ear (Figure 6 X) and around the throat, Figure 5 XIII. A dull green colour was noted in the folds of the garment on the figure's lap (Figure 5 XV) and along the edges of the sword, Figures 5 I and 5 II. A brighter blue-green is present on the cloak over the proper left shoulder and under the proper left arm, Figure 5 XIV.

Technical imaging

The visible-reflected and visible-induced luminescence (VIL) images of the front of the sculpture are shown in Figure 7. Very few materials exhibit the unusual property of luminescing in the infrared (IR) range when excited by visible light. Of these materials the only pigment likely to be found in this context is Egyptian blue, the most common blue in the Egyptian palette [9]. Egyptian blue is a calcium copper tetrasilicate ($CaCuSi_4O_{10}$) that has the same composition and structure as the rare natural mineral cuprorivaite and is one of the earliest known synthetic pigments. This bright blue inorganic compound was extensively used and highly prized throughout the Mediterranean from the Fourth Dynasty in Egypt (*c.*2500 BC) until the end of the Roman period [10]. When excited by radiation in the visible region of the electromagnetic spectrum, Egyptian blue produces an intense and broad emission (full width at half peak height of *c.*120 nm) in the IR region, centred at about 910 nm [11, 12]. This emission can be recorded by using visible excitation sources and a camera with some sensitivity to IR radiation in the *c.*800–1000 nm range of the electromagnetic spectrum, as described in the experimental appendix. White or very pale areas in the monochrome VIL image represent the emission from Egyptian blue, while all other materials appear black or dark grey. Grey levels higher than those for a 99% reflectance standard, which is placed alongside the object under investigation and included in the image, are almost certainly due to luminescence from the Egyptian blue. Grey levels less than the reference standard are considered to result from reflected 'stray' IR radiation.

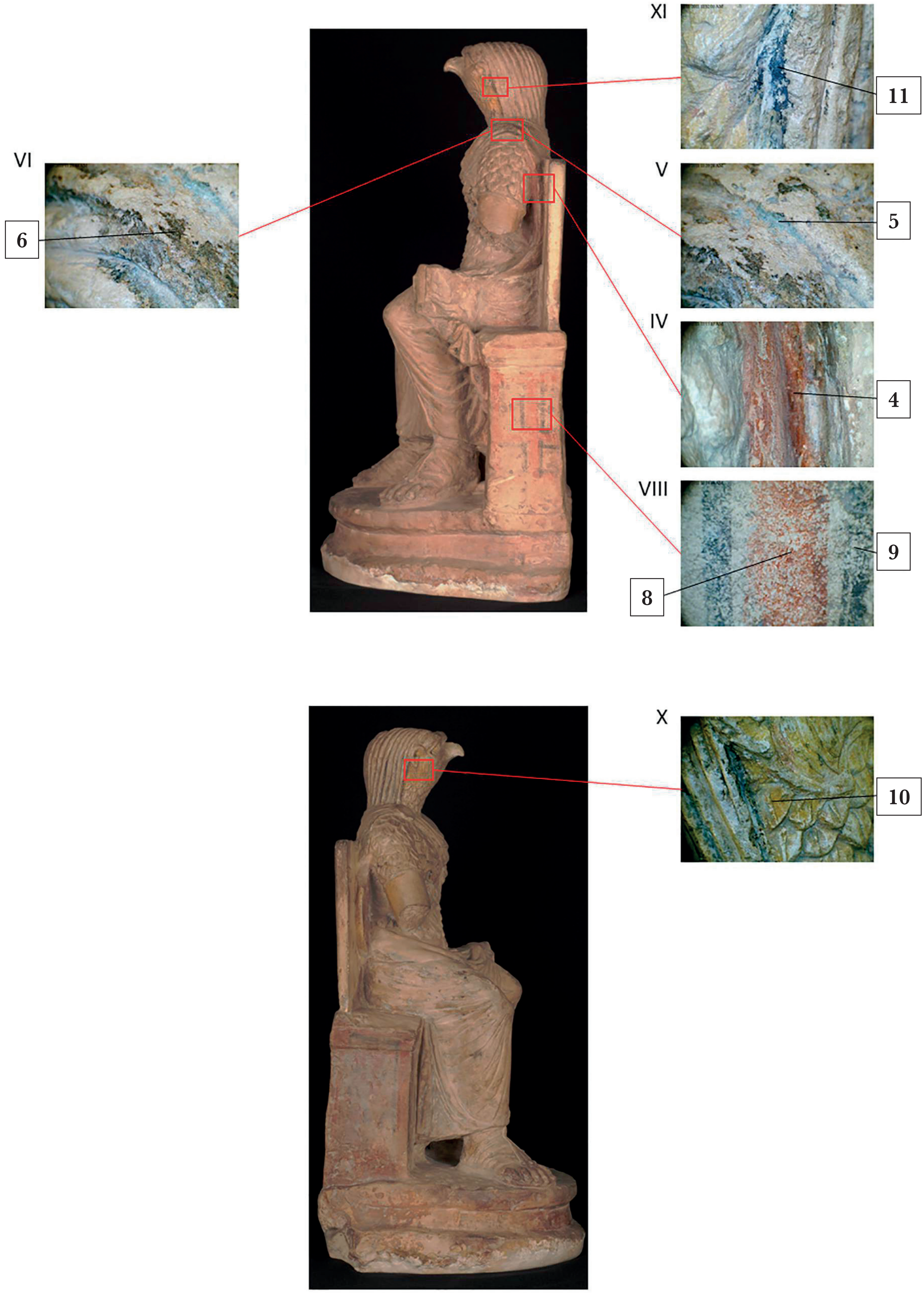

Figure 6. Detailed images of the traces of polychromy on the proper left side (top) and on the proper right side (bottom) of the sculpture (numbered with Roman numerals). Locations from which the samples listed in Table 1 were taken for analysis are also shown (indicated by Arabic numerals)

Figure 7. The front of the sculpture: (a) visible-reflected image; and (b) visible-induced luminescence image in the infrared range (800–1000 nm). Light white areas correspond to the presence of Egyptian blue

Comparing the VIL and visible-reflected images allows the spatial distribution of surviving Egyptian blue pigment to be mapped, and it is clear that its presence is much more extensive than was discernible with the naked eye. Traces can be seen around the outer rim of the eyes and possibly within the proper left eyeball, as well as in the folds of the cloak worn across the shoulders. Perhaps more dramatically, remnants are also evident on many of the feathers around the lower throat and ears, and the feathers or scales that make up the *lorica plumata*. Scattered particles are observed elsewhere on the figure, such as on the garment covering the lap, but these are likely to be due to contamination from other areas.

The ultraviolet-induced luminescence (UVL) image of the front of the sculpture is shown in Figure 8b. UVL images are particularly useful in locating the presence of organic materials and colourants. These include lake pigments, ancient binders or varnishes and many modern retouching or coating materials. In this case, no evidence was found for the presence of organic colourants, with only a slightly blue luminescence in some areas. Most of this is probably due to dust particles, although some may represent a coating over broken surfaces, such as on the sword hilt and arms. While there is little luminescence there are some very noticeable areas of absorption, which show as dark regions in Figure 8b and coincide with fills used to repair the object. These are visible to the naked eye (Figure 8a), but are much more evident in the UVL image. In particular, the areas of restoration in the beak, waist and base of the sculpture, as well as the back of the throne (not shown) appear dark. In addition, some areas of dull red and black pigments, discussed in the earlier section, appear darker in the UVL image. This is particularly evident on the proper left side of the throne (Figure 8d), which may suggest that the red and black pigments are red ochre (coloured by hematite, Fe_2O_3) and a carbon-based black respectively, consistent with the strong quenching properties of iron-based pigments and the strong absorption properties of carbon. The tentative assignment of the latter to a carbon-based black is supported by the infrared-reflected false colour image: see the black lines on the side of the throne in Figure 9. In infrared false colour images, carbon appears black as it absorbs in both the visible and infrared ranges. This is in contrast to areas that appear black in the visible image but red in the false colour image due to absorption in the visible but not in the infrared range. Such areas can be observed on the base and toes of the sculpture, Figure 9b.

Although these observations are informative, and to some extent may be indicative of the composition of the pigments on the sculpture, technical imaging alone cannot be used as a basis for pigment identification, which in this case was carried out by FTIR and Raman spectroscopy.

Pigment analysis

Table 1 summarizes the findings from the analyses with FTIR and Raman spectroscopy of samples taken from the sculpture, the locations of which are given in Figures 5 and 6.

Every sample analysed was found to contain calcite ($CaCO_3$), in keeping with the limestone substrate, and gypsum ($CaSO_4.2H_2O$), which may be present as a degradation product or may have been added as a preparation layer prior to the application of the paint. The latter is difficult to confirm, since samples were not taken from which cross-sections might be made to provide information on the stratigraphy of the pictorial layers. However, it is likely that a preparation layer such as gypsum would have been added before polychromy was applied to the porous surface of the limestone.

Figure 8. Visible and ultraviolet reflected images of the sculpture: (a) visible-reflected image of the front; (b) UV-induced luminescence image in the visible range (400–700 nm) of the front; (c) visible-reflected image of the proper left side; and (d) UV-induced luminescence image in the visible range (400–700 nm) of the proper left side

- *Black pigment*: Samples of black pigment taken from the cloak over the proper left shoulder (sample 6: Figure 6 VI), the edges of some of the feathers on the *lorica plumata* (sample 7: Figure 5 VII), the hairline behind the proper left ear (sample 11: Figure 6 XI), the rim of the proper left eye (sample 15: Figure 6 XVI) and the black lines decorating the sides of the throne (sample 9: Figure 6 VIII) were analysed using Raman spectroscopy. Bands at 1340 and 1595 cm^{-1}, characteristic of the presence of amorphous carbon, were found in the Raman spectra of samples 6, 9, 11 and 15, although none was identified in the spectrum of sample 7. This is consistent with observations made from the infrared-reflected false colour image of the black lines on the throne, Figure 9b. Since amorphous carbon is IR inactive, the FTIR spectra of the samples of black pigment are dominated by bands characteristic of gypsum and calcite, most noticeably at 3545, 3405, 3245, 1685, 1620, *c*.1100 and 670 cm^{-1} for gypsum and 1796, *c*.1420, 878 and 712 cm^{-1} for calcite. In addition, for all the black samples a band was observed at 798 cm^{-1} and the absorption for gypsum at *c*.3200 cm^{-1} showed a 'tail', while in some cases the bands at *c*.1100 cm^{-1} (gypsum, 1134 cm^{-1})

Figure 9. The proper right side of the sculpture: (a) visible-reflected image; and (b) infrared-reflected false colour image

and at *c*.1420 cm^{-1} (calcite, 1445 cm^{-1}) were displaced; this was more noticeable in certain cases, for example, sample 6. Sample 6 also displayed a broad band centred at 1620 cm^{-1} and a shoulder at 1370 cm^{-1}, features that suggest the presence of at least one additional species, perhaps an ochre.

- *Red pigment*: The UV-induced luminescence image (Figure 8d) indicated that the dull red colour of the horizontal and vertical crossing stripes on the throne (sample 8: Figure 6 VIII), was possibly due to red ochre (containing hematite), which was confirmed by Raman analysis of sample 8. Hematite was also identified in the samples taken from the back of the cloak on which the figure reclines (sample 4: Figure 6 IV) and from the feathers at the base of the neck (sample 12: Figure 5 XIII). The bands observed in the Raman spectra at 224, 291, 406, 500 and 611 cm^{-1} are characteristic of hematite. However, as all the samples contain a small proportion of other minerals, often including quartz, they are best described as ochres, rather than as pure hematite. The FTIR spectra of samples 4, 8 and 12 were also consistent with the presence of ochre; this was evident from a band at *c*.800 cm^{-1} (observed in all the samples) and the width of the band centred at 1100 cm^{-1}. Bands characteristic of gypsum and calcite, as listed above, were also observed in these samples.
- *Yellow pigment*: Most of the samples where hematite was identified also contained particles of goethite (α-FeO(OH)) and a small proportion of other crystalline material such as quartz, as expected in an ochre. Goethite was also identified as the yellow colour on the upper arms of the figure (sample 3: Figure 5 III), as well as on some of the feathers below the proper right ear (sample 10: Figure 6 X). The bands observed in these Raman spectra at 299, 386, 418, 482, 581, 681 and 999 cm^{-1} are characteristic of goethite, suggesting the use of a yellow ochre in these areas. In addition, the FTIR spectra of samples 3 and 10 contained bands characteristic of gypsum and calcite as listed above, while a band at *c*.800 cm^{-1} and the width of the band centred at 1100 cm^{-1} are consistent with the presence of an ochre, as mentioned above.
- *Blue-green pigment*: The VIL images strongly suggest that the blue pigment is Egyptian blue (Figure 7b), which was confirmed by analysis of samples taken from the cloak over the proper left shoulder of the figure (sample 5: Figure 6 V) and from under the proper left arm (sample 13: Figure 5 XIV). The bands observed in the Raman spectra at 432, 570, 1100 and 1086 cm^{-1} are characteristic of Egyptian blue. Bands attributable to Egyptian blue were also observed in the FTIR spectra for samples 5 and 13, most noticeably at 1163, 1060, 1007, 877, 798 and 670 cm^{-1}. In addition, several of the bands listed above as characteristic of gypsum and calcite were observed. Bands centred at 1620 and 1420 cm^{-1} and a shoulder at *c*.1360 cm^{-1} also suggest the presence of at least one additional species, which may be an ochre, and indeed yellow ochre (goethite) was identified in these samples by Raman spectroscopy. Mixtures of goethite and Egyptian blue to create a green are consistent with a bluish green colour on this region of the sculpture and accord with Egyptian practice at this period.
- *Green (earth) pigment*: The much duller green colour noted along the edges of the sword (samples 1 and 2: Figures 5 I and 5 II) and in the folds of the garment over the figure's lap (sample 14: Figure 5 XV), was identified as containing celadonite ($K(Mg,Fe^{2+})(Fe^{3+},Al)[Si_4O_{10}](OH)_2$), by FTIR spectroscopy. The bands at 3545, 3603, 3558, 3534, 1117, 1073, 971, 801 and 685 cm^{-1} observed in samples

Figure 10. Two digital reconstructions of EA 51100 (1912,0608.109), recoloured to suggest its original appearance: (a) an interpretation using saturated colours; and (b) using a softer palette. In both cases, colour has only been applied to those areas where analysis and imaging provided strong evidence for the original pigments; areas which have been restored or where there was no analytical evidence for polychromy are coloured grey

1, 2 and 14 are consistent with a green earth containing celadonite. Bands centred at 1620 and 1420 cm^{-1}, and a shoulder at *c.*1360 cm^{-1}, suggest the presence of at least one additional species, which may be an ochre. In addition, bands characteristic of gypsum and calcite, as listed earlier, were also observed.

- *Paint binders*: No clear evidence was found for the binder used as the medium for these pigments. This is not unusual for objects of this period; paints used on these surfaces tend to be lightly bound, and the hot and arid ambient conditions to which the objects have been subject are not conducive to the survival of such organic materials.

Colour reconstruction

The results from the technical imaging and analytical examination were used as a basis to create digital reconstructions suggesting how the sculpture might originally have looked, Figures 10a and 10b. Images of the object were processed in Adobe Photoshop v.6; each area to be recoloured was selected, using either the 'lasso' or 'colour range' tool, and allocated its own 'layer'. The selections in these layers could be filled with the colour suggested by scientific analysis, adjusted using the 'colour balance' tool and overlaid onto the original image. The individual coloured layers were then manipulated using Photoshop tools (blur, emboss, drop shadow, transparency effects) to obtain a visually convincing reconstruction. Where parts of the figure were missing, or no information from analysis was available, a grey tonality was applied.

Conclusions

Visible traces of red, yellow, green and black pigment evident on this limestone sculpture depicting the Egyptian god Horus in Hellenistic and Roman costume were investigated using a combination of visible-reflected, infrared-reflected, VIL and UVL imaging, along with FTIR and Raman spectroscopy. The palette used was found to consist of red ochre (hematite-containing), yellow ochre (goethite-containing), carbon black and green earth (celadonite-containing), as well as Egyptian blue, which was found to be present in far greater quantities than were visible to the naked eye. This palette was probably applied over a gypsum ground. No evidence of the binder used was found. While most of the palette is strictly within well-defined Egyptian traditions, the use of green earth (celadonite), one of the most common green pigments found in Roman art [13], is virtually unknown in dynastic Egypt [14]. All of the pigments are ancient, helping to confirm the sculpture's authenticity.

This evidence has been used to produce two digital reconstructions of the colour of the object, giving an impression of what it may have looked like originally. One version employs more saturated colours (Figure 10a), while the other uses a softer palette based on contemporaneous depictions of deities on painted wooden panels, Figure 10b [15]. It should be noted that without further information on the nature of the organic binding media an accurate rendering of the painted surface is almost impossible. Nevertheless, by considering information on the particle size of the pigments employed and comparisons to contemporaneous objects where large expanses of polychrome surface decoration remain, an impression of what this object may have looked like can be derived.

Experimental appendix

In situ *microscopy*

A VMS-004D ×400 USB microscope (×20 to ×400 magnification) was used to image details of the sculpture.

Technical imaging

All images were taken using a Canon 40D camera, modified by removing the inbuilt UV-IR blocking filter to exploit the full sensitivity of the CMOS sensor (*c*.300–1000 nm), and fitted with a Canon EF 50mm f/1.8II lens. A set of filters was used to select the appropriate range of wavelengths for the various types of imaging undertaken. The camera was operated in fully manual mode and a reference greyscale (a set of Lambertian black, grey and white tiles) was placed alongside the sculpture. These Spectralon® reference tiles have uniform reflectance properties across the ultraviolet, visible and infrared spectral ranges and show no luminescence properties. All the images were acquired as 'raw' images and transformed into 4256 × 2848 pixel resolution images in 16-bit TIF (tagged image file) format [9]. The images were then calibrated and processed using the VIPS/nip image processing package [16], and Adobe Photoshop CS2. The object was imaged from all four sides and selected results are shown in Figures 5–9.

- *Visible-reflected imaging*: The sculpture was illuminated by two photographic Classic Elinchrom 500 xenon flashlights equipped with softboxes (diffusers) that were positioned symmetrically at approximately 45° to the focal axis of the camera and at about the same height. A UV- and IR-blocking IDAS-UIBAR interference filter (bandpass, *c*.400–700 nm) was placed in front of the camera lens.
- *Infrared-reflected imaging*: The sculpture was illuminated as above and a Schott RG830 cut-on filter (50% transmittance at *c*.830 nm) was placed in front of the camera lens to block the visible component and investigate the range between 800 and 1000 nm. Infrared-reflected false colour images were produced by splitting the visible image into its red, green and blue (RGB) components and shifting the red and green components into the green and blue channels respectively. The values from the IR image were then inserted into the red channel.
- *Ultraviolet-induced visible luminescence imaging (UVL)*: Excitation was provided by two Wood's lamps (maximum output at 365 nm) positioned symmetrically at approximately 45° with respect to the focal axis of the camera; each source was fitted with a Schott DUG11 bandpass interference filter (280–400 nm). The emission from these sources is a relatively sharp line centred at 365 nm. A Schott KV418 cut-on filter (50% transmission at *c*.418 nm) and an IDAS-UIBAR bandpass filter (*c*.400–700 nm) were placed in front of the camera lens, in order to investigate the visible range (*c*.400–700 nm) [17].
- *Visible-induced infrared luminescence imaging (VIL)*: Excitation was provided by high power (1 W) red, green and blue LED sources. A Schott RG830 cut-on filter (50% transmittance at *c*.830 nm) was placed in front of the camera lens to block the visible component and investigate the emission of IR radiation in the 800–1000 nm region. In the monochrome VIL images, materials that emit IR radiation are recognizable as 'bright white' areas [9].

Fourier transform infrared (FTIR) spectroscopy

FTIR spectra were acquired with a Nicolet 6700 spectrometer attached to a Continuum IR microscope equipped with MCT/A detectors. The sample was analysed in transmission mode, flattened in a diamond microcompression cell. The cell was opened and the flattened sample supported on one diamond window, a clean area of which was used for background spectra. The field of view was controlled by the sliding aperture which, when fully open, gives a maximum area of analysis of 100 × 100 μm. The spectra, which were acquired over the range 4000–650 cm^{-1} using 32 scans at a resolution of 4 cm^{-1} and automatic gain, were identified by comparison with inbuilt databases.

Raman spectroscopy

Raman spectroscopy was carried out with a Jobin Yvon LabRam Infinity spectrometer using green (532 nm) and near IR (785 nm) lasers with maximum powers of 2.4 and 4 mW at the sample respectively, a liquid nitrogen cooled CCD detector and an Olympus microscope system. Samples of a few grains were collected using a clean scalpel, placed onto a microscope slide and measured without any further treatment. The resultant spectra were identified by comparison with a British Museum in-house database.

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Notes

1. Deities seated on high-backed chairs in this pose are common, see for example the contemporaneous sculptures of Serapis found in Egypt that are now in the Bibliotheca Alexandrina Archaeology Museum (BAAM 247, dated to the Roman period) and the Fitzwilliam Museum (Loan Ant.103.93, dated AD 100–300) or found in Cyprus and now in the Fitzwilliam Museum (GR.1.1891, dated AD 100–200). In earlier periods, depictions of the falcon-headed Horus seated are typically in traditional Egyptian style: frontal, on a low-backed chair, knees together and wearing an Egyptian kilt; a rare Roman period example is the terracotta figure in the Musée du Louvre (AF 1045).
2. Roman period depictions of the falcon-headed Horus wear nemes headdresses sometimes with the combined white and red crown. Examples wearing nemes headdresses include: a sandstone sculpture in equestrian pose in the Muséee du Louvre (E 4850); a seated terracotta figure in the Musée du Louvre (AF 1045); a standing copper alloy figure in the British Museum (EA 36062); busts in the Musee d'Archéologie Méditerranéenne, Marseille (MAM 1300) and Ashmolean Museum (AN1964.181). Examples wearing the combined red and white crown with the nemes headdress include: a copper-alloy weight(?) in the form of a bust in the British Museum (EA 36053) and standing copper alloy figures in the Musée du Louvre (E 16265, E 10666 and E 7977).
3. A copper alloy figure found at Kingham, Oxfordshire, dated AD 50–150 is in the collection of the Ashmolean Museum (AN1964.181).
4. Between 1912 and 1916, Mohassib sent two or three letters each year in reply to Budge; these are archived in the Department of the Middle East at the British Museum.