Diversamente bianco
la policromia della scultura romana

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'In picturae modum variata circumlitio'?: the reconstruction of the polychromy of a Roman ideal female head (Treu Head)

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Introduction

The purpose of this article is to re-acquaint a wider scholarly public with the 'Treu Head', a Roman marble head in the British Museum (BM GR 1884,0617.1 / SC 1597) that retains rich traces of its original polychromy and has recently been extensively examined scientifically.[4] The results of this examination, which included both non-invasive and invasive methods, are of considerable significance and secure the 'Treu Head' a prominent place in the discussion of ancient sculptural polychromy – a place it held in the late nineteenth century, before doubts about its authenticity set in. The recent study was designed to address these lingering doubts, which had remained unresolved for more than half a century, to compare the state of preservation of the pigments on the head now to that at the time of its discovery and, most importantly, to expand our general knowledge of ancient sculptural polychromy by bringing to bear the latest investigative scientific techniques.

For the first time, it is now possible to compare in some detail the pigments and painting techniques applied to marble sculpture with those used for contemporaneous two-dimensional panel painting, in particular painted funerary (also known as mummy or Fayum) portraits from Roman Egypt. Importantly, the results also provide evidence for some of the technical details and artistic refinements experimentally introduced for visual effect in painted modern reconstructions of ancient marble sculptures, but not always hitherto clearly confirmed on ancient originals.[5] This is especially true with regard to the skin tone, the rendering of the eyes and

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[4] Verri *et alii* 2010.

[5] For these, see the various reconstructions presented in the 'Bunte Götter' series of exhibitions and catalogues; for the most recent, cf. Brinkmann – Scholl 2010.

certain stylistic devices, such as the positioning of highlights and shadows. Prior to the planned creation of a physical painted replica, we suggest here a new way of developing a two-dimensional reconstruction of the head's original polychromy that is based on selected and particularly appropriate ancient parallels identified through our ongoing research and scientific analysis.

Methodology

The examination of the Treu Head started with an investigation of the physical history of the head. This first step allowed research questions to be framed: what painting materials were used to paint the sculpture? The extent of surviving pigment showed promise in revealing the answer to this and a very important additional question: can scientific investigations provide useful information on the painting technique used? In most cases, the surviving original material on Greek and Roman sculpture is so fragmentary that only a list of pigments, and in some fortunate cases binders[6] or organic colorants,[7] can be provided. Very little information is known today on the painting technique used by the ancient artists: i.e. in what sequence were the colours applied? How were they mixed together to achieve particular effects? How many layers are present? Finally, and perhaps most importantly, what was the 'original' appearance of the sculpture? In addition, as reported in Verri *et alii* 2010, the technical examination of the head was instrumental in proving that the head, and its polychromy, is an original Roman work of art and not the product of a forger, as discussed below in more detail.

Based on the scientific investigations undertaken in 2010, the head is now shown to be an original 2nd century AD ideal female portrait. The polychromy on the sculpture is also shown to be original. Following visual observations with the naked eye and under magnification, imaging techniques were applied in the attempt to map the presence of pigments and painting materials in general. Ultraviolet- and visible-induced luminescence imaging, UIL and VIL respectively, provided valuable information on the distribution of Egyptian blue and madder lake. Egyptian blue is possibly the earliest synthetic pigment used in antiquity[8] from approximately 2500 BC. The use of the pigment declined after the end of the Roman Empire, although a recent study identified it in a painting from AD 1524.[9] In the VIL image,[10] Egyptian blue shows as glowing white against a grey background, while, in the UIL image,[11] madder lake shows a typical orange emission. On the basis of both visual observations and imaging, sampling areas were identified for Raman and Fourier transform mid-infrared spectroscopy (FTIR), scanning electron microscopy with energy dis-

[6] Bartolucci *et alii* 2009.
[7] Brinkmann – Scholl 2010.
[8] Riederer 1997.
[9] Bredal-Jorgensen *et alii* 2011.
[10] Verri *et alii* 2008a, Verri 2009 a, Accorsi *et alii* 2009, Verri 2009 b.
[11] Verri *et alii* 2008 a, Verri *et alii* 2008 b.

persive X-ray spectrometry (SEM-EDX), high performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS). More detail on the experimental set-ups is provided in the technical appendix at the end of this paper.

Great importance was given to comparative materials, such as other painted stone sculptures, terracottas and Fayum portraits from Egypt. The surviving pigments on the head and their stratigraphy were closely compared to such works of art in order to increase the understanding not only of the pigments used, but of the painting technique employed to create the polychromy on the sculpture.

The results of such comparisons are reported below.

The Treu Head

The Treu Head (GR 1884,0617.1 / SC 1597, see Fig. 1) is a life-sized, female head carved from Parian marble (see below). It measures 21.5 cm from chin to crown and 37.5 cm including the neck, which was fashioned with a tenon for insertion into a draped body.[12] The sculpture is well preserved, only the very tip of the nose and the bottom front section of the tenon have broken off and are now missing. The top and back of the head were only roughly finished. The marble was cut back here beyond the natural profile, creating two downward-sloping, angled planes. In antiquity, there was a metal dowel in the back of the crown (see Fig. 2), which has since been removed.[13] Above the ears, a section of hair on either side was added as a separate piece of marble, also fixed with metal dowels. These fragments had been removed at some point during the 20th century and then become separated from the head.[14] They were recently re-identified unregistered in the store-rooms, examined scientifically and have now been re-attached to the head.[15]

The head is turned to the left, with the lips slightly parted. The face is even, with a strong chin and high cheekbones, framed by a simple coiffure. The hair is parted in the centre and leads upwards and to the back in parallel, wavy strands. A short, forward-curving, sickle-shaped lock falls down in front of each ear. In the back, the hair is gathered in what appears to be a thick, loose plait, its shape only broadly roughed out in the marble. In places, the strands of hair above the forehead are divided by deeply drilled grooves. These in turn are crossed by thin marble bridges. This sculptural technique can first be found on the later portraits of Hadrian and then becomes

[12] The tenon is relatively shallow and varies in thickness from circa six to nine centimetres.

[13] This dowel was removed in 1889, presumably to prevent damage to the marble through metal corrosion. It was then registered as GR 1884,0617.2.

[14] Presumably this was also done to prevent further damage through corrosion of the dowels; the marble around the dowel holes shows dark, orangey discolorations and one of the fragments has broken in two, with the line of the break running through the dowel hole.

[15] The fragments were reattached with spots of polyester resin and, because of the limited contact between the back of the fragments and the surface of the head, recess fill them with a mixture of Paraloid B72 in acetone/IMS 20% with micro balloons and retouched with acrylic washes to match the colour of the marble. This treatment is considered re-treatable.

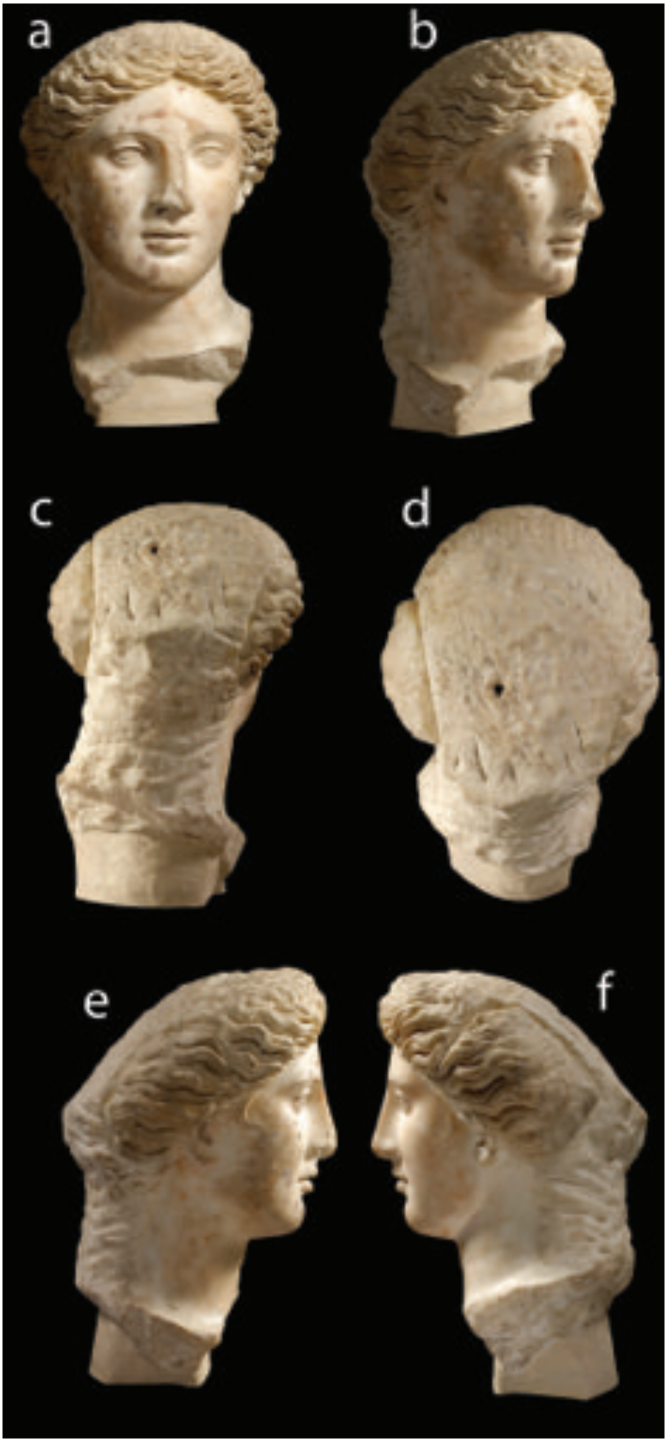

Fig. 1. The Treu Head (GR 1884,0617.1 / SC 1597). a) front view; b) three quarters view; c) back view; d) top view; e) proper right view and f) proper left view.

more common in the Antonine period, suggesting a date for the head in or after the AD 140s-150s. In the eyes, the marble surface was left unmarked, more of an indication perhaps that this was an ideal head rather than a meaningful dating criterion. Ideal heads frequently, though not exclusively, were rendered with painted (presumably) rather than drilled pupils, even after drilled pupils had been widely introduced for portrait heads. An example for the combination of portrait statues with drilled pupils and ideal statues with painted pupils in the same monument is the nymphaeum of Herodes Atticus at Olympia, dated to the AD 150s.[16] Ideal female heads with this type of coiffure were commonly used for representations of Aphrodite-Venus and Athena-Minerva (see below). The treatment of the top and back of the head might suggest the presence of an additional element that concealed the only roughly worked and therefore rather unsightly marble surface here. This may have been a veil, added in stucco or carved in marble in one piece with the missing body, so that the head in its current state would have been slotted into the resulting cavity.[17] However, the shallow tool marks in this area do not correspond to those normally found on surfaces prepared for the addition of stucco, and the fact that a braid was indicated, at least in outline, at the back of the head makes the presence of a marble veil unlikely. Perhaps the additional element was therefore a bronze helmet, which could mark the figure out as Minerva.[18] A parallel can be found in the head of Minerva (see Fig. 3) in the British Museum (BM SC 1571). It has a coiffure not dissimilar to the Treu head, including the plait at the back (here carved in more detail). It was mounted on a modern bronze bust and given a bronze Corinthian helmet by the 18th-century restorer Carlo Albacini, based on good ancient parallels.

Fig. 2. The iron dowel (GR 1884,0617.2).

Archive material in the British Museum suggests that the Treu Head was discovered in early 1884 on the Esquiline Hill in Rome.[19] This was the period of Rome's

[16] Bol 1984.

[17] For this technique see for example a female statue from the so-called Library of Celsus in Ephesus, now in Vienna (Kunsthistorisches Museum, inv. ANSA I 852).

[18] This seems more likely than the previously proposed presence of a meniskos (cf. Treu 1889, 19); the ancient dowel hole in the crown is not placed centrally but a little to the left and at an angle that would place a meniskos too far back.

[19] While the exact date of discovery is not given, in combination the various documents cited below give the impression that not much time had lapsed between its discovery and Newton's first sight of it, cf. below notes 15 and 16. Coincidentally, the Minerva sculpture (BM Sc 1571) also is a Roman marble head from the Esquiline.

Fig. 3. Minerva (BM SC 1571). a) front view; b) proper left view. The coiffure and the treatment of the hair of the Minerva at the British Museum are very similar to those of the Treu Head.

rapid urban expansion following its recent designation as capital of the newly unified Italy. In antiquity, this area was particularly known for its richly decorated imperial gardens.[20] The head's exact provenance on the Esquiline was, however, deliberately never officially disclosed by the finders.[21] It may have come to light during the construction work connected to the laying out of Via Nazionale and the streets south of Stazione Termini (the former Villa Montalto), but this remains speculative.[22] In antiquity, this area contained important sanctuaries, for example of Venus Erycina and Minerva Medica, and the vast Gardens of Sallust. [23]After its discovery, the head was immediately given (or more likely sold) to the well-known Roman dealer Francesco Martinetti, in whose premises it was seen in early March 1884 by Sir Charles Newton of the British Museum. Newton was particularly struck by its unusually well-preserved polychromy that, remarkably, included a pinkish skin tone. While excavating the remains of the Mausoleum at Halicarnassos, he had become very interested in the original colouring of ancient sculpture.[24] It seems that he at once expressed a wish to purchase the head, and accordingly in April Martinetti sent the sculpture to London.[25] In June, Newton formally recommended its acquisition to the Museum's Trustees, specifically on account of its well-preserved colour traces.[26] This was duly

[20] For the horti of Republican and Imperial Rome cf. Cima – La Rocca 1998 with further literature; for the Esquiline gardens in particular see Wiseman 1992, Wiseman 1998 and Häuber 1998.

[21] For the circumstances of the discovery see a letter of 13.12.1888 (cf. below, note 29).

[22] For an account of Rome's fast-paced urban development in this period and the main archaeological discoveries associated with it, see Lanciani 1988.

[23] Cf. Häuber 1998.

[24] Jenkins 2006, 34-44.

[25] Cf. Department of Greek and Roman Antiquities, Letter books, 1883-1884, nos. 212-213: two letters by Martinetti to Newton. The first asked by which mode of transport the head should be consigned to London (fast and expensive or cheap but slow), the second gives details of the elaborate crating that was meant to ensure the preserved colour was not damaged.

[26] Cf. Department of Greek and Roman Antiquities, Reports 1882-1884, 293-294 (11 June 1884): "[…] It represents a fine type and is in excellent condition. On many parts of the surface may be seen the remains of the original ground of the colour with which it has been painted. These traces are rarely to be met with in ancient sculpture & give this head a peculiar interest."; Department of Greek and Roman Antiquities, Minutes etc. 1882-1884, p. 426 (14 June 1884): "[…]

granted; the head was registered as part of the Museum collection on 16 June 1884 and soon put on display. Its first recorded location in the Museum's sculpture galleries was by a doorway leading from the so-called First Graeco-Roman Room to the Second, a fairly prominent position near the beginning of the run of the ground floor classical sculpture galleries suitable for the brief introductory remarks on ancient polychromy given on the label.[27]

Here it was seen in c. 1887 by the German scholar Georg Treu (1843-1921), who equally seems to have immediately recognised its significance for the study of ancient sculptural polychromy, a topic that concerned him greatly in those years.[28] Together with some colleagues at the BM, Treu studied the head very closely and made careful notes, copies of which he afterwards sent back to London, asking the Museum staff to verify their accuracy. In addition, he requested photographs and a watercolour of the head that should carefully document the colour traces before they might fade.[29] Treu went on to present his findings in a lecture at the Berlin Archaeological Society in 1888, and in the following year published an article on the head (including a reproduction of the watercolour) in the Jahrbuch of the German Archaeological Institute.[30] This article was widely read and ensured that the London head was illustrated and prominently mentioned in subsequent studies of ancient sculptural polychromy.[31]

When the head arrived at Martinetti's, it was still partially covered in moist soil.[32] In places where the cloth with which it had been covered had rubbed against the head and removed some of the soil, traces of a reddish-white skin tone, which in the moist conditions had the 'consistency of an oily paste', could be observed. Because of this, the marble was not cleaned mechanically or washed, as would have been the normal practice at the time. Instead, the head was merely exposed to the

a female marble head, lately discovered, in excellent condition […] The head is of special value from the remains of the original ground of colour which can be traced in many parts of its surface". Newton's request for leave to go to Rome and view antiquities from the collection of the late Alessandro Castellani prior to their sale in Paris, ibid., p. 381 (23 February 1884). It was during this trip that he also saw the Treu Head at Martinetti's.

[27] This location is attested in a letter by Georg Treu, cf. Department of Greek and Roman Antiquities, Letter books, 1888, no. 356 (see also below, note 29). While the exact label text is not recorded, it is likely to have echoed the entry in a later printed gallery guide: "1597. A head of Venus (?) from Rome, which retains to a marked extent the flesh tint with which ancient sculptures were probably often covered, although in most cases it does not survive." *Guide* 1899, 71 no. 29*.

[28] On Georg Treu (1843-1921), excavator at Olympia and long-time director of the sculpture collection at the Albertinum in Dresden, see *Albertinum* 1994. For Treu's interest in polychromy see Knoll 1994. Still well worth reading is Treu's own essay, Sollen wir unsere Statuen bemalen?, Berlin 1884. It is in Treu's honour, that we refer here to the marble head as 'Treu Head'.

[29] Cf. Department of Greek and Roman Antiquities, Letter books, 1886-1887, nos. 561 (8 November 1887); 562 (7 December). Ibid., 1888-1889, nos. 356 (no date – these may in fact be the 'notes on a separate sheet' mentioned in the letter of 8 November 1887); 358 (3 February 1888); 360 (15 November 1888); 361 (13 December 1888). The original watercolour by F. Anderson of the British Museum was sent to Dresden and is now lost.

[30] Treu 1889.

[31] Collignon 1898, 68-71 fig. 4; Richter 1929, 116 fig. 459; Reuterswärd 1960, 20, 31, 193, 220, fig. 30; Østergaard 2008, 50 figs. 42-43.

[32] This account is based on information Treu gleaned from the archaeologist Wolfgang Helbig, which he communicated in a letter to the BM and repeated again almost verbatim in his published article (Treu 1889, 19-20).

sun, which caused the soil to dry out and fall off as dust, while apparently leaving the pigment mostly intact. It is this very fortunate decision not to clean the head in the short space of time immediately after its discovery, that has made the following study possible.[33] Perhaps this was partly due to the presence of the archaeologist Wolfgang Helbig (1839-1915), a noted expert on ancient art, who happened to be at Martinetti's when the head was brought in.[34]

In his 1889 article, Treu carefully listed the pigment remains that could still be observed by eye:[35] The brows were drawn in black directly on the marble surface, followed underneath by a parallel line in red. The lids, too were framed in black with an outer line in red. Above the upper lid, this red line was interrupted, perhaps where there had originally been painted lashes. The pupil and outer rim of the irises were also rendered in black. The irises were half-covered by the upper lid, leaving only a semicircle, a stylistic phenomenon well known from sculptured Antonine portraits with drilled pupils and incised irises. The reddish-white skin tone, preserved in patches all over the surface of face and neck, also covered the lips. The hair (only the carved sections) was covered in a light yellow, with individual strands and the locks in front of the ears highlighted in a reddish-brown. A narrow strip of light yellow pigment continued beneath the plastically rendered locks above the forehead, providing a smooth transition between hair and skin tone.

Treu's observations, frequently set into context through comparison with other marbles, particularly in the Dresden collection, have proved highly detailed and accurate. Even where no pigment was visible by eye, his proposed restorations, as will be shown below, have proved entirely correct.[36] Given his pioneering interest in ancient sculptural polychromy and remarkable expertise in this field, Treu's exasperation (expressed privately to his colleagues in London) with scholars who doubted the authenticity of the head, or at least of the pigment on it, is perfectly understandable. It did prompt him, however, to be particularly thorough in his research.[37]

[33] Given that even today, almost 130 years after the discovery of the Treu Head, in far too many excavations in the Mediterranean and Near East ancient marble sculpture is still routinely washed and soil crudely scraped off with a brush without any regard to potential pigment residues, this is the more remarkable. It underlines once more how important it will be in the near future to raise awareness of sculptural polychromy among excavators in the field.

[34] Helbig's presence is reported in Treu's letter of 13.12.1888 (Department of Greek and Roman Antiquities, Letter books, 1888-1889, no. 361). For Helbig, see also Moltesen 1987.

[35] Treu 1889, 20-21.

[36] This included for example a separate red for the lips and tear ducts, as well as a further pigment, such as blue, mixed in with the white of the eye, cf. Treu (1889), 21-22.

[37] Treu mentioned Adolf Furtwängler (1853-1907), professor of archaeology and museum director. In his letter of 15 November 1888 (see above, note 19), Treu says: "[…] Furtwängler und Loeschke nämlich, welche den Kopf neulich in London sahen, scheinen mir nämlich an der Echtheit der Bemalung insbesondere der Gesichtshaut zu zweifeln; und zwar begründen sie ihre Zweifel damit, dass die Fleischfarbe sich auch auf der Versinterung finde. Ich halte nun diese Zweifel für völlig unbegründet und auch den angeführten Grund für durchaus nicht stichhaltig: die Farbe wird eben in der Erde oder bei Waschungsversuchen nach der Auffindung feucht geworden und auch über den Sinter geflossen sein. Da jenes Bedenken aber wahrscheinlich irgendwo auch öffentlich ausgesprochen werden wird, so habe ich es doch für wünschenswert gehalten, alle Tatsachen festzustellen, welche irgend geeignet scheinen die Echtheit für alle Welt außer allem Zweifel zu setzen."

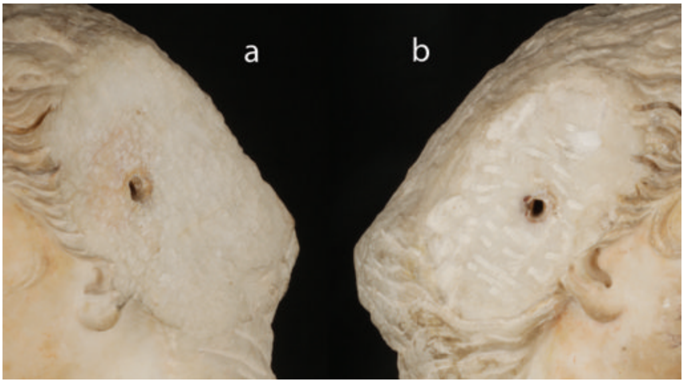

Fig. 4. The Treu Head. detail of the tooling on the proper left (a) and right (b).

In the British Museum, the head's relative status can be traced through a series of gallery guides. By 1899, it had been moved, somewhat out of context, into the so-called Ephesus Room, where an undated photograph shows it in a glass case under a protective, diaphanous cloth. Some twenty years later, however, it seems to have been removed from display.[38] This may have been prompted by a general reorganisation of the galleries after the First World War, but it seems that eventually the head's authenticity was doubted even by curators at the British Museum. At some time before 1960, P. E. Corbett of the Museum wrote to the Swedish scholar P. Reuterswärd, who was then in the process of researching his book on ancient sculptural polychromy, that he was "not absolutely certain that the head has not been tampered with in modern times, or even that it is ancient". He was particularly troubled by the modern-looking tool marks that showed on the sides of the head where the separately carved marble sections would join. These tool marks do indeed look unusual. On the left side of the head, the surface of the join appears fairly smooth, with only shallow, short pick marks, whereas on the right, there are much longer and wider, irregularly placed chisel marks.

Reuterswärd, although he never actually saw the head himself, quoted Corbett's reservations in a footnote; nevertheless, he discussed it in the text along with an illustration, albeit with a caveat as to its authenticity. [39] The uneven treatment of the two surfaces and the peculiar tooling could possibly be explained by a modern intervention (carried out at Martinetti's?) – perhaps the fragments had become loose on their dowels and had to be re-attached more securely.[40] What is more puzzling, however, is the fact that they do in fact appear somewhat smaller than the surfaces prepared to receive them.[41] In view of the high technical competence with which the head was

[38] Cf. *Guide* 1899, 71 no. 29*; (1902), 78 no 29*; (1908), 80 no. 1597; (1912), 88 no. 1597. It is not included any more in the 1920 guide and the following editions.

[39] Cf. Reuterswärd 1960, 193.

[40] However, there are other instances of different tool marks on the same ancient piece, cf. for example an early Hellenistic marble head of Asklepios from Kos, now in the British Museum (BM Cat Sc 550).

[41] This was not mentioned by Treu or Corbett.

carved, this is hard to interpret; perhaps it is due to some problems that occurred when the proposed metal helmet had to be added in antiquity.[42]

A careful examination of the fragments has now, however, made absolutely clear that they belong with the rest of the head (see below) and fully vindicated Treu against his critics. Had the scientific means available at the time, Treu would undoubtedly have carried out much of the research described here 130 years ago. In a letter of 15 November 1888, he offered to pay for a chemist to examine the pigments and wax content, that is, binding medium.[43] This task has now been largely fulfilled.

The analysis of the Treu Head and comparative materials

As mentioned in the Methodology section, the colour reconstruction is based on the comparisons with other artworks. The comparison with contemporaneous 2nd century mummy portraits from Egypt[44] was particularly useful. As described in detail below, many similarities were observed between the Treu Head and two portraits in particular; the skin tones, the shadows and the highlights, the eyes and the mouth of the Treu Head were rendered in a very similar way to 2nd century funerary portraits from Egypt. However, it should be highlighted here that some of the comparative material used in this study is not of the same date as the Treu Head[45].

The comparison between the technical examination of the Treu Head and other ancient works of art is separated in facial features and carried out considering the phase of application of painting materials on the marble surface, starting from the sealant, continuing with the paint layers and ending with the application of organic translucent glazes. No evidence of a final protective coating could be found. This approach takes into account the sequence of application, illustrated at the end of the paper, of the painting materials.

Stone support

Three marble samples were analysed. Sample TH1 was taken from the lower section of the head, sample TH2 from the hair fragment belonging to the proper right of the head and sample TH3 from hair fragment belonging to the proper left of the head. The petrographic study of the three marble samples revealed typical features of a fine-grained very pure marble (the only 'impurities' are finely dispersed graphite

[42] In addition, there is damage to the marble along the edges, particularly where the strands of hair on the fragments join the main part of the coiffure.

[43] Cf. above, note 29.

[44] Walker – Bierbrier 1997.

[45] The comparison with non-contemporaneous artworks is a debatable operation and the authors clearly see the limits and dangers of such tools. However, as very little is known at present on ancient Greek and Roman painting techniques on stone, any reasonable comparison that may provide an insight on the subject is welcome at this stage.

particles) with an equilibrium mosaic fabric and curved, sometimes straight, calcite crystal boundaries (see Fig. 5a-c and Table 1). The study also clearly shows that all samples share identical minero-petrographic characteristics in agreement with those of the best quality Parian marble from the quarries of Stephani in the Island of Paros, Greece (Fig. 5d).

OBJECT	Sample	Fabric		Calcite Crystals Boundaries	M.G.S. mm	Carb.m./ Graphite	$\delta^{18}O$ PDB (-)	$\delta^{13}C$ PDB(+)	Probable provenance
HEAD	TH 1	HE	Mosaic	curved	0.96	++	3.58	5.05	Stephani, Island of Paros (GREECE)
PROPER RIGHT	TH 2	HE	Mosaic	curved	1.44	+	3.69	5.10	Stephani, Island of Paros (GREECE)
PROPER LEFT	TH 3	HE	Mosaic	curved	0.98	++	3.94	4.98	Stephani, Island of Paros (GREECE)

Tab. 1: minero-petrographic and isotopic analysis of the the Treu Head.

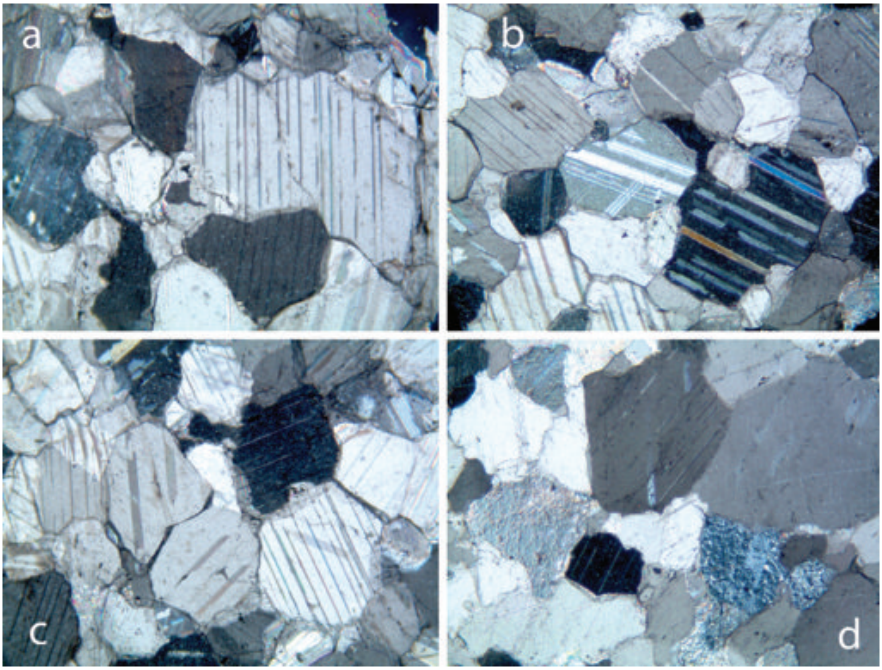

Fig. 5. Photomicrographs of the thin sections. a) sample TH1 from the lower section of the Treu Head; b) sample TH2 from the proper right fragment; sample TH3 from the proper left fragment; d) marble sample from the Lychnites quarries of Stephani, Island of Paros, Greece. All samples show a slight heteroblastic fabric formed by calcite crystals with curved boundaries. N+, long side = 2.5 mm.

In this locality marble was mined at least from the Greek archaic period from galleries illuminated with oil lamps (hence its ancient Greek name of Lychnites, from lychnos, lamp) to follow the natural dipping of the outcrop (Lazzarini, 2007). The identification of the three marble samples as Lychnites was confirmed by isotopic analysis (Table 1, Fig. E) showing very close values for ^{18}O and ^{13}C.

This results indicate that the head and the two fragments are carved in the same marble; the small differences in the oxygen values (negativisation) can be attributed to a different level of alteration during burial (exchange with the oxygen of groundwater) of the different parts of the head. That the marble is slightly deteriorated is also proven by the presence in all the three samples of a weak inter-and-intracrystalline decohesion of the calcite grains. In conclusion, the minero-petrographic and isotopic analysis proved that the two hair fragments are carved in the same marble as the head and are therefore from the same sculpture.

Sealant and organic binder

GC-MS and FTIR investigations revealed no evidence for the use of an organic material, such as egg, animal glues, waxes, oils or gums, to seal the surface of the stone prior to the application of paint. Similarly, no evidence of an organic material used to bind the pigment particles could be found in any of the paint layers. However, some areas of the skin around the neck and the cheeks show a high sheen or 'waxy' appearance under the naked eye, as observed by Treu. In addition, UIL imaging showed the presence of yellow luminescence around the eyes and mouth, possibly corresponding to the presence of a sealant (see below). Although the scarce evidence does not allow any conclusive argument for the identification of binders and sealants, their use cannot be excluded and the negative results could be due to the small sample available for analysis, the small amounts of surviving organic materials within the samples or their complete degradation or mineralization. The cross section analysis of sample TH2 revealed the presence of a red-brown superficial layer or scialbatura[46] atop the marble support[47] (maximum thickness 0.32 mm), possibly corresponding to original polychromy (see Fig. 7a).

The scialbatura shows the typical optical behaviour of a calcium oxalate patina: FTIR analysis confirmed the presence of weddellite ($CaC2O4 \cdot 2H2O$) together with calcite. The very thin red layer on top of it is formed by hematite as confirmed by its optical properties. SEM analysis of the section confirmed the presence of iron (Fig. 7b), with traces of silicon and aluminium. The presence of the scialbatura may suggest the use of lime mixed with an organic binder as a preparatory layer; over time, the former has carbonated forming calcite, while the latter has mineralised forming weddellite. The penetration of the red pigment in the scialbatura layer may suggest that the paint

[46] Italian term for a calcium oxalate patina, commonly brown-orange in colour because of iron oxide impurities.

[47] Lazzarini – Salvadori 1989.

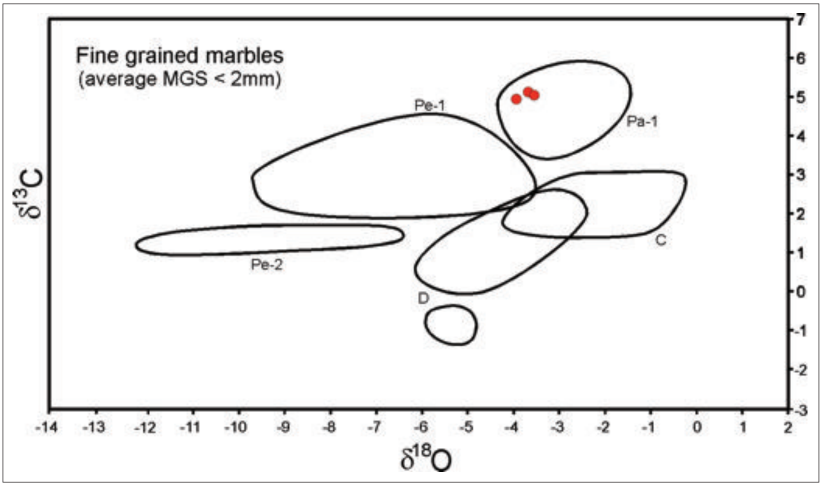

Fig. 6. Isotopic analysis of the three samples. Reference diagram of the principal fine-grained marbles used in antiquity. Pe = pentelic; Pa-1 = Parian from Stephani, C = Carrara, D = Docimaean.

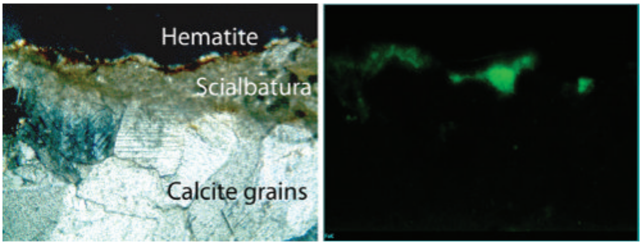

Fig. 7. Micrographs of thin section TH2 (hair fragment belonging to the proper right of the Treu Head. a) a layer of hematite can be seen atop a calcium oxalate-containing scialbatura; b) SEM iron map of cross section a).

was applied when the preparation was still wet. However, a mixture containing calcium carbonate and an organic binder cannot be excluded at this stage.

Underdrawing

A preliminary linear drawing, or underdrawing, was traced with a carbon-based (amorphous carbon) black pigment. The underdrawing was found in the outline of the eyes, the irises, the pupils, the eyelashes and the eyebrows. The black line drawing is considered an underdrawing, as opposed to a final layer, because it is found under the flesh tones and the white of the eyeballs. Fig. 8 a-g shows details of the black underdrawing of the eyes of the Treu Head under magnification. The black pigment seems to have been applied directly onto the surface of the marble. This preliminary paint layer is what Treu observed and reported in his article and watercolour[48]. A

[48] The use of preliminary drawings and setting out lines prior to the application of colour should not be considered surprising; although chronologically and geographically different from the Treu Head, a

line drawing, possibly similar to that observed on the Treu Head, can be seen on the eyes and eyebrows of the sculpture of a Wounded Amazon recently excavated at Herculaneum, Naples, Italy, Inv. No. 87021 (see Fig. 8).[49] It is unclear whether this line drawing corresponds to the final paint layer or to a preliminary drawing for

Fig. 8. The underdrawing of the eyes of the Treu Head: a) locations of the areas observed under magnification; b) underside of the proper right eye (x20); c) as (b) (x100); d) external area of the proper right eye (x20); e) as (d) (x100); f) external area of the proper right eyebrow (x20); g) as (f) (x200). The carbon-based black underdrawing can be seen below the skin tones in many locations, see (e) and (g); h) head of a wounded Amazon from Herculaneum, Naples, Italy. The outline of the eyes, irises, eyelashes and eyebrows is carefully drawn using a red pigment, while the pupils are executed using a brown pigment. The hair is painted with a seemingly uniform red pigment. It is unclear whether this paint layer is intended to be an underdrawing or the final stage of the composition. The head was photographed during the conservation treatment and still retains some of the burial deposits on the hair, the cheek and the neck.

preliminary drawing of the eyes, as well as setting out of lines along the profile, the philtrum (or infranasal depression) and the nostrils, can be clearly observed on the brown quartzite head of Queen Nefertiti from Tell el-Amarna (18th Dynasty, reign of Akhenaten, 1372-1355 BC; JE 59286) at the Cairo Museum, Egypt (El-Shahawi 2005, entry 121, 197). The black and red line drawing and the setting out marks were used by the artist to help preserve the symmetry during the carving process and to inform later stages in the creation of the object.

[49] Moesch 2008.

other now-lost paint layers. Although earlier in date (second half of the 1st century AD), the comparison with the Treu Head may suggest that the surviving paint on the Wounded Amazon in Naples may correspond to a remnant of a preparatory drawing, not to the final layer. However, it is also possible that different painting styles were used in the same period: our present knowledge of ancient polychromy on stone does not allow us to exclude that some sculptures could have been entirely painted in an attempt to imitate reality, while some others were only highlighted, for example, the eyes, the mouth and the hair using relatively simple line drawings.[50]

Skin tones, Highlights and Shadows

The skin tones were executed using a sophisticated mixture of, in decreasing amounts, calcium carbonate (present as both calcite and aragonite, two polymorphs of $CaCO_3$), red ochre (the colouring principle is hematite, α-Fe_2O_3), yellow ochre (the colouring principle is goethite, α-$FeO\cdot OH$, or limonite, $FeO\cdot nH_2O$), carbon-based black (amorphous carbon) and Egyptian blue ($CaCuSi_4O_{10}$). The average thickness of the skin tone layer is approximately 70 μm, while that of the highlights and shadows is often around 10 μm. The presence of calcium carbonate makes the paint layer translucent. Therefore, the optical nature of the paint possibly reflects the intention of the artist to retain the quality of the marble support by using partially transparent painting materials. White highlights, executed using calcium carbonate, can be clearly observed on the neck and in other different locations on the head, such as the cheekbones. Carbon-based and vermilion (HgS) paints were used to execute shadows around the mouth and on the eyelid, respectively. Madder lake (a natural plant extract from the Rubia species, containing anthraquinone colorants including alizarin and pseudo-purpurin, that is precipitated or deposited onto an aluminium-containing substrate) was also used in the highlights around the eyes; see the section on the mouth for more details of the use of madder lake in the skin tones. The white highlights are not only found above the skin tones, but also below, indicating a highly sophisticated painting technique, which made use of recurrent applications of paint and reworking of the same areas, possibly even wet on wet (see Fig. 9). Similar reworking of paint layers was also observed at the hairline where the hair meets the forehead and cheeks (see below, Hair).

Fig. 9 shows the visible, VIL and UIL images of the Treu Head and details of the skin tones. The UIL image shows the presence of a faint yellow luminescence around the eyes and the mouth, possibly corresponding to the use of an organic material to seal the surface of the stone prior to the application of the paint layers, as mentioned

[50] The difference between a fully painted sculpture and a sculpture where only some crucial features (such as the eyes, nose and mouth) are highlighted might reflect the contrast between the representation of reality by means of μίμησις or διήγησις; where the one shows the other describes/narrates, where the one embodies the other refers to, respectively, Elam 1980, 68; Pfister 1988, 2-3.

above. Fig. 9d-f show details of the skin tones under magnification; single large red and yellow particles can be clearly seen in e) and f). Fig. 9g-h show the white highlights applied above the skin tones in the groove of the neckline. Fig. 9 i-j shows a detail of skin tones and white highlights on the proper right cheekbone. The use of white highlights and black shadows can be seen at the top-right of the patch of skin tones in Fig. 9d, where the a black layer can be seen above a layer of highlights, which is atop a layer of skin tones. Different applications of skintones, highlights and shadows can be observed in several locations on the sculpture. The highly stratified paint layer can be seen in Fig. 9j-k, showing a detail of the proper right eye, where white pigment is applied below the skin tones and madder lake; the latter is bright pink as compared to the dull pink of the skin tones. These observations seem to indicate that pure pigments and mixtures of pigments have been applied in several stages and on top of each other to achieve a realistic effect. The distribution of Egyptian blue particles can be seen to correspond to the surviving areas of skin tones (see Fig. 9b). The ancient practice of adding Egyptian blue to the skin tones was unknown until VIL imaging was developed in 2009. Parallels can be observed in 2nd century sculpture[51] and mummy portraits from Egypt. Art-historical details of the portraits described below are reported in Walker – Bierbrier 1997. Egyptian blue was found in the skin tones on a variety of mummy portraits. Fig. 10 shows the visible and VIL images of four mummy portraits; three of the paintings show clear evidence of the use of Egyptian blue in the skin tones: in the Trajanic funerary portrait EA74708 (Fig. 10a-b; AD 100-120: Walker – Bierbrier 1997, 51-52), extensive amounts of Egyptian blue were used in different concentrations in the skin tones, the lower lip and the white of the eyeballs; in the Antonine female portrait EA65346 (Fig. 10c-d; AD 150-170: Walker – Bierbrier 1997, 95-96), the blue pigment was used in the shadow of the hairline, in the skin tones, the lower lip and the white of the eyeballs; by contrast, in the Antonine portrait of a man EA74832 (Fig. 10e-f; AD 150-170: Walker – Bierbrier 1997, 94-95), Egyptian blue was only used in the lower lip, although some individual strands of the luminescent pigment can be seen in the moustache. Finally, in the portrait of a military officer EA65345 in the style of portraits of Lucius Verus (Fig. 10g-h; AD 160-170: Walker – Bierbrier 1997, 88), Egyptian blue is present in the hairline, the skin tones, the philtrum and the lips in varying concentrations. As with the Treu Head, this portrait shows high amounts of Egyptian blue in the philtrum. Despite the stylistic differences, the presence of a blue pigment within the flesh tones has been found for works of art from the Trajanic period up to the reign of Lucius Verus, indicating a continuous painting tradition[52]. Although chronologically far apart, the use of 'cool'

[51] Sargent – Therkildsen 2010 a.

[52] Investigations on a large number of funerary portraits should be undertaken to determine how common this practice was in the ancient world and how this translates into more recent similar practices as reported in, for example, Lucas – Plesters 1978, 40: "A few tiny particles of a paler ultramarine (perhaps ultramarine ash, the last residue of the extraction process) occurred in the shadows of Ariadne's flesh (Plate 6a, p. 47).

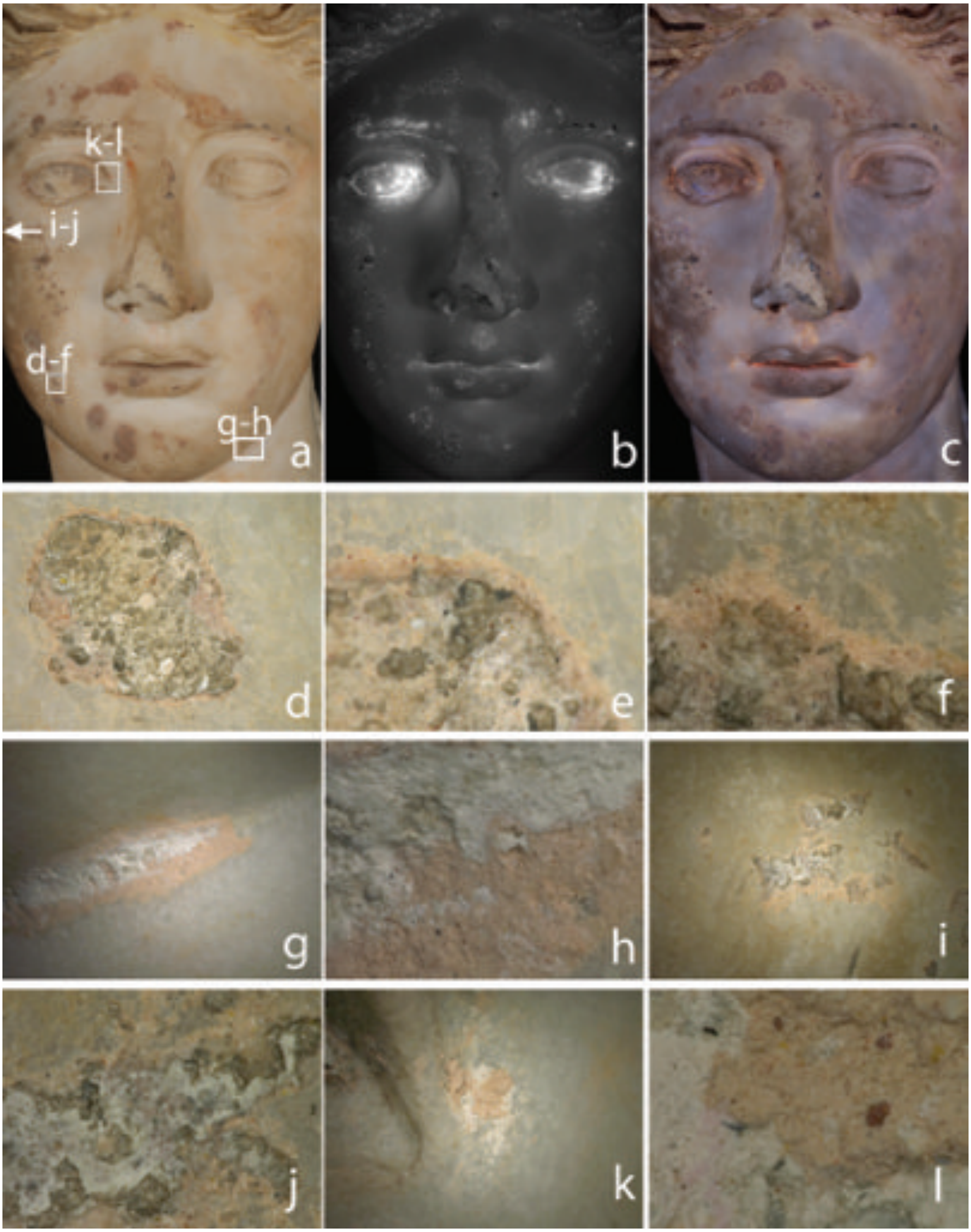

Fig. 9. a) visible, b) VIL and c) UIL images of the Treu Head; d-f) details of the skin tones (x50; x150; x200) ; g-j) details of the white highlights atop the skin tones (x20; x100; x20; x200); k-l) madder lake on top of skin tones and white highlights (x20; x150). The insets in (a) indicate the positions of the following images.

Fig. 10. Visible (top) and VIL (bottom) images of funerary portraits from Egypt. The VIL images show the presence of Egyptian blue in the skin tones, the hairlines, the white of the eyeballs and the lips as glowing white; a-b) EA74708; c-d) EA65346; e-f) EA74832 and g-h) EA65345.

pigments in the skin tones is also found in the Italian Renaissance. An earth-based dull green pigment or pigment mixture named verdaccio was commonly used as an undertone prior to the application of translucent skin tones.[53] Similarly, lapis lazuli was used by Titian in the skin tones of Ariadne in his famous painting Bacchus and Ariadne in the National Gallery, London.[54]

As mentioned above, a carbon-based black pigment was used on the Treu Head at the side of the mouth to paint shadows. Red paint, containing vermilion and red ochre, was used for the shadows on the eyelids. Similar features can be observed on the Antonine female portrait EA65346 (see Fig. 11a). Although stylistically different, a recently excavated fourth-century BC terracotta head (see Fig. 11b) from Temple A in Cumae and now in the Museo Archeologico dei Campi Flegrei, Naples, Italy, shows a comparable surface treatment to the Treu Head and EA 65346; the skin tones of the terracotta head are painted with white highlights

[53] Cennini 1993.

[54] Lucas – Plesters 1978.

Fig. 11. a) funerary portrait of a woman EA65346, detail of the black shadows at the side of the mouth; b) terracotta head of a goddess from the Capitolium in Cumae, Naples, Italy, showing white highlights around the eyes, red shadows along the eyelid and black shadows at the side of the mouth. The black material on the proper left side of the mouth is not part of the original decoration, but is probably the results of splattered pitch from the roof under which the sculpture was standing. The object is still partially covered in soil. Courtesy of Prof Carlo Rescigno, Seconda Università di Napoli, Italy.

under the eyes and with black and red shadows at the side of the mouth and on the eyelids, respectively.[55]

Mouth, Nostrils

Traces of flesh tones can be seen on the lower and upper lips. Fig. 12 shows the visible, VIL and UIL images of the mouth of the Treu Head and of the funerary portrait EA74832. The VIL images show the presence of Egyptian blue as glowing white, while madder lake shows a typical orange fluorescence in the UIL images (see also Fig. 9c). In the Treu Head, the lake is mostly found within the deepest recesses of the mouth, on the upper lip (see Fig. 13), in the nostrils (see Fig. 13) and, as explained later, in the lachrymal ducts, as Treu suggested. Small quantities of madder lake can also be seen on the upper lip. The proper left side of the mouth of the funerary portrait of a man is not original and was added at an unknown date. A similar lumi-

[55] Zevi *et alii* 2008, 257-258; Rescigno 2010.

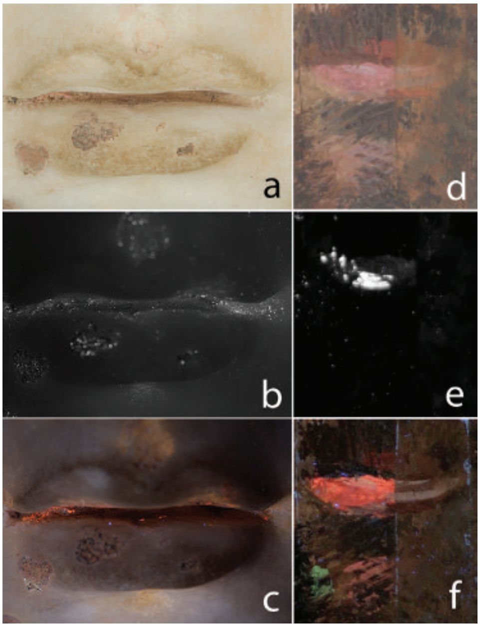

Fig. 12. Visible, VIL and UIL images of a detail of the mouth of: a-c) the Treu Head and d-f) the Antonine funerary portrait EA74832; both show the presence of Egyptian blue and the use of madder lake as a glaze on the lips. The green luminescence in (f) corresponds to the presence of a modern conservation material.

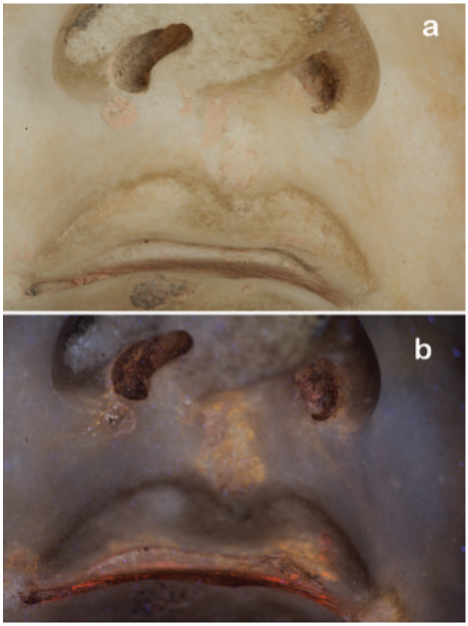

Fig. 13. The Treu Head, detail of the mouth and nostrils. a) visible image and b) UIL image showing the presence of organic lake in the deepest recesses of the mouth, the upper lip and the nostrils.

nescent material was used on the lower and upper lips of the male figure. The lake is applied as a thick layer on the lower lip and thinly on the upper lip. In addition, individual thin strokes of the same material are used on the chin, to create highlights. Lakes are highly translucent materials, traditionally used as glazing agents.[56] The presence of a thin layer of madder lake on the upper lip of the Treu Head seems therefore to suggest that the lake was used as a glaze on the lips of the sculpture, once more in the attempt to create a more realistic appearance.

Eyes

As mentioned, the eyes and eyebrows were first outlined using a carbon-based black pigment. The white eyeballs were painted with a mixture of lead white ($(PbCO_3)_2 \cdot Pb(OH)_2$) and Egyptian blue, while the lachrymal ducts were executed using madder lake. Fig. 14 shows the visible, VIL and UIL images of the prop-

[56] Eastaugh *et alii* 2008, 250-251.

er right eye of the Treu Head. The characteristic orange fluorescence of madder lake can be seen in the UIL image at each extreme of the eye. A similar treatment was found on IN 822 [Østergaard 2011] and IN 2687 at the Ny Carlsberg Glyptotek.[57] The VIL image shows the presence of Egyptian blue in the white of the eyeball. The use of Egyptian blue in the eyeballs was a common practice which can now be traced back at least from the Classical up to the Roman period. As for the use of Egyptian blue in the skin tones, this ancient practice of mixing Egyptian blue and a white pigment for the eyes was not known up until VIL imaging was developed. A limited number of significant examples will be reported here; Fig. 15 shows the visible and VIL images of: a) classical panel painting from Saqqara, Egypt (BM 1975,0728.1; early 4th century BC); b) so-called head of Apollo from the late-classical Mausoleum at Halicarnassos, modern Turkey (BM 1857,1220.264; c. 350 BC) and c) Hellenistic terracotta statuette of a draped woman from Egypt (BM 1981,0210.9; c. 250-200 BC). All the figures show the presence of Egyptian blue in the white of the eyeballs. Similarly, a late Classical marble head from the Temple of Artemis at Ephesos, modern Turkey (BM 1872,0405.121; 4th C. BC), shows the presence of the blue pigment in the eyes.[58] A blue pigment, most likely Egyptian blue, can also be seen with the naked eye in the terracotta head from Cumae (see Fig. 11b). Similarly, Egyptian blue was found in the eyeballs of the Sciarra Amazon in the Ny Carlsberg Glyptotek in Copenhagen.[59]

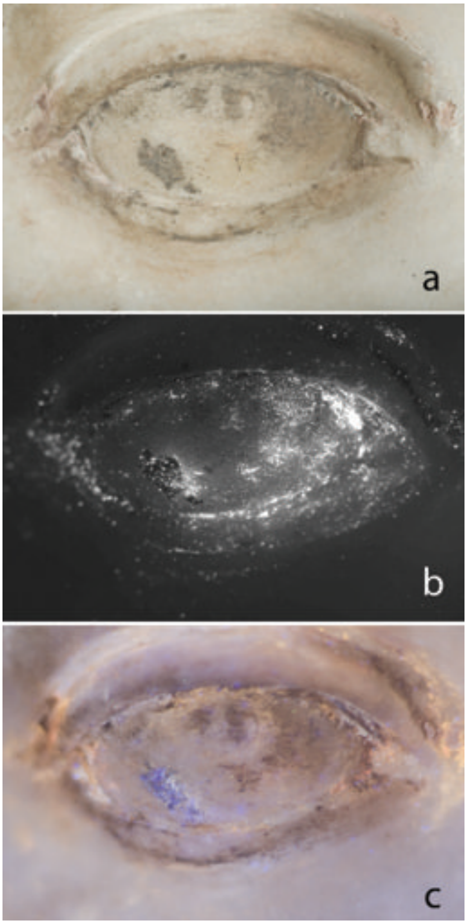

Fig. 14. Detail of the proper left eye of the Treu Head; a) visible; b) VIL and c) UIL images. Egyptian blue (glowing white particles in (b)) was mixed with white lead for the white of the eyeballs, while madder lake (orange luminescence in (c)) was used to paint the lachrymal ducts and can be seen at both extremes of the eye.

[57] Sargent – Therkildsen 2010 b.

[58] Verri 2009 a.

[59] Sargent – Therkildsen 2010 a.

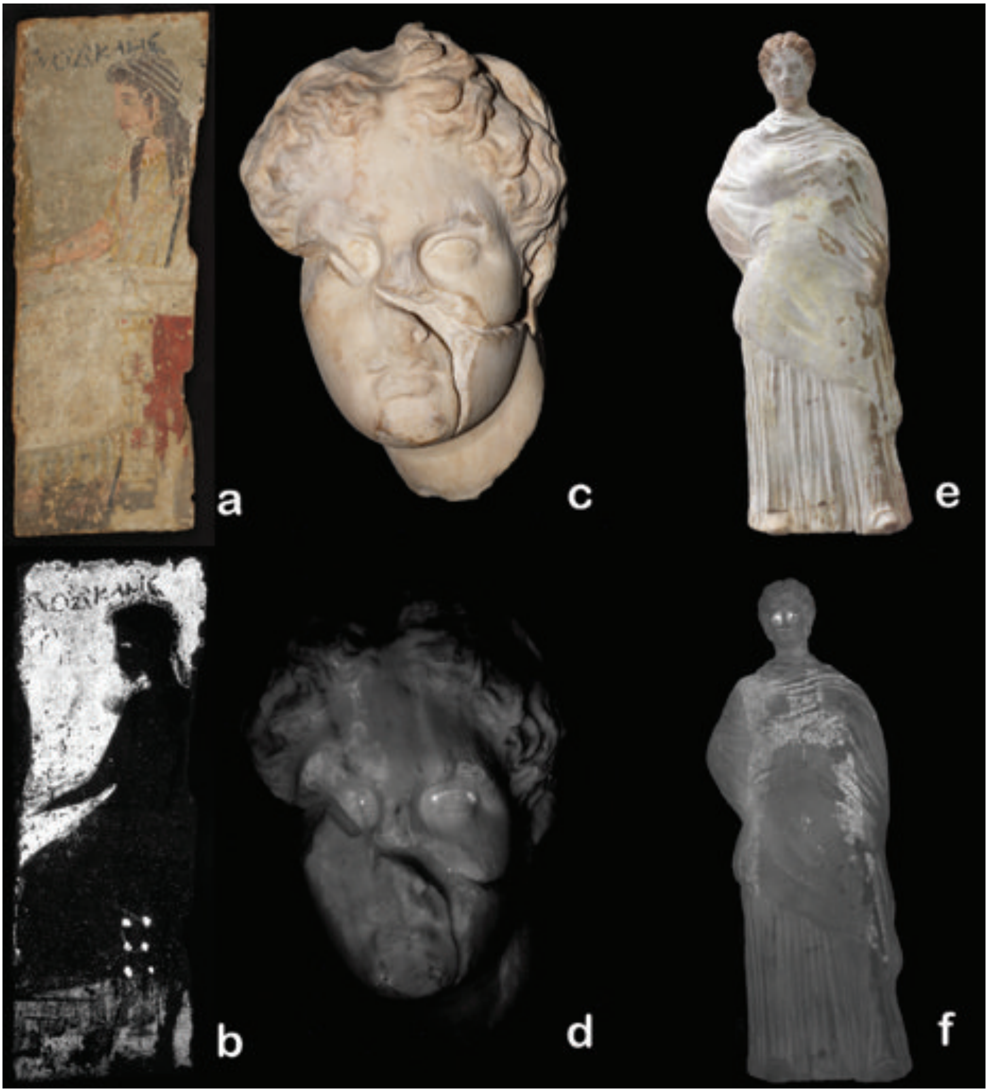

Fig. 15. Top) visible and bottom) VIL images of Ancient Greek artworks showing the use of Egyptian blue in the white of the eyeballs. These examples span temporally from the Classical to the Hellenistic period, demonstrating a continuity in the painting tradition; a-b) classical panel painting of a seated goddess from Saqqara, Egypt (BM 1975,0728.1; early 4th century BC); c-d) late Classical so-called Head of Apollo, from the Mausoleum at Halycarnassos, Modern Turkey (BM 1872,0405.121; 4th C. BC). Despite being rather battered and considerably weathered, the head still preserves small remnants of Egyptian blue on the underside of the upper eyelid, suggesting it might have been heavily painted; e-f) Hellenistic terracotta statuette of a draped woman from Egypt (BM 1981,0210.9; c. 250-200 BC).

Hair

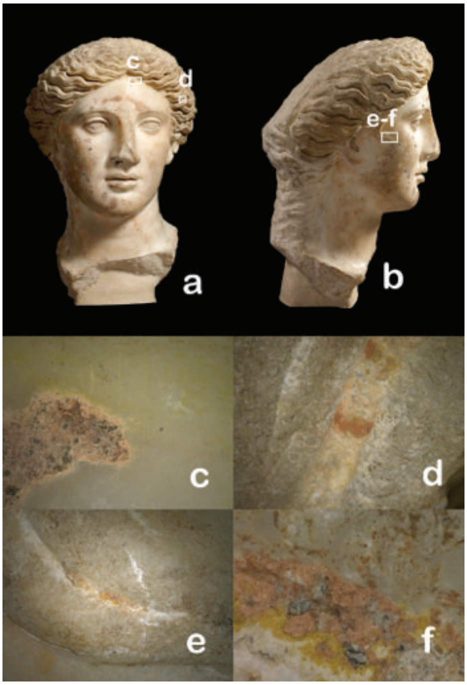

Fig. 16. The hair of the Treu Head; a-b) front and proper right side; c) detail of the forehead showing the application of the yellow colour on the surface of the marble, prior to the application of the skin tones (x20); d) individual strand of red applied in the grooves as shadows (x20); e-f) the transition between the hair and the skin tones on the proper right lock. The insets in (a) and (b) indicate the positions of the following images.

The hair of the Treu Head (see Fig. 16) was painted using yellow ochre with individual strokes of red ochre. The red strands are applied on top of the yellow ochre and usually correspond to recessed areas and were therefore possibly meant as shadows. In the area of the forehead and the locks at the side of the cheeks, where the hair meets the skin tones, the surviving yellow paint seems to have been applied below the skin tones; Fig. 16c shows a detail of the forehead where the yellow paint is applied directly onto the surface of the marble. In some other areas, the flesh tones are applied both above and below the yellow hair (see Fig. e-f), possibly indicating reworking of the hair and maybe the application of paint wet in wet to better mark the transition between the skin tones and the hair. Therefore, the yellow line along the hairline observed by Treu in his article seems to correspond to a first preparatory layer of yellow paint. Similarly to the white of the eyes and the skin tone, the hairline seems to have been reserved some attention in antiquity; the hairline of the female figure in the portrait of a woman (EA65346) was painted using Egyptian blue and, similarly, the hairline and beardline of the portrait of a military officer (EA65345) was executed with individual brush strokes of skin tone containing Egyptian blue. A similar treatment of the hair was found in the hair of the Sciarra Amazon in the Ny Carlsberg Glyptotek in Copenhagen.[60]

The Colour Reconstruction

The extent of surviving pigment on the head is too small to allow a satisfactory reconstruction; the painting technique, which makes use of a complex combination of base colours with highlights and shadows, used to colour the Treu Head

[60] Sargent – Therkildsen 2010 a.

is far too sophisticated to be reproduced solely on the basis of the remaining pigmentation. With the aim of excluding a modern re-interpretation of ancient painting techniques, the colour reconstruction proposed here was created by digitally stretching and deforming images of sculptures and mummy portraits showing paint layers similar to those observed on the Treu Head. The evidence for the comparison is based on the scientific investigation undertaken on the Treu Head and the comparative sculptures and mummy portraits presented above. The novelty of this colour reconstruction lies not only in the thorough scientific reliability of the data, but also in the use of only Roman painted objects. As mentioned above, while our understanding of the pigments used in antiquity can be considered satisfactory, almost nothing is known about the painting techniques or the way in which colour was applied to stone sculpture in ancient Greece and Rome. The final appearance of the head is therefore not intended as a definitive reconstruction of the 'original' appearance of the head, but as a 'possible' appearance. In other words, from the scientific evidence the head could have looked like the reconstruction proposed here.

The comparative materials used in the colour reconstruction are:

Underdrawing: Head of an Amazon from Herculaneum. The red and brown line drawing from the head of the Amazon was first digitally transformed into black, to match the carbon-based underdrawing observed, and applied virtually on the Treu Head;

Skin tones, highlights, shadows and eyes: Antonine female portrait EA65346. Most of the reconstruction is based on this portrait. The portrait was firstly inverted horizontally and elements were cut out and deformed to match the rather different facial features of the Treu Head. In order to separate the various application stages, parts of the painting were cancelled and replaced with adjacent areas; e.g. the shadows on the skin tones were removed and replaced with the base skin tones. In addition, the cracks and imperfections of the wood were partially removed.

Lips: Antonine male portrait BM74832. The lips of the portrait were cut out, extended and deformed to be applied on the lips of the Treu Head. The same colour was applied on the upper lip.

Hair: no suitable comparative material was found. Therefore, the hair was simply painted slightly yellow using a tone similar to that of the surviving yellow ochre. Single shadows of red were also painted based on highlights from the surviving hair on the Treu Head. The tone of the yellow and red used in the reconstruction is based on the colour analysis of the pigments.

Helmet: bronze helmet from the figure of Minerva (BM SC 1571). The addition of the helmet, based on stylistic evidence and on the presence of a metal dowel, is partially conjectural.

The likely sequence of execution of the painted surface by the ancient painter is proposed here (see Fig. 17):

1) Transparent sealant applied to the marble head (represented here by the digital image from which the remnants of polychromy have been virtually removed)
2) Underdrawing of the eyes, eyelashes and eyebrows (Wounded Amazon from Herculaneum);
3) Layer of yellow paint in the hair extending over the forehead;
4) First layer of skin tones, including skin colour on the lips (EA65346);
5) Second layer of skin tones, highlights and shadows, including some red on the lips (EA65346);
6) White eyeballs (EA65346);
7) Irises (EA65346);
8) Eyelashes and eyebrows (EA65346);
9) Pupils (EA65346);
10) Highlights (white dots) in the pupils (EA65346);
11) Transition from yellow hair to skin tones and red shadows in the hair;
12) Lips and lachrymal ducts (EA74832);
13) Bronze Helmet (BM SC 1571).

Conclusions

The Treu Head stands as evidence for the highly sophisticated and technically accomplished Roman production of ideal sculpture, in which key formulae of the Classical style were competently applied in a contemporary setting.

The evidence gathered here also invites some more general statements about Roman sculptural polychromy. Even to pioneering 19th-century experts like Treu, there was still little doubt that works of the Roman period could at best be products of proficient craftsmanship, as opposed to the true artistry of the Classical age. The apparent quality of the British Museum head thus could only be relative.[61] While the limited nature of the evidence available at present does indeed not allow direct comparisons between Classical and Roman works, the Treu Head clearly demonstrates a very high level of technical competence and sophistication to be found in the Imperial period. The close comparison between the pigment palette and painterly technique applied to the Treu Head and to the Fayum portraits brings to mind, albeit in a different context, Seneca's well-known phrase *in picturae modum variata circumlitio* ('a chromatic rendering (of marble) varied in the manner of painting').[62] This may provide important insights into the actual appearance of at least some of the painted

[61] Cf. Treu 1889, 22: 'It is due to our poor evidence, if in this, despite an awareness of the subtle differences between a Greek master and a Roman craftsman, the passage in Pliny on the painting of Praxiteleian statues by Nikias comes to our mind.' - "Es ist die Schuld unserer kümmerlichen Überlieferung, wenn uns dabei, trotz allem Bewusstsein von den Gradunterschieden zwischen einem griechischen Meister hohen Ranges und einem römischen Handwerker, die Pliniusstelle von der Bemalung Praxitelischer Statuen durch Nikias in den Sinn kommt."

[62] Sen., Ep. 86.6. The original quote refers to painted borders on marble slabs used for ornate room decorations.


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Fig. 18. a) funerary portrait of a woman (EA65346) on which the colour reconstruction is based; b) the Treu Head in its present state; c) the proposed digital colour reconstruction.

Fig. 19. The Treu Head.

Fig. 20. The proposed digital colour reconstruction of the Treu Head.

on the left page:
Fig. 17. Colour reconstruction of the Treu Head. 1) Marble head digitally cleaned (virtual removal of remnants of polychromy); 2) Underdrawing of the eyes, eyelashes and eyebrows (Wounded Amazon from Herculaneum); 3) Layer of yellow paint in the hair extending over the forehead; 4) First layer of skin tones, including skin colour on the lips (EA65346); 5) Second layer of skin tones, highlights and shadows, including some red on the lips (EA65346); 6) White eyeballs (EA65346); 7) Irises (EA65346); 8) Eyelashes and eyebrows (EA65346); 9) Pupils (EA65346); 10) White dots in the pupils (EA65346); 11) Transition from yellow hair to skin tones and red shadows in the hair; 12) Lips and lachrymal ducts painted with a thin, translucent layer of madder lake (EA74832); 13) Helmet. Steps 1-12 might indicate the sequence in which the head was painted in antiquity.

marble sculptures, which could perhaps be considered as 'three-dimensional Fayum portraits' in terms of visual effect.

The statue to which the Treu Head belonged most likely involved the collaboration of a number of different workmen, from expert marble carvers to painters and metal workers. Each aspect may have involved a more experienced craftsmen supported by apprentices. The carving of the marble, at any rate, was only one stage in a much more complex multi-stage process.

The use of higher-grade Parian marble for the insert head, quite a common phenomenon, is perhaps another indication that the famous Parian lychnites, in addition to allowing the carving of particularly fine detail, was not only much appreciated for the visual qualities of the marble itself but because it offered a better ground for the application of pigment.[63]

Yet even here, polychromy was only one of several elements that added to the final visual appearance of the marble sculpture. It was further augmented by the addition of metal components, which may have been painted or patinated themselves.

It is difficult to fathom the criteria by which such decisions of adding metals to marble sculpture were made. Ultimately, they seem to have been led by considerations of price and prestige far more than practical matters. In the British Museum there is, for example, a fine though sadly very fragmentary portrait of Marcus Aurelius from Cyrene (SC 1470) that still retains clear traces of polychromy but in addition had eyes inlaid in a different material. The combination of such different techniques, undoubtedly adding to the price of a commission, must have been a mark of quality and prestige.

The Treu Head has now been laser-scanned to allow the creation of three-dimensional replicas without harming the remaining pigments and a first 3D nylon print has been produced.[64] Eventually, a series of physical reconstructions could demonstrate the main stages of the painting process, from the underdrawing to the various paint layers and highlights and thus bring the sophisticated work of the ancient craftsmen back to life for a modern museum audience. From a curatorial point of view, it should be stressed that the results discussed in this article could only be obtained through a carefully considered combination of historical records, visual observations, imaging techniques and invasive/destructive and non-destructive sampling.

Although the research described in this article has shed some light on important aspects of ancient Roman polychromy on stone, it should be stressed that more sculptures have to be thoroughly investigated to provide more evidence on the paint-

[63] Further practical experiments on the visual effect of the same pigments on different marbles might be useful in this context.

[64] This work was carried out by Annemarie La Pensée and Martin Cooper from the National Museums of Liverpool's Conservation Technologies. The authors gratefully acknowledge their work.

ing technique(s) used in antiquity. Our research so far indicates, however, that the Treu Head remains a highly important and at this moment quite unparalleled sculpture in terms both of its remarkable pigment preservation and quality.

Acknowledgments

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EXPRIMENTAL APPENDIX

In situ microscopy

A Keyence VHX-600 microscope equipped with a VH-Z20R lens (×20-200 magnification) was used to image details of the sculpture.

Photo-induced luminescence imaging

All images were taken using a Canon 40D camera body modified by removing the IR-blocking filter. For UIL imaging the excitation was provided by two Wood radiation sources (365 nm) filtered with a Schott DUG11 interference bandpass filter (280-400 nm) and the camera was fitted with a Schott KV418 cut-on filter (50% transmission at c.418 nm) and an IDAS-UIBAR bandpass filter (400-700 nm) [29]. For VIL imaging the excitation was provided by red LED light sources (emission centred at 629 nm) and the camera was fitted with a Schott RG830 cut-on filter (50% transmittance at c.830 nm). In the VIL images, materials that emit IR radiation are recognizable as 'bright white' areas in the image [17, 30].

Minero-petrographic analyses

All examination and analysis was made on a single very small fragment of marble. Part of it was finely ground and the powder subjected to isotopic analysis (as specified below).

The remaining part was embedded in a cold-setting polyester resin and then used for the preparation of a thin section for minero-petrographic study of the marble under a polarizing microscope. The purpose of this examination was to determine the fabric, accessory and secondary minerals, and the calcite characteristics.

More specifically, the following parameters were determined in the following way:

- type of fabric (homeoblastic = with roughly isodiametric grains, heteroblastic = with grains of various dimensions), in direct relationship with the type (equilibrium, non equilibrium, retrograde metamorphism, polymetamorphism, etc.) and metamorphic grade;
- boundary-shapes of the calcite/dolomite grains, also connected to the type of metamorphic event(s) that generated the marble;
- maximum grain size (MGS), a parameter of significant diagnostic importance since it is linked to the grade of metamorphism achieved by the marble.

For the petrographic description, previous specific studies of ancient marbles,[65] as well as classical treatises on petrotectonics[66] were taken into consideration.

Isotopic analyses

The isotopic analyses were carried out on the carbon dioxide derived from small portions (20-30 mg) of the powdered sample subjected to a chemical attack with

[65] Lazzarini *et alii* 1980; Gorgoni *et alii* 2002.

[66] Spry 1986.

100% phosphoric acid at 25°C in a vacuum line, according to the procedure suggested by McCrea (1950) and Craig (1957). The resulting CO_2 was then analysed by mass spectrometry. The instrument used is equipped with a triple collector and permits the measurement of both isotopic ratios ($^{13}C/^{12}C$ and $^{18}O/^{16}O$) at the same time.

The analytical results are conventionally expressed in δ units, in parts per thousands: $\delta = [(Rsample/Rstd) - 1] \cdot 1000$, in which Rsample and Rstd represent the isotopic ratio of oxygen and carbon in the sample and in the reference standard, respectively. The standard adopted is PDB for both oxygen and carbon (the PDB standard is the rostrum of the Belemnitella americana of the Cretaceous Pee Dee Formation of South Carolina).

Isotopic characterisation has proved to be very useful in the marble identification of ancient artefacts.[67] Its use is becoming more and more widespread owing to its outstanding sensitivity, to the small quantity of material necessary for the analysis and to the availability of a rapidly growing data-base[68] that permits increasingly trustworthy comparisons, especially if the isotopic data are evaluated together with the minero-petrographic results from the same samples, as in the present study.

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 [31].

FTIR

FTIR spectroscopy was performed on a Nicolet 6700 with Continuum IR microscope equipped with MCT/A detectors. The samples were analysed in transmission mode, flattened in a diamond micro-compression cell. Maximum area of analysis: 100 × 100 μm. The spectra were acquired over a range of 4000-650 cm^{-1} using 32 scans at a resolution of 4 cm^{-1} and automatic gain.

SEM-EDX

Scanning electron microscopy (SEM) using a Hitachi S-3700N variable pressure SEM (20 kV, 50 Pa) with microanalysis was used to analyse uncoated cross-sections for elemental composition. Imaging was carried out using a Centaurus backscattered electron detector.

HPLC-PDA

A sample of a few micrograms was extracted in 20 μL of a 5% boron trifluoride/methanol solution. Analyses were carried out using a Hewlett-Packard (now Agilent) HPLC HP1100 system comprising a vacuum solvent degasser, a binary

[67] Gorgoni *et alii* 2002.

[68] Gorgoni *et alii* 2002.

pump, autosampler and column oven. The column used for the separation was a Luna C18(2) 100 Å, 150 × 2.0 mm, with 3 μm particle size (Phenomenex) stabilized at 40°C. Detection was performed using an HP1100 DAD with a 500 nL flow cell and using detection wavelengths from 200 to 700 nm [32]. Two solvents were used: (A) 99.9% water/0.1% trifluoroacetic acid (v/v); and (B) 94.9% acetonitrile/5% methanol/0.1% trifluoroacetic acid (v/v/v). The elution programme was a first gradient from 90% A/10% B to 60% A/40% B over a period of 60 minutes followed by a second linear gradient to 100% B after a further 30 minutes. After 10 minutes elution with pure B, a third linear gradient was used to return to the initial composition (90% A/10% B). The flow rate was fixed throughout at 0.2 mL per/minute creating a system back-pressure of 128 bars (12.8 MPa).

GC-MS

Each sample was hydrolyzed with 100 μL of 6M hydrochloric acid by heating overnight at 105°C, then dried under nitrogen. The samples were dried again after agitation with 100 μL of deionized water and 100 μL of denatured ethanol. Prior to analysis the samples were derivatized with N-(tert-butyldimethylsilyl)-N-methyl-trifluoroacetamide (MTBSTFA) to which 1% tert-butyldimethylsilyl chloride (TBDMCS) was added. The analyses were performed on an Agilent 6890N gas chromatograph (GC) coupled to an Agilent 5973N mass spectrometer (MS). Injection was in splitless mode at 300°C and 10 psi (70 kPa), with a purge time of 0.8 minutes. An Agilent HP5-MS column (30 m × 0.25 mm, 0.25 μm film thickness) fitted with a 1 m × 0.53 mm retention gap was used. The carrier gas was helium in constant flow mode at 1.5 mL per minute. After a one minute isothermal hold at 80°C the oven was temperature programmed to 300°C at 20°C per minute, with the final temperature held for three minutes. The MS interface temperature was 300°C. Acquisition was in scan mode (29-650 amu per second) after a solvent delay of five minutes. Chemstation software (G1701DA) was used for system control and data collection/manipulation. Mass spectral data were interpreted manually with the aid of the NIST/EPA/NIH Mass Spectral Library version 2.0 and comparison with published data [32].

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