

Article

Unveiling the Original Polychromy of Archaic Architecture: The Gigantomachy on the West Pediment of the Temple of Apollo at Delphi (6th c. B.C.)

Giasemi G. Frantzi ^{1,*} , Georgios P. Mastrotheodoros ¹ , Panayiotis Theoulakis ¹, Sotiria Kogou ², Athanasia Psalti ³ and Hariclia Brecolouki ⁴

¹ Department of Conservation of Antiquities and Works of Art, University of West Attica, Ag. Spyridonos Str., 12243 Egaleo, Greece; gmastrotheod@uniwa.gr (G.P.M.)

² School of Science and Technology, Nottingham Trent University, Nottingham NG11 8NS, UK

³ Ephorate of Antiquities of Fokis, 33054 Delphi, Greece

⁴ National Hellenic Research Foundation of Greece, Institute for Historical Research, 48 Vassileos Constantinou Ave., 11635 Athens, Greece

* Correspondence: gfrantzi@uniwa.gr or gfrantzi@yahoo.gr; Tel.: +30-210-3312481



Academic Editor: Claudia Pelosi

Received: 2 December 2024

Revised: 29 December 2024

Accepted: 2 January 2025

Published: 6 January 2025

Citation: Frantzi, G.G.; Mastrotheodoros, G.P.; Theoulakis, P.; Kogou, S.; Psalti, A.; Brecolouki, H. Unveiling the Original Polychromy of Archaic Architecture: The Gigantomachy on the West Pediment of the Temple of Apollo at Delphi (6th c. B.C.). *Heritage* **2025**, *8*, 17. <https://doi.org/10.3390/heritage8010017>

Correction Statement: This article has been republished with a minor change. The change does not affect the scientific content of the article and further details are available within the backmatter of the website version of this article.

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

Abstract: The Gigantomachy depicted on the west pediment of the Late Archaic temple of Apollo at Delphi marks a significant milestone in early Greek architectural sculpture. Crafted from porous stone and enhanced with plaster and paint, the surviving fragments differ markedly from the marble figures of the east pediment of the same temple. Among the preserved figures of the Gigantomachy are a standing male figure, possibly representing Apollo or Dionysos, a warrior female identified as Athena, and a recumbent male, likely symbolizing the Giant Enkelados. This study aims to investigate the polychromy of the west pediment through a thorough investigation of the remnants of the original decoration. The adopted methodology includes exclusively non-destructive techniques and advanced imaging methods, such as portable X-ray fluorescence spectrometry, visible-induced luminescence (VIL), and 3D microscope observation. Analytical results confirmed the presence of extensive traces of once-vibrant colors on the plaster's surface, which were often invisible to the naked eye. Specifically, our data support the employment of pigments like Egyptian blue, cinnabar, ochre-based reds and yellows, as well as copper-based green. Notably, these pigments were applied over a white calcium-rich layer, which served as a primer for the porous stone. Ongoing research on the Gigantomachy promises to deepen our understanding of color usage and painting techniques in Archaic Greek art.

Keywords: Archaic polychromy; non-destructive analysis; XRF; VIL

1. Introduction

Color was a key feature in all aspects of ancient art, encompassing both sculpture and architecture. Since the 18th century, our understanding of polychromy and the research into its original appearance have both evolved significantly, transitioning from in situ autopsy and macroscopical observation into rigorous scientific documentation and investigation. This advancement has provided us with far deeper insights into the composition and application of color in the sculptural decoration of architectural monuments, confirming that the same techniques were employed in free-standing sculptures as well [1,2].

This comprehensive approach highlights the essential role of color in the art of Archaic and Classical Greece, illuminating the continuity and sophistication inherent in its techniques. However, the fragmentation and severe degradation of polychromy in both

sculptural and architectural decoration, largely resulting from long-term exposure to harsh environmental conditions, pose significant challenges for conservators and archeologists. Nevertheless, through a combination of historical research, conservation science and scientific investigation, exciting new discoveries about the original colors that adorned ancient structures have recently come to light. The collection of new data on the distribution and composition of colors, by means of state-of-the-art techniques, confirms that architectural polychromy is not merely a historical footnote; it is an essential component of ancient visual aesthetics, attesting to the creativity and inventiveness of ancient Greek craftsmen and artists.

The Temple of Apollo in Delphi

The temple of Apollo served as the focal point of the Delphic worship and was home to the famous Oracle of Delphi. Following the destruction of a previous temple by fire in the 6th century B.C., the prominent Athenian family, the Alcmaeonids, took on the ambitious task of building a new structure [3,4]. The plans for the new temple were intended to emphasize the significance and power of Athens. The prosperous Alcmaeonids supervised the construction, using Parian marble for the facade and a variety of materials for other sections. The east pediment, crafted from Parian marble [5,6], illustrated Apollo's journey to Delphi from Delos via Athens, while the west pediment, made from soft porous stone, depicted a scene from the Gigantomachy: the battle between the Olympian gods and the Giants. The temple's roof was further adorned with marble-winged Nikai as acroteria, enhancing its grandeur. Unfortunately, the temple collapsed due to a rockfall that occurred after a significant earthquake in 373 B.C. [5–7].

In the temple of Apollo, the stone used for the sculptures is clearly different from that of the architectural pieces. This indicates that the original quarry was likely different, suggesting that higher-quality and more expensive materials may have been reserved for the decorative sculptures. [8]. An important supply of stones was sourced from the Peloponnese, possibly from the large and well-known building stone quarries of Corinth, as suggested by Piccard and Messelière [6] and also recognized as a strong possibility by Kokkorou-Alevras et al. [9]. The soft limestone found in the Corinthian region varies in color from light gray to yellowish and is classified geologically as oolitic limestone [9,10]. Ancient sources indicate that this material was widely utilized in significant Greek sanctuaries, including Delphi (CID 2: 34, 46, 56, 62, 63, and FD III 5:25), since the 7th century B.C. [9]. However, Higgins and Higgins, as well as Keramopoulos, reported that the buildings of ancient Delphi were constructed from local gray limestone [3,11].

Piccard and Messelière [6] describe the latter material as a beautiful, fine-grained stone that is not only very solid and dense but also sufficiently soft to allow for detailed carving without breaking or cracking. They further note that this stone is strong enough to support heavy structures when used as a single block, and that its polished surface retains well-preserved layers of coating that appear to have penetrated deeply into the material. In areas with fragments and nearby breaks, signs of damage are evident and can be easily distinguished from the marks left by the carving process [6]. Further investigation through chemical analysis by atomic absorption, differential thermal analysis, or micro X-ray diffraction, on micro-samples from the stones, for example, would lead to the assessment of their mineralogical composition. Nevertheless, the micro-destructive nature of this type of analyses has hitherto hindered the performance of pertinent tests.

The Gigantomachy was the battle of the Olympian gods against the Giants, who were the sons of Gea, the Earth. According to the myth, the Olympian gods faced considerable challenges before they could ultimately defeat the Giants. One of the most well-known episodes of the Gigantomachy is the struggle between Athena and Enkelados, the personi-

fictionation of earthquakes. In this confrontation, Athena killed the Giant with her chariot and then threw the island of Sicily upon him (Appolodorus i.6.2).

Euripides' play *"Ion"* offers valuable insights into the West Pediment of the Temple of Apollo, which depicts the Gigantomachy. Surviving fragments of this pediment, including a fighting female and various male figures, offer glimpses of this dramatic scene. In *"Ion"*, the chorus references notable characters such as Herakles; Iolaos, a figure on a winged horse; Athena; Enkelados; Zeus; Mimas; Dionysos; and several monsters. The proposed reconstruction of the pediment by the French excavators enhances our understanding of its iconography. The reconstruction places the Giant near the left corner and Athena's figure midway back on the left side, with a figure draped in animal skin close behind her (Figure 1) [6].



Figure 1. The left part of the west pediment of the Late Archaic temple of Apollo at Delphi as depicted at the Archaeological Museum of Delphi. © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/L. Hatzis.

The first figure positioned at the left corner of the pediment is likely a Giant, depicted kneeling with his torso in a three-quarter view and his extended right leg shown in profile. While much of the original detail has been lost, multiple and extensive traces of red paint that were uniformly applied to the body are still somewhat discernible. According to Theodore Homolle, these traces were "visible in all the parts that remained intact, often very intense." The recumbent Giant has no parallel in the East pediment; however, the figure's torsion represents a development not seen in slightly earlier sculptures. This indicates that the sculptures of both pediments can be attributed to a single workshop under the direction of Antenor, and it has been suggested that all these works can be dated to around 510 B.C. [6–8].

The second fragment depicts a female figure moving to the left, dressed in a chiton and short himation with a mass of stone identified as an aegis, associated with the goddess Athena. Although the paint remnants have now mostly faded away, they were relatively visible at the time of discovery. Homolle noted, "The edges and the large central fold as well as the seam of the garment are decorated with a meander, the type of which varies for each of the two pieces of the costume: there are traces of white, red, yellow, blue and green, which should be altered blue" [5]. Athena's figure closely resembles the Nike acroterion, with specific details in her drapery reflecting similar characteristics found in the East Pediment, such as the broad expanses and sharp ridges of the chiton over the legs and the tubular folds of the himation. The treatment of the drapery in the striding male figure is consistent in both pediments. Ancient Greek clothing emphasized freedom of movement and highlighted the beauty of the human figure. Women typically wore peplos, Doric chitons, and later Ionic chitons, in various colors and decorative motifs such as geometric shapes and animal figures [12]. The fabrics were primarily made of wool and linen. Most clothing was painted, and ornamental patterns were more common on female statues. Male

skin was likely painted red or brown, while female skin was white. Additionally, details such as hair, eyebrows, eyes, and lips were also enhanced with color. Relief backgrounds were usually painted dark blue or red [12–15].

The third figure, only partially preserved from the waist down, is believed to be a male, potentially Apollo or Dionysos. Numerous traces of blue paint on the upper part of the garment, and red and green on the lower part have been reported [5]. Additionally, there is a pervasive presence of white, suggesting that a preparatory layer may have initially been applied across the entire surface of the stone [5]. According to Homolle, this fragment displayed traces of blue on the upper part of the garment and vibrant red color on the lower part, with rounded, ascending folds resembling the drapery of a raised chiton. On the right side, lines indicate a chiton draped over the thigh of a figure turned three-quarters to the right. The figure is preserved from the belt down to the left hock and right ankle, facing left with the right leg extended forward. It is draped in a chiton secured at the belt, extending to mid-calf, with the left thigh featuring slightly oblique folds, reminiscent of Athena's chiton. A simple coat, possibly made of animal skin, covers the waist and left buttock, suggesting a bare leg underneath. Homolle asserts the figure's male identity, likely due to the short chiton and absence of a hem [5].

The Gigantomachy was a popular myth in Athens, connected with the cult of Athena. This myth was commemorated during the Panathenaia festival, where a peplos depicting the Gigantomachy was presented to Athena Polias. This myth symbolized the triumph of the Olympian gods, reinforcing Athena's cultural and religious significance in Athenian society [12].

In this study, the three figures have been investigated for evidence of ancient polychromy using non-destructive methods such as imaging techniques and portable X-ray fluorescence spectrometry. The goals were to uncover painted patterns that are currently invisible to the naked eye, to identify the preserved pigments, and to detect any signs of corrosion.

2. Materials and Methods

When conducting scientific investigation of ancient polychromy, nowadays, researchers typically use non-invasive and non-destructive techniques [16,17]. In our case, the initial steps involved documenting the remaining traces of color through meticulous macroscopic probing. Visible-induced luminescence (VIL) was employed to enhance the visibility of the painted decorations on the front sides of the Gigantomachy figures and to identify areas where Egyptian blue was originally applied, particularly on the himation of Athena [18,19]. Following this documentation, a 3D digital microscope was used to microscopically examine areas displaying white, yellow, dark blue, green and red hues. After completing these analyses, X-ray fluorescence spectrometry (XRF) analysis was conducted on-site. Details about the methods and instruments used are provided below.

Methodology and Instrumentation

Visible-induced infrared luminescence (VIL imaging) employs a white light source made up of PAR CAN 36 x 3W LEDs, consisting of 12 red, 12 green, and 12 blue lights, along with a Light-Emitting Diode (LED) lamp that does not emit stray infrared (IR) radiation (EXcLED 470–630 nm). Two images (the Figures 3b and 6b) were captured using a digital DMX DSLR Canon EOS D50 camera, which has been modified by removing the IR blocking filter. Moreover, a Schott filter (plate_number_1) with a cut-on wavelength of 830 nm at 50% was placed in front of the lens (52 mm.) In all the other images, VIL was performed in daylight using a digital DMX DSLR Canon EOS 350D camera that was modified by replacing the IR blocking filter with a 720 nm filter, and a Speedlight 580EXII

flash with 2 blocking IR spectrum components (so-called hot mirror filters). The specific filters used are those removed from the Canon EOS 350D and from a digital mirrorless camera, the Canon EOS M. When illuminated, the pigment emits infrared (IR) radiation, allowing luminescence to be recorded by a camera sensitive to IR light. This highly sensitive technique enables even single particles of Egyptian blue to be imaged, appearing as “glowing white” in the IR images [18,19]. Based on the specifications given above and the sensitivity of the sensors of the utilized cameras, it is concluded that the VIL images were acquired in the range between approximately 720 and 900 nm.

The HIROX HRX-01 3D digital microscope was used for 3D digital microscope observation. It features a high-precision tabletop stand with an adjustable column and a flexible arm. This design is ideal for inspecting objects that are horizontal, flat, vertical, and inclined at magnifications of $40\times$, $100\times$, $160\times$, and $320\times$, while the instrument is capable of capturing images with up to $\times 10,000$ magnification. The Hirox microscope enables multifocal imaging, which is utilized in this study. It allowed us to capture OM images of rough areas, often with curvature, at magnifications between $\times 100$ and $\times 320$, ensuring that the entire field of view (FOV) was in focus.

XRF analysis was conducted using a portable spectrometer (Tracer 5g, Bruker, Billerica, MA, USA). From each spot/area of interest, two distinct spectra were collected; the first spectrum was collected with the instrument operating in a 15 kV and 70 μ A mode (no filter) while the second was obtained using a 40 kV and 100 μ A setup (with a composite Ti/Al filter). In both cases, spectra were collected through a 3 mm collimator for 10 s [20,21]. Subsequently, spectra were processed using the Artax software (Bruker). After assigning the peaks to specific chemical elements, spectra were further analyzed to calculate spectral peak areas (counts). In detail, peak areas were calculated from the 15 kV spectra for the elements Al, Si, S, Cl, Ca, Fe (in all cases on the peak that corresponds to the $K\alpha$ transition), while the peak intensities of the elements Cu and Sr ($K\alpha$ transitions) as well as Hg and Pb ($L\alpha$ transitions) were calculated based on the 40 kV spectra. Note that the data presented here are by no means semi-quantitative; instead, they correspond merely to qualitative data, as our primary aim was to reveal the characteristic elements in areas of different color. In addition, most of the analyzed areas bear severely corroded colors, and, hence, the collected spectra pertain to the analyzed color remnants, to their substrate (due to penetration depth of the X-rays), and to the areas of the exposed stone (which are exposed due to paint and substrate losses). For these reasons, calibration was not required. However, it should be noted that the groups of spectra (15–40 kV) were collected using the same parameters in all cases; therefore, the calculated spectral peak areas allow for the direct comparison between elemental peak intensities from different spectra.

3. Results and Discussion

3.1. VIL Imaging Technique

3.1.1. The Figure of Enkelados

The VIL imaging confirmed that the figure is indeed Enkelados, as the formation of scales painted with Egyptian blue, appearing as glowing white, creates the impression of a serpent (Figure 2) [22]. According to ancient textual sources, Giants are generally depicted as having serpent-like legs that are covered in scales (Apollodorus, I, 34–38; 6, 1–2). Pausanias denied that the Giants had serpent feet (Paus. 8.29.3), yet this representation is frequently observed in later monuments of antiquity [23].

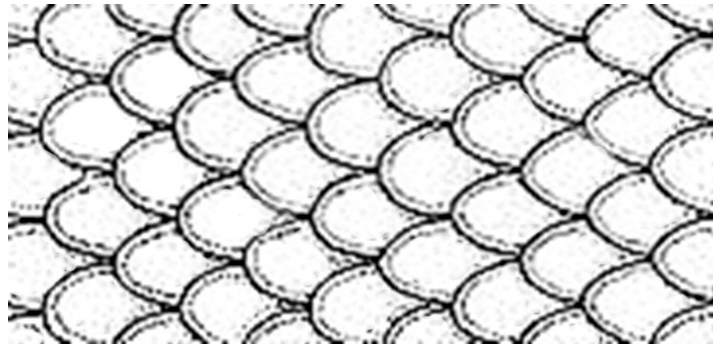


Figure 2. The formation of scales (based on a figure displayed by René Ginouvè and Roland Martin [22]).

Even though extensive traces of red are still visible today, and were found to have been applied in a uniform coat over the entire body, blue traces are notably absent and cannot be identified with the naked eye. However, the presence of Egyptian blue was documented through VIL, and it is indeed remarkable that the VIL revealed such a significant scale-type pattern painted with this very pigment (Figures 3 and 4). As for the Egyptian blue, it shall be noted that Verri [18] states that, beyond this pigment, Han blue and Han purple exhibit intense luminescence in the 800–1000 nm range. Nevertheless, the use of Egyptian blue remains more plausible in our case, since Han blue and Han purple developed independently in China approximately two and a half millennia after the invention of Egyptian blue (EB) [24,25], and, in particular, because no barium (Ba) was detected in the XRF analysis of the architectural items that were examined herein (see next).

It is worth noting that, in contrast to the literature, the Enkelados' scale pattern appears to cover the entire body rather than just the legs. This observation warrants further investigation, as it is not documented in the existing bibliography. Moreover, traces of Egyptian blue have also been identified on the serpent tail of the Parthenon Sculptures at the British Museum by Giovanni Verri and colleagues, suggesting the presence of snakeskin [26].

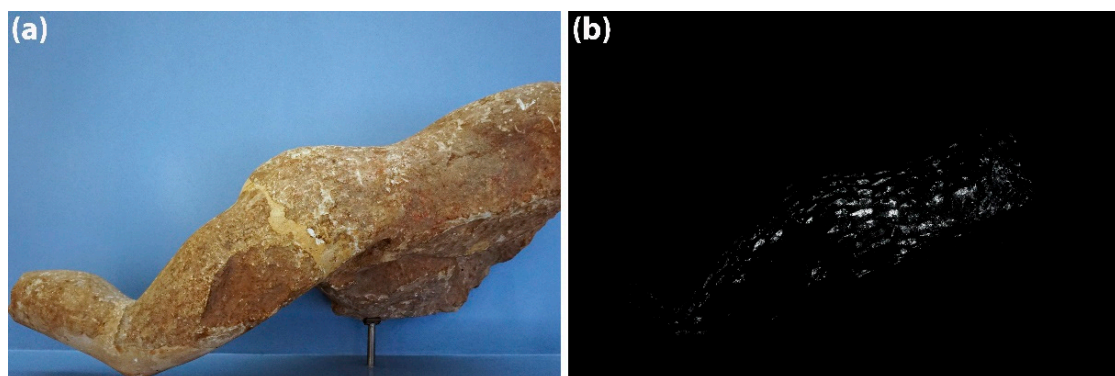


Figure 3. The figure of “Enkelados”: (a) digital images of the sculpture; (b) VIL image general depiction of “Enkelados’s” snake-formed scales. VIL under excitation from a red LED. © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

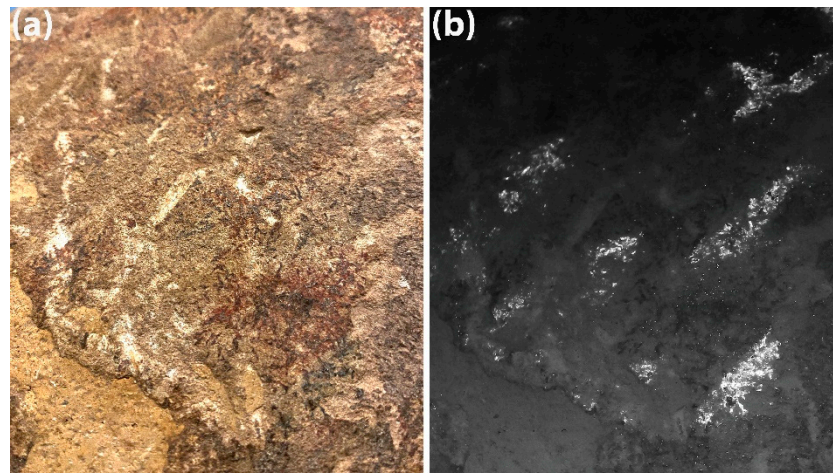


Figure 4. The figure of “Enkelados”: (a) digital image of a detail from the sculpture; (b) VIL image of the same detail revealing scales formed from Egyptian blue. The VIL was performed in daylight using two flashes with 2 blocking IR spectrum components, © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

3.1.2. The Figure of Athena

The results obtained through VIL imaging on the figure of Athena were very revealing. They confirmed that on the surface of her garment, significant remnants of original paint layers composed of Egyptian blue have been preserved, which are almost invisible to the naked eye (Figure 5a–d).

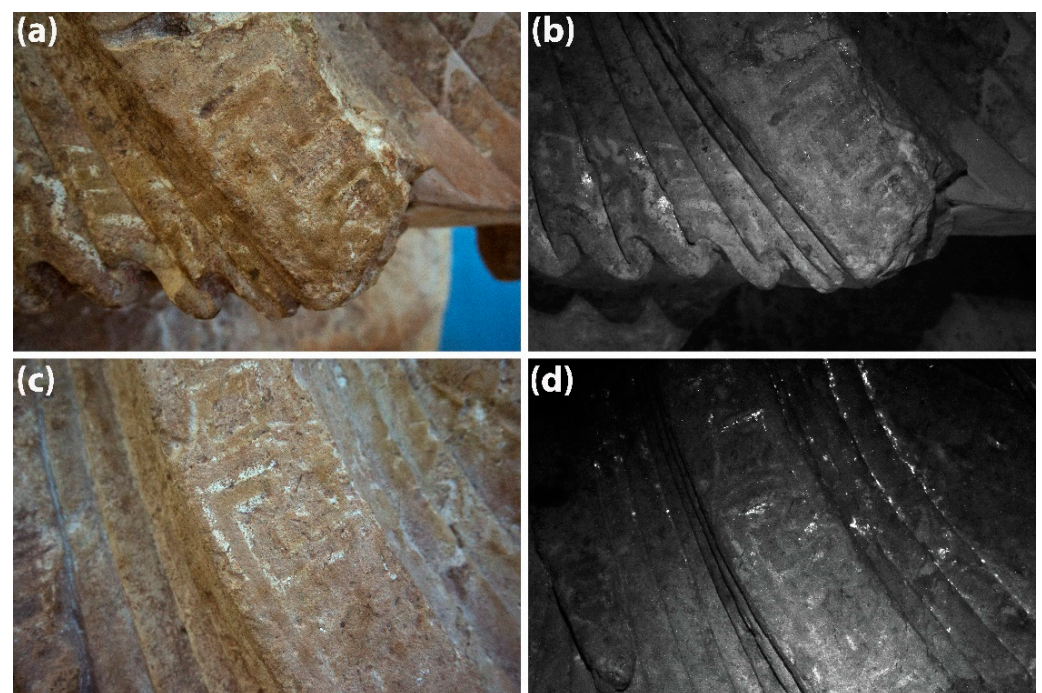


Figure 5. The figure of “Athena”: (a) digital image of a detail from the lower part of the sculpture; (b) VIL image of the same detail, revealing the type of a continuous meander flowing into another, which forms the shape of a svastika (type A 2) on the left-hand side; (c) digital image of a detail from the central part of the sculpture (VIL was performed in daylight using two flashes with 2 blocked IR spectrum components); (d) VIL image of the same detail showcases the use of Egyptian blue within the meander pattern (VIL was performed in daylight using two flashes with 2 blocking IR spectrum components); © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

In this case, it appears that Egyptian blue was initially used to define the contours of the curved folds of the garment and its decoration, which possibly consisted of a meander with a svastika (type A 2) on the left-hand side and squares along its borders (Figure 6d) [22,27,28]. Additionally, larger vertical areas of the garment feature a meander with a svastika (A 2) on the left-hand side (Figure 6b) [22]. Notably, black spots correspond to the areas that bear traces of Egyptian blue, according to the VIL images, raising concerns about the potential blackening of Egyptian blue under certain conditions (Figure 6c,d) [29,30].

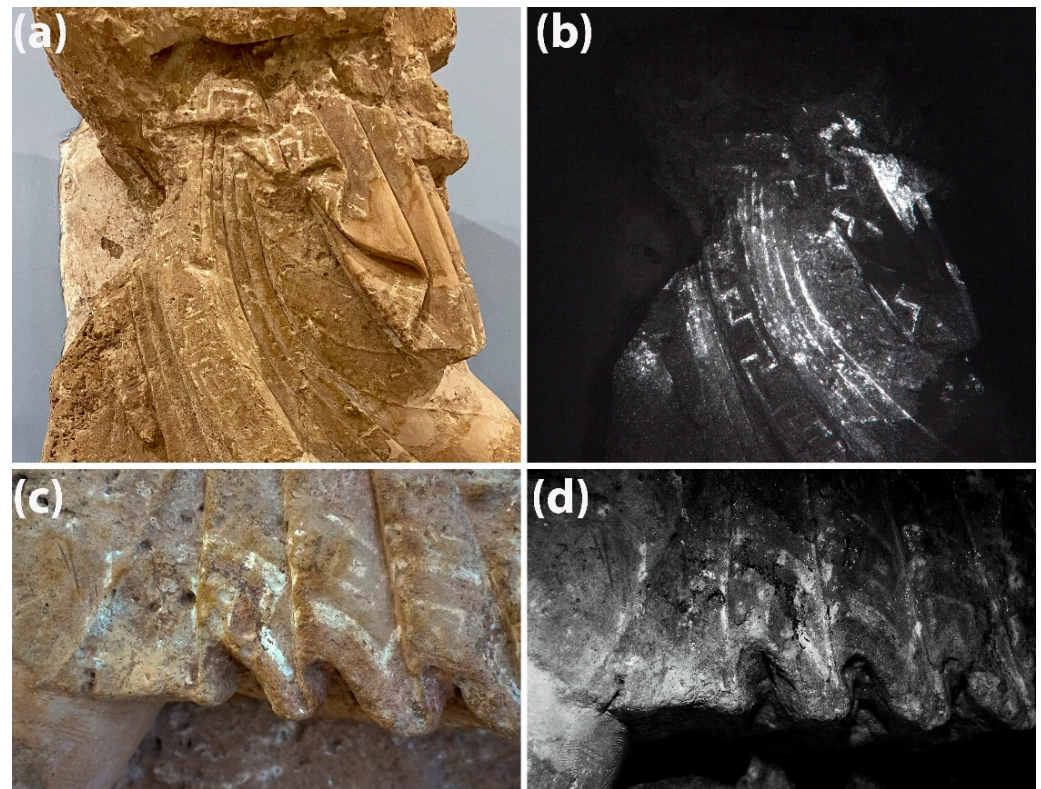


Figure 6. The figure of “Athena”: (a) a general digital image of the sculpture; (b) VIL image detailing the revealed meander patterns; VIL under excitation from a red LED; (c) digital image of a detail from the folds of the himation; (d) VIL image indicating the use of Egyptian blue around the squares. The VIL was performed in daylight using two flashes with 2 blocking IR spectrum components; © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

Furthermore, on the upper part of the sculpture, just below the form of the “aegis”, two decorative patterns are discernible due to their white outlines. One pattern, which is positioned horizontally along the edge of the garment’s overfold, corresponds to a U-shaped meander [22]. The other is a diagonal pattern that appears to create two parallel zigzag lines along the border of the himation, which became visible through VIL imaging (Figure 7).

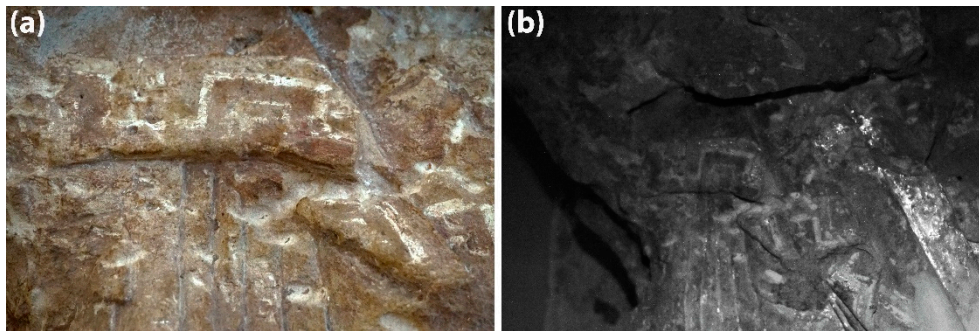


Figure 7. The figure of “Athena”: (a) digital image of the upper part of the sculpture; (b) VIL image making a U-shaped meander, and possibly a zigzag decorative pattern, more discernible. The VIL was performed in daylight using two flashes with 2 blocking IR spectrum components; © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

3.1.3. The Figure of Standing Male

It appears that blue color originally played a significant role in the overall effect of the statue’s polychromy, as extensive areas of Egyptian blue were often detected on the garments. According to literature on iconography, Apollo is frequently depicted either naked or, more commonly, wearing a short chiton or himation. In some Attic black-figure vases, he is illustrated with a helmet, winged boots, and an animal skin, and at times he is shown with a beard. In depictions from the 6th century B.C., he often appears in a short chiton along with an animal skin [23] (Figure 8).

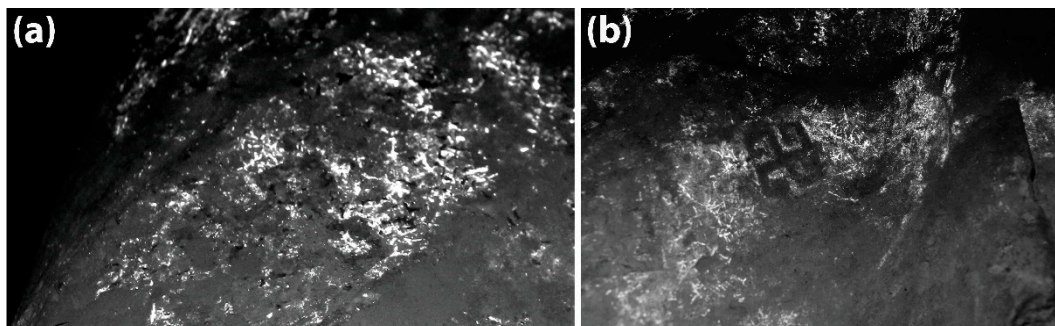


Figure 8. The figure of Apollo or Dionysos: VIL images (a,b) revealed two types of meander patterns. The VIL was performed in daylight using two flashes with 2 blocking IR spectrum components; © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

In contrast, Dionysos’s clothing, even from the Archaic age, is characterized by a long chiton that reaches the feet (Paus. 5, 19, 6). His attire often includes colorful decorations, such as the ποικίλον—a large, probably embroidered garment—or a flowered belt, and his clothes are often brightly colored, with purple used for the chiton and cloak, sometimes further embellished with gold embroidery. A typical piece of Dionysus’s clothing is a very fine “crocus” (yellow)-colored overgarment worn over the chiton, which is also common in women’s attire. However, the most significant item in this clothing, due to its connection with maenadism and the omophagy of the Dionysian rites, is the nebris—the skin of a fawn or even a leopard kid—worn by the god and his followers [23]. In our case, VIL imaging revealed different types of meanders on the robe of the standing male figure of Apollo or Dionysos, namely a meander with a svastika on the left-hand side and a meander forming a square with an embedded cross [22] (Figure 9a,b).

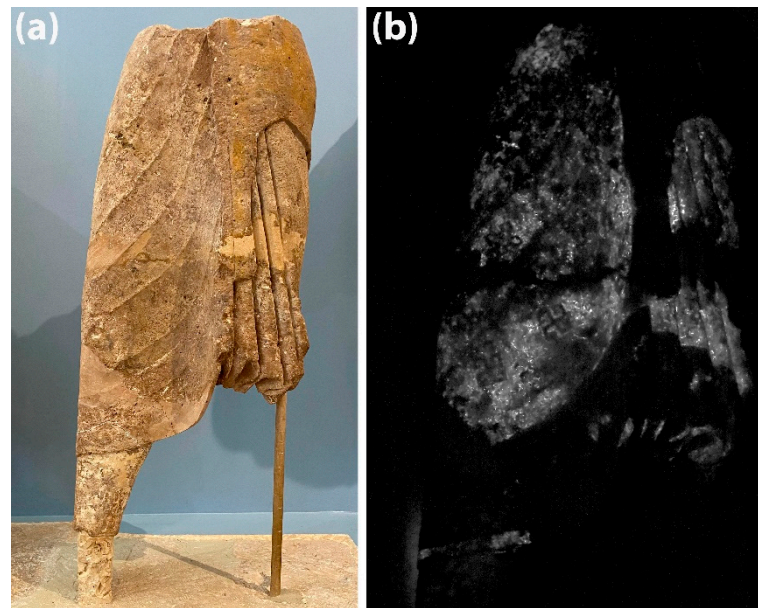


Figure 9. The figure of “Apollo or Dionysos”, as shown in VIL images: (a) showcases a meander with squares and crosses; (b) details a revealed meander with a svastika on the left-hand side. The VIL was performed in daylight using two flashes with 2 blocking IR spectrum components; © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

3.2. Microscopic Observation

3.2.1. The Figure of “Athena”

The observation of the surface of the statue of Athena, which was conducted using a portable digital optical microscope with a flexible arm, allowed us to confirm the presence of red paint layers inside the folds of the garment. Dark blue to black spots correspond to the areas of Egyptian blue in the VIL images, and this finding raises concerns about the potential blackening of Egyptian blue under specific conditions; additionally, the presence of a whitish layer (possibly a substrate for the polychromy) is documented (Figures 6c,d and 10b) [29–31].

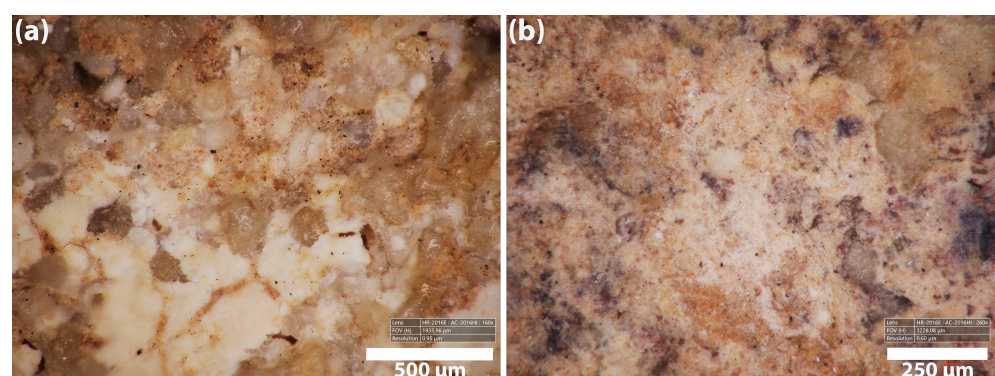


Figure 10. The figure of “Athena”: 3D microscope Hirox observation: (a) the examination area is within the white meander of the garment ($\times 160$); (b) the examination area is inside the fold of the garment ($\times 260$). © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/S. Kogou.

3.2.2. The Figure of the Standing Male

In the chiton of the male figure, microscopic analysis revealed the presence of grains exhibiting intense blue and red hues, along with traces of a white line. Additionally, a

broad area of uniform yellow was identified, and was found to contain scattered red and brown grains (Figure 11).

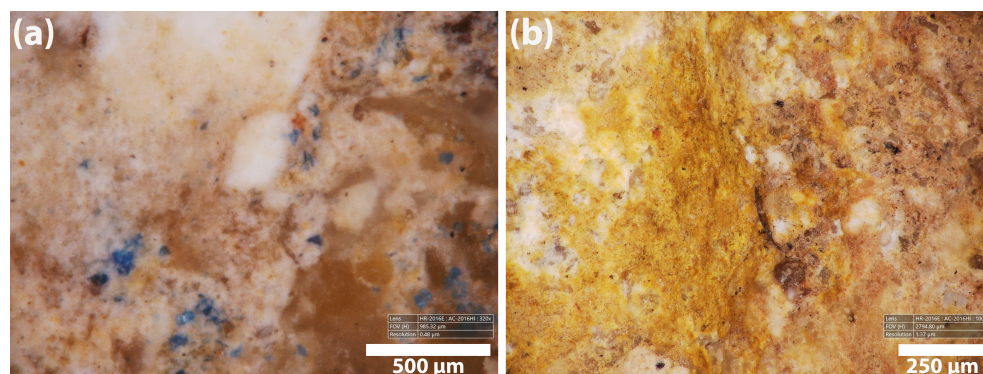


Figure 11. The figure of the standing male. Three-dimensional microscope Hirox observation: (a) The examination area is located at the white line on a fold of the robe ($\times 320$). (b) The examination area is the bright yellow zone identified as animal skin. ($\times 100$). © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/S. Kogou.

While the blue grains correspond to glowing areas in the VIL images (Figures 8 and 9a,b) and, hence, are identified as Egyptian blue, the yellow layer and the red grains will be more clearly differentiated after further investigation with elemental analysis (p-XRF, see next).

3.3. XRF Analysis

Before presenting the XRF data, it is important to emphasize that the studied spots correspond to partially preserved—and, in most cases, severely decayed—paint layers. Consequently, during XRF analysis, the beam interacted not only with the remaining paint layers, but also with their exposed substrate, in areas where paint layers had perished, as well as with any incrustations or other extraneous materials deposited on the surface. The exact positions of XRF analysis are documented in Figures 12 and 13, while the corresponding results are summarized in Table 1.

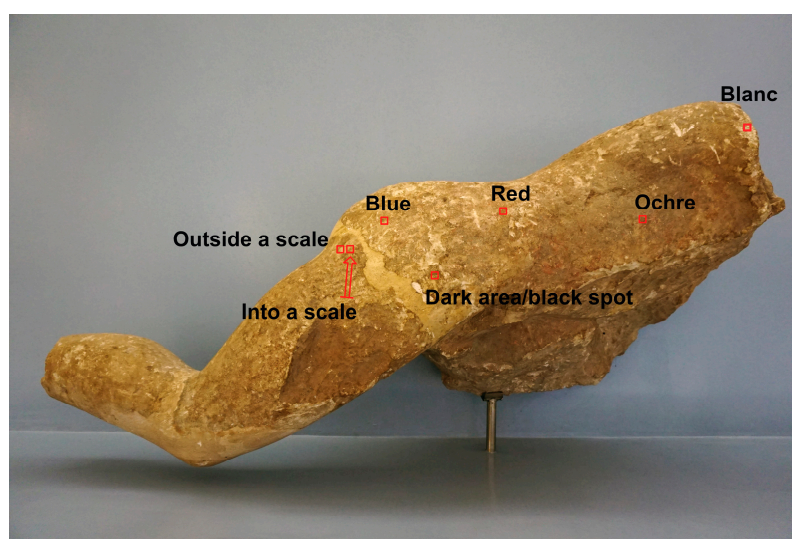


Figure 12. The figure of the Enkelados: XRF measurements points. The spots labeled “Into a scale” corresponds to an analysis conducted on a scale, as revealed by VIL imaging (see Figure 3) and on its periphery. © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

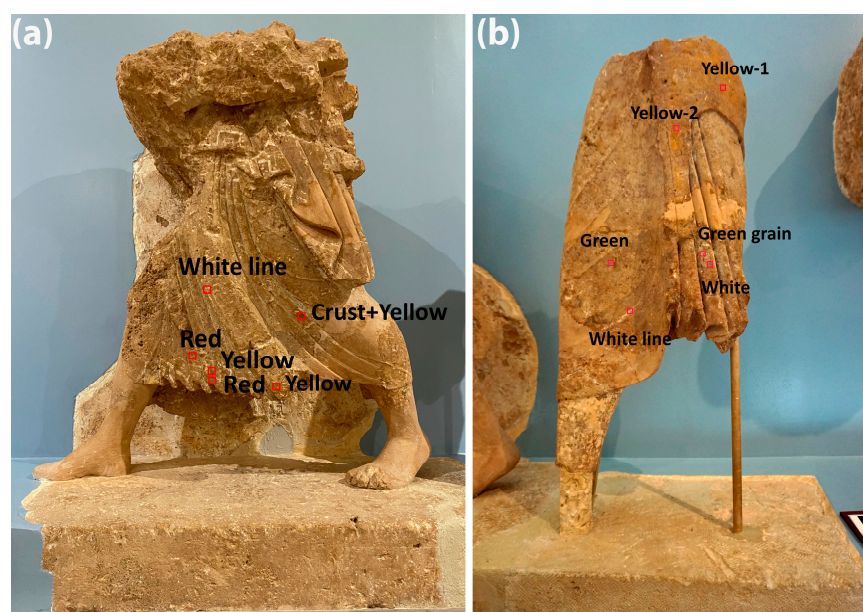


Figure 13. XRF measurement points. (a) The figure of “Athena”; (b) the standing male figure. © Hellenic Republic, Ministry of Culture, Ephorate of Antiquities of Phocis/G. Frantzi.

Table 1. Elemental analysis by means of portable XRF, Enkelado’s figure; numbers correspond to elemental peak areas (calculated in counts, see Section 2, Materials and Methods).

Analysis Spot	Al	Ca	Cl	Cu	Fe	Hg	K	Pb	S	Si	Sr
Blank	1203	589,306	1726	94	13,082		3471	364	5777	5909	18,244
Blue	1720	418,787	16,645	10,197	32,863	139	6416	14,513	12,710	17,490	13,818
Ochre	3994	308,034	345	1332	82,351	575	24,266	4817	5604	26,281	30,960
Dark area	1476	595,698	3383	2188	18,335	20,682	5627	6412	7223	15,720	16,637
Red	948	417,974	707	2504	20,058	43,762	3417	34,600	14,391	7339	13,875
Scale in	916	525,866	2628	1261	9470		2716	716	6578	5946	18,073
Scale out	2283	471,858	2198	1194	38,079	13,946	12,105	1513	4625	16,045	12,683

3.3.1. Enkelados

It is evident that in all the cases, the most prominent elemental peaks are those of calcium (Ca). This element is primarily associated with the sculpture stone, which is evidently a calcium-rich stone according to spot analysis conducted on the bare stone of Enkelados (“Blank”, Table 1, Figure 13); the latter finding corroborates earlier references which indicate that a gray limestone was used to construct the buildings of ancient Delphi [3,11].

As for the composition of the paint layers, it appears that the observed colors can be mostly linked to specific pigments in a relatively straightforward manner. Indeed, according to the results of XRF analysis, the blue area analyzed on the figure of Enkelados exhibits enhanced presence of copper (Cu) and silicon (Si), suggesting the use of Egyptian blue, which is considered to have been the earliest synthetic blue pigment [32–34] (Figure 14). In addition, the extensive use of Egyptian blue has been indeed attested through VIL imaging in all three statues (Figures 3–9). Here, it shall be noted that the predominance of Egyptian blue might well pertain to the fact that copper (Cu) was detected in all the analyzed spots (in all of the figures), regardless of their observable color (Tables 1–3). Indeed, in most of the XRF analyses, the Cu spectral peaks show relatively low intensity, suggesting that the presence of this element may not be directly linked to the use of Egyptian blue or

other Cu-containing pigments. Instead, it seems possible that copper originating from the Egyptian blue-containing paint layers has been diffused in other areas via dissolution upon weathering or/and burial.

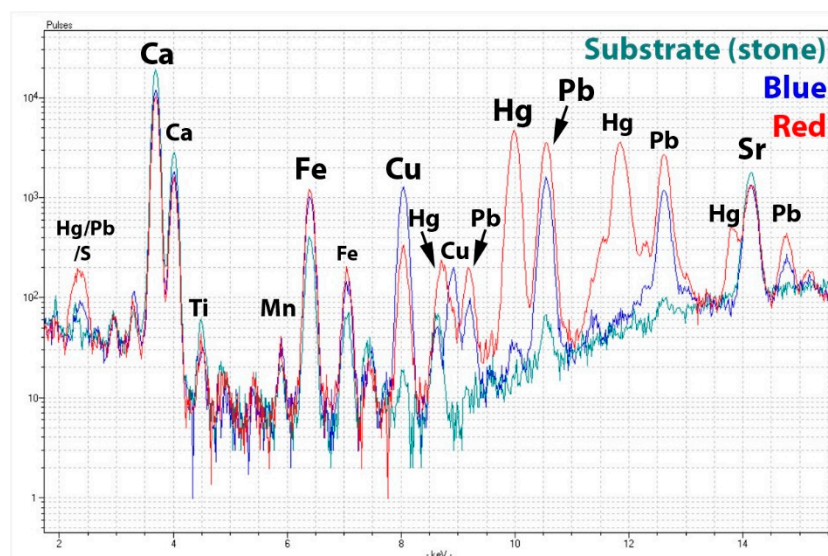


Figure 14. p-XRF spectra from the Enkelados stone and remnants of blue and red color. Details of 40 kV spectra in logarithmic scale.

Table 2. Elemental analysis by means of portable XRF, Athena's figure; numbers correspond to elemental peak areas (calculated in counts, see Section 2, Materials and Method).

Analysis Spot	Al	Ca	Cl	Cu	Fe	Hg	K	Pb	S	Si	Sr
Crust+yellow	2431	378,078	2253	59,165	39,894	184	10,923	669	8611	20,202	16,117
Red	1560	415,359		1223	14,497	156,786	4663	4775	28,264	9195	20,470
White	1473	657,087	2303	1482	11,064		4890	2991	10,046	6904	22,355
Yellow-1	1913	557,406	1306	4370	20,164	1861	6655	2359	10,027	12,155	27,363
Yellow-2	1547	518,027	2752	12,283	16,108	286	6531	7774	26,781	9092	23,939

Table 3. Elemental analysis by means of portable XRF, Standing male's figure; numbers correspond to elemental peak areas (calculated in counts, see Section 2, Materials and Method).

Analysis Spot	Al	Ca	Cl	Cu	Fe	Hg	K	Pb	S	Si	Sr
Green	1317	462,907	2785	96,598	16,623	520	4712	630	7033	16,060	20,924
Green grain	740	326,076	814	24,589	16,187		2045	405	1400	8641	16,014
White	1130	587,201	784	11,724	11,906		2378	723	2659	7225	20,926
Yellow	1659	529,505	761	310	59,593		5277	1553	3048	11,275	23,735
White line	925	310,385	15,333	484	10,807		2420	804	4119	8202	12,429
Yellow	1431	494,415	1030	269	48,473		4505	1728	3866	13,622	24,036

Regarding the intense red remnants, spectroscopic analysis revealed the presence of mercury (Hg) in the corresponding areas of the figure of Enkelados, and this element hints towards the employment of cinnabar, a naturally occurring mercury sulfide [34–36] (Figure 14, Table 1). Additionally, the detection of mercury on the outlines of the scales

suggested by VIL imaging, along with the presence of red color that is still visible over an extensive area of the statue of Enkelados, suggests that cinnabar might be the primary color covering the entire figure. The intense blue of the snake scales highlights the serpentine nature of the sculpture (Table 1), and this might have created a rather impressive optical effect. Interestingly, mercury was detected on a dark spot, too (Table 1), and this finding raises concerns about the potential darkening of cinnabar, a long-observed and debated phenomenon [37]. Finally, the XRF analysis on a yellow-colored spot returned notably high elemental peaks of iron (Fe), aluminum (Al), potassium (K), and titanium (Ti), clearly suggesting the use of an earth-type pigment, most probably yellow ochre [38].

3.3.2. Athena

In case of the Athena figure, analysis of a spot that currently appears yellow and partially covered by a superficial crust (“Crust + yellow”, Table 2) returned notably high levels of copper. This finding indicates that copper-based pigments might be present in areas that currently do not appear to be associated with typical copper blue or green pigments. However, the analyzed spot lies in proximity with the Egyptian-blue rendered folding of the Athena garment, and this area shows faint luminescence in VIL (Figure 6); therefore, the presence of Egyptian blue might be inferred. Also, the elevated iron detected on the same spot might either pertain to soiling remnants (crust) or to a partial coincidence of the analyzed spot with a yellow-colored (ochre) area.

In line with the findings from the XRF analyses of the statue of Enkelados, the predominant chemical element on the Athena red is mercury (Hg, Table 2), suggesting the employment of cinnabar. Of particular interest are the results of the analysis conducted on the whitish substrate of the paint layers: the corresponding spectra show a slightly enhanced presence of calcium (Ca), which is accompanied by sulfur, silicon, potassium and iron. Notably, the elemental peaks of iron are of rather low intensity (Table 2), suggesting that this element may originate either from the stone (see Table 1) or from soil contamination (Figure 15). The elevated presence of calcium indicates that a calcium-rich substance might have been used as a substrate for the colored decorations; however, the possibility of kaolinite usage cannot be excluded (Figure 15, Table 2). Finally, yellow-colored areas show enhanced presence of iron, silicon, potassium and titanium; hence, the usage of a yellow ochre is assumed [38] (Table 2, Figure 15).

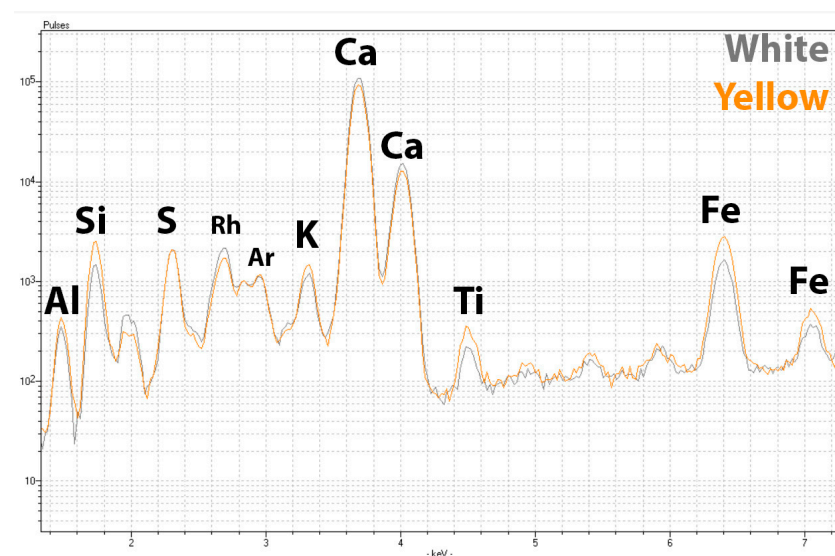


Figure 15. p-XRF spectra from the white substrate and a yellow spot (Athena figure); note the differences in the intensity of Fe, Si, K and Ti. Details of 15 kV spectra, logarithmic scale.

3.3.3. Standing Male Figure

Yellow-colored areas can be clearly spotted on the standing male figure (Figures 9 and 10), but they are also present on the other two statues. As mentioned above (Sections 3.3.1 and 3.3.2), the pertinent XRF analysis revealed a strong presence of iron (Fe), which is accompanied by elements typically associated with earthy pigments, such as silicon, aluminum, and potassium (Si, Al, and K, respectively), suggesting the use of an ochre (Figure 15, Table 3). Additionally, the white-colored areas of this figure once again show enhanced presence of calcium, corroborating the findings of the analyses of the statues of Athena and Enkelados.

Notably, high levels of chlorine (Cl) were detected in the analysis of a white line on the male figure (Table 3, Figure 16), while enhanced chlorine was also detected on a blue spot on Enkelados's figure (Table 1). Chlorine-rich compounds, such as sodium chloride, may well have accumulated on the surfaces of monuments located near the sea [39]. However, in most of the analyzed spots, the chlorine peaks are of relatively low intensity (Tables 1–3). Therefore, the significant presence of chlorine in these two instances warrants further investigation.

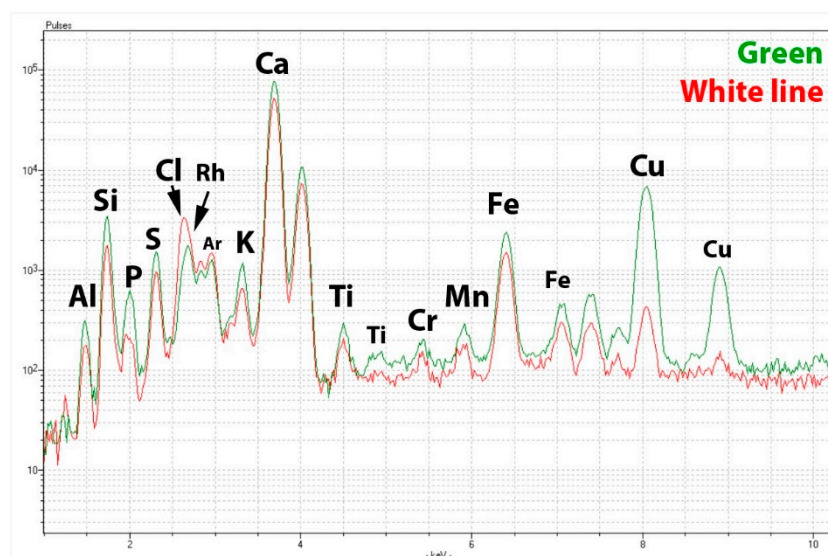


Figure 16. p-XRF spectra from a green spot and a whitish line on the statue of the male figure. Details of 15 kV spectra, logarithmic scale.

Regarding the green area and a green spot analyzed on the male figure, copper emerges as the most prominent element (Figure 16), while the silicon levels are only moderate (Table 3). This suggests that the use of Egyptian green—a pigment with a similar composition and manufacturing process to Egyptian blue [33]—can be reasonably excluded. Similarly, the low silicon and aluminum contents allow for the exclusion of the use of chrysocolla [34]; hence it may be inferred that another copper-based pigment—presumably malachite—had been utilized. It is worth noting that the use of natural Cu-based pigments such as azurite and malachite has recently been identified on the Athenian Acropolis by Aggelakopoulou et al. [40].

3.3.4. Further Considerations

A further evaluation of the analytical XRF data has revealed additional insights regarding the analyzed areas. For instance, it is evident that spectral peaks of lead (Pb) have been identified in all the 40 kV spectra, and, in some instances, these peaks show considerable intensity. Specifically, the highest Pb peaks are observed in spectra collected

from different-colored spots, such as a blue and a red spot on Enkelados's figure, and a red spot on the figure of Athena (Figure 17). This suggests that the presence of Pb is not limited to specific colors. It is possible that a Pb-based compound, presumably either white lead or red lead (minium), was mixed with other colored pigments to achieve specific hues, as seen in the red spots on Enkelados, where the presence of Pb is significant (Table 1). Both of these lead-based pigments began circulating in the Aegean in the Early Bronze Age [41]. Nonetheless, based on the currently available data, we cannot rule out the possibility that the Pb-rich substance is located beneath, above, or in close proximity to other paint layers.

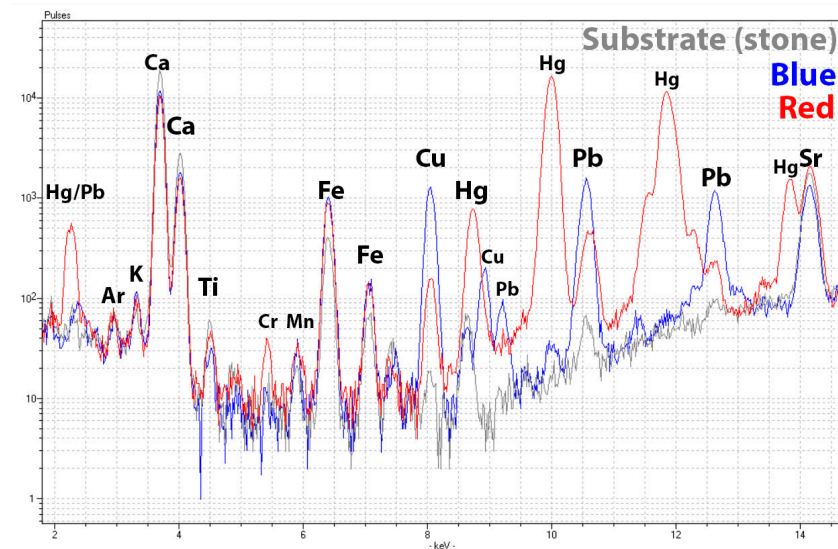


Figure 17. p-XRF spectra from the blue pigment on Enkelados's statue and the red pigment on Athena's statue; for comparative purposes, the spectrum from the substrate (stone/Enkelados) is also shown. Details of 40 kV spectra, logarithmic scale.

Additionally, it appears that mercury (Hg) is almost always accompanied by elevated levels of iron (Fe) (Figures 14 and 17 and Tables 1 and 2), and this may imply that cinnabar was applied over layers of iron-based ochre or in a mixture with iron-based pigments. Indeed, at the “scale out” and the “red” spot measurement points on Enkelados's statue, (Table 1) iron is slightly elevated and co-exists with mercury. However, the studied sculptures date back to the 6th century B.C.; hence this cinnabar was probably of natural/mineral origin (artificial cinnabar (vermilion) was not available before Roman times [34]), which suggests that iron could have entered the pigment batch through minor impurities. Finally, one may not exclude the possibility that the analyzed spots preserve remnants of contamination/soiling that gave rise to iron.

4. Conclusions

The unveiling of the original polychromy of the west pediment of the Apollo Temple at Delphi (6th c. B.C.) was achieved through an exclusively non-invasive methodology.

It appears that blue played a significant role in the overall effect of all the statues' polychromy, as extensive areas of Egyptian blue were often detected on the statues' garments through VIL imaging [26,42–44]. Various decorative patterns have also been confirmed, including the formation of scales, a meander with a svastika (type A 2) to the left, a meander with squares, and an included cross. Additionally, there are two patterns that do not clearly correspond to a zigzag pattern but instead resemble a U-shaped meander [22].

Observation of the surface by means of a portable digital optical microscope on the figure of Athena confirmed the presence of red paint layers within the folds of her robe.

Notably, dark blue to black spots align with the areas of Egyptian blue in the VIL images, raising concerns about the potential blackening of Egyptian blue under specific conditions. There is also a whitish layer present, possibly serving as a substrate for the polychromy; XRF analysis revealed predominance of calcium in this very layer.

In the chiton of the male figure, microscopic analysis revealed grains with intense blue and red hues, along with traces of a white line. A broad area of uniform yellow, containing grains of red and brown, was also identified.

The extensive use of cinnabar [35,36] has been attested through p-XRF analysis; interestingly, mercury was detected on a black spot, too, suggesting that part of the original cinnabar might have undergone blackening. Furthermore, the p-XRF analysis revealed the presence of pigments like yellow ochre, a calcium-rich white substance, and a copper-based green; the currently available data indicate that, most probably, the latter shall be identified as malachite. The mixing or superposition of pigments is also suggested, indicating a rather complex painting process on the stone's surface. Research is ongoing, aiming to shed more light on ancient Archaic polychromy.

Author Contributions: Conceptualization, G.G.F., H.B. and P.T.; methodology, G.G.F., H.B. and P.T.; validation, G.G.F., G.P.M., H.B. and P.T.; investigation, G.G.F., G.P.M. and S.K.; resources, G.G.F., G.P.M. and S.K.; data curation, G.G.F., G.P.M. and S.K.; writing—original draft preparation, G.G.F., G.P.M. and H.B.; writing—review and editing, G.G.F., G.P.M., A.P. and H.B.; visualization, G.G.F.; supervision, G.G.F.; project administration, G.G.F.; funding acquisition, G.G.F. and S.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Data are available upon request.

Acknowledgments: Acknowledgments are owed to the personnel at the Archaeological Museum in Delphi (conservators of antiquities and guardians of antiquities) for their contributions during the in situ measurements. In particular, we would like to acknowledge the conservator, Christos Pantermakis, for his active participation. Sotiria Kogou would like to thank the ISAAC (Imaging & Sensing for Archaeology, Art History & Conservation) group at Nottingham Trent University for granting access to the Hirox OM. Giasemi Frantzi would like to extend her profound gratitude to Symeon Gesafidis, a photographer at the Directorate of Research and Technical Support for Restoration Projects. His invaluable contribution enabled the acquisition of VIL images in daylight. His extensive knowledge and expertise, coupled with the use of his modified camera and equipment, were instrumental in facilitating the daylight VIL imaging. For the LED light source VIL imaging, Giasemi Frantzi would like to express her gratitude to YSMA (the Acropolis Restoration Service) for providing the equipment. Additionally, she thanks Eftihia Koutsouraki for her valuable participation, and Eirini Pervolaraki for her extensive help with editing.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Zink, S. Polychromy, Architectural, Greek and Roman. Oxford Classical Dictionary. 26 March 2019. Available online: <https://oxfordre.com/classics/view/10.1093/acrefore/9780199381135.001.0001/acrefore-9780199381135-e-8184> (accessed on 31 October 2024).
2. Østergaard, J.S. Polychromy, Sculptural, Greek and Roman. Oxford Classical Dictionary. 26 February 2018. Available online: <https://oxfordre.com/classics/view/10.1093/acrefore/9780199381135.001.0001/acrefore-9780199381135-e-8118> (accessed on 31 October 2024).
3. Keramopoulos, G. *Guide to Delphi, The Athenian Archaeological Society (1935)*; Bommelaer, J.F., Laroche, D., Eds.; Guide de Delphes, Le Site; EFA: Athens, Greece, 1991.
4. Coste-Messelière, L. Les Alcmeonides à Delphes. *Bull. De Corresp. Hellénique* **1946**, *70*, 271–287. [CrossRef]
5. Homolle, T. Monuments figurés de Delphes. Les frontons du temple d'Apollon. *Bull. De Corresp. Hellénique* **1902**, *26*, 587–639. [CrossRef]

6. Picard, C.; Messelière, P.; de La, C. Fouilles des Delphes IV, 3. Monuments figurés: Sculpture. *Art archaïque: Sculptures des Temples, École française a" Athènes*, Paris, De Boccard. 1931. Available online: https://www.persee.fr/doc/rea_0035-2004_1932_num_34_3_2670_t1_0326_0000_2 (accessed on 31 October 2024).
7. Aurigny, H.; Braunstein, D.; Martinez, J.L. Recherches sur la sculpture archaïque de Delphes: Nouvelles propositions et perspectives. *Open Ed. J. Bull. Corresp. Hellénique* **2018**, *142*, 71–96. [CrossRef]
8. Jacquemin, A.; Laroche, D.; Aurigny, H.; Jockey, P.; Martinez, J.L. Delphes, 130 ans de découvertes. *Archéologia* **2022**, *612*, 28–45.
9. Kokkorou-Alevras, G.; Poupaki, E.; Chatziconstantinou, A.; Efstathopoulos, A. *Corpus of Ancient Greek Quarries*; National and Kapodistrian University of Athens, School of Philosophy, Department of History and Archaeology: Athens, Greece, 2014; Volume 176, p. 641.
10. Hayward, C.L. The geology of Corinth: Study of a basic resource. In *Corinth XX. The Centenary, 1896–1996*; Bookidis, N., Williams, C.K., Eds.; The American School of Classical Studies, Harvard University Press: Cambridge, MA, USA, 2003; pp. 15–42.
11. Higgins, M.D.; Higgins, R. *A Geological Companion to Greece and the Aegean*; Cornell University Press: New York, NY, USA, 1996.
12. Shear, J.L. *Serving Athena: The Festival of the Panathenaia and the Construction of Athenian Identities*; Cambridge University Press: Cambridge, UK, 2021.
13. Mireille, M.L. Dress and Adornment in Archaic and Classical Greece. In *A Companion to Women in the Ancient World*; James, S.L., Dillon, S., Eds.; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2012; pp. 179–190.
14. Deacy, S.; Villing, A. What was the colour of Athena's Aegis? *J. Hell. Stud.* **2009**, *129*, 111–129. [CrossRef]
15. Boardman, J. *Greek Sculpture, The Archaic Period, a Handbook*; Oxford University Press: London, UK, 1978.
16. Janssens, K.; Van der Snickt, G.; Vanmeert, F.; Legrand, S.; Nuyts, G.; Alfeld, M.; Monico, L.; Anaf, W.; De Nolf, W.; Vermeulen, M.; et al. Non-Invasive and Non-Destructive Examination of Artistic Pigments, Paints, and Paintings by Means of X-Ray Methods. *Top. Curr. Chem.* **2016**, *374*, 81. [CrossRef]
17. Annemie, A. Non-destructive analysis and testing of museum objects: An overview of 5 years of research. *Spectrochim. Acta Part B* **2005**, *60*, 1503–1516.
18. Verri, G. The application of visible-induced luminescence imaging to the examination of museum objects. In *Proceedings of SPIE, the International Society for Optical Engineering*; Springer: Berlin/Heidelberg, Germany, 2009; p. 7391. [CrossRef]
19. Verri, G.; Saunders, D. Xenon Flash for Reflectance and Luminescence (Multispectral) Imaging in Cultural Heritage Applications. *Br. Mus. Tech. Res. Bull.* **2014**, *8*, 83–92.
20. Alfeld, M.; Mulliez, M.; Martinez, P.; Cain, K.; Jockey, P.; Walter, P. The Eye of the Medusa: XRF Imaging Reveals Unknown Traces of Antique Polychromy. *Anal. Chem.* **2017**, *89*, 1493–1500. [CrossRef]
21. Karydas, A.G.; Brecoulaki, H.; Bourgeois, B.; Jockey, P. In-situ X-Ray Fluorescence analysis of raw pigments and traces of polychromy on Hellenistic sculpture at the Archaeological Museum of Delos. In *Proceedings of the 7th International Conference of Association for the Study of Marble and Other Stones in Antiquity, ASMOSIA VII 2003, BCH 51, Thasos, Greek, 15–20 September 2003*; Maniatis, Y., Ed.; École Française d'Athènes: Athens, Greece, 2009; pp. 811–829.
22. Ginouvès, R.; Martin, R. *Dictionnaire Méthodique de L'architecture Grecque et Romaine. Tome 1, Matériaux, Techniques, de Construction, Techniques et Formes du Décor*; Ecole français d'Athènes; Ecole française de Rome: Rome, Italy, 1985; pp. 52, 55, 57, 181.
23. *Lexicon Iconographicum Mythologiae Classicae (LIMC)*. Artemis & Winkler Verlag (Zürich, München, Düsseldorf), Vol. III: Atherion-Eros. 1988, pp. 414–416. Available online: https://archive.org/details/limc_20210516/Lexicon%20Iconographicum%20Mythologiae%20Classicae/LIMC%20III-1%20Atherion-Eros/ (accessed on 31 October 2024).
24. Berke, H. The invention of blue and purple pigments in ancient times. *Chem. Soc. Rev.* **2006**, *36*, 15–30. [CrossRef]
25. Xia, Y.; Ma, Q.; Zhang, Z. Development of Chinese barium copper silicate pigments during the Qin Empire based on Raman and polarized light microscopy studies. *J. Archaeol. Sci.* **2014**, *49*, 500–509. [CrossRef]
26. Verri, G.; Granger-Taylor, H.; Jenkins, I.; Sweek, T.; Weglowska, K.; Wootton, W.T. The goddess' new clothes: The carving and polychromy of the Parthenon Sculptures. *Antiquity* **2023**, *97*, 1173–1192. [CrossRef]
27. *Lexicon Iconographicum Mythologiae Classicae (LIMC)*. Artemis & Winkler Verlag (Zürich, München, Düsseldorf), Vol. IV: Eros (in Etruria), Herakles. 1988. Available online: https://archive.org/details/limc_20210516/Lexicon%20Iconographicum%20Mythologiae%20Classicae/LIMC%20IV-1%20Eros-Herakles/ (accessed on 31 October 2024).
28. *Lexicon Iconographicum Mythologiae Classicae (LIMC)*. Artemis & Winkler Verlag (Zürich, München, Düsseldorf), Vol. II-1: Aphrodisias-Athena. 1988, p. 309. Available online: https://archive.org/details/limc_20210516/Lexicon%20Iconographicum%20Mythologiae%20Classicae/LIMC%20II-1/ (accessed on 31 October 2024).
29. Scott, D.A. A review of ancient Egyptian pigments and cosmetics. *Stud. Conserv.* **2016**, *61*, 185–202. [CrossRef]
30. Scott, D.A. *Copper and Bronze in Art: Corrosion, Colorants, Conservation*; Getty Publications: Los Angeles, CA, USA, 2002; pp. 122–144.
31. Daniels, V.; Stacey, R.; Middleton, A. The Blackening of Paint Containing Egyptian Blue. *Stud. Conserv.* **2004**, *49*, 217–230. [CrossRef]

32. Kovalev, I.; Rodler, A.S.; Brøns, C.; Rehren, T. Making and working Egyptian blue—A review of the archaeological evidence. *J. Archaeol. Sci.* **2023**, *153*, 105772. [\[CrossRef\]](#)
33. Hatton, G.D.; Shortland, A.J.; Tite, M.S. The production technology of Egyptian blue and green frits from second millennium BC Egypt and Mesopotamia. *J. Archaeol. Sci.* **2008**, *35*, 1591–1604. [\[CrossRef\]](#)
34. Eastaugh, N.; Walsh, V.; Chaplin, T.; and Siddall, R. *The Pigment Compendium. A Dictionary of Historical Pigments*; Elsevier Butterworth-Heinemann: Amsterdam, The Netherlands, 2004.
35. Gliozzo, E. Pigments, Mercury-based red (cinnabar-vermilion) and white (calomel) and their degradation products. *Archaeol. Anthr. Sci.* **2021**, *13*, 210. [\[CrossRef\]](#)
36. Gettens, R.; Feller, R.; Chase, W. Vermilion and Cinnabar. In *Artists Pigments*; Roy, A., Ed.; National Gallery Publications, 1993; Volume 2, pp. 159–182. Available online: <https://www.nga.gov/research/publications/pdf-library/artists-pigments-vol2.html> (accessed on 31 October 2024).
37. Neiman, M.K.; Balonis, M.; Kakoulli, I. Cinnabar alteration in archaeological wall paintings: An experimental and theoretical approach. *Appl. Phys. A* **2015**, *121*, 915–938. [\[CrossRef\]](#)
38. Mastrotheodoros, G.P.; Beltsios, K.G. Pigments, Iron-based red, yellow, and brown ochres. *Archaeol. Anthr. Sci.* **2022**, *14*, 35. [\[CrossRef\]](#)
39. Cardell, C.; Delalieux, F.; Roumpopoulos, K.; Moropoulou, A.; Auger, F.; Van Grieken, R. Salt-induced decay in calcareous stone monuments and buildings in a marine environment in SW France. *Constr. Build. Mater.* **2003**, *17*, 165–179. [\[CrossRef\]](#)
40. Aggelakopoulou, E.; Sotiropoulou, S.; Karagiannis, G. Architectural Polychromy on the Athenian Acropolis: An In Situ Non-Invasive Analytical Investigation of the Colour Remains. *Heritage* **2022**, *5*, 756–787. [\[CrossRef\]](#)
41. Sotiropoulou, S.; Perdikatsis, V.; Apostolaki, C.; Karydas, A.G.; Devetzi, A.; Birtacha, K. Lead pigments and related tools at Akrotiri, Thera, Greece. Provenance and application techniques. *J. Archaeol. Sci.* **2010**, *37*, 1830–1840. [\[CrossRef\]](#)
42. Brecolaki, H. Precious colours in ancient Greek painting and polychromy: Material aspects and symbolic values. *Révue Archéologique* **2014**, *1*, 3–5. [\[CrossRef\]](#)
43. Brinkmann, V. Τα χρώματα των αρχαϊκών και πρώιμων κλασσικών γλυπτών. Πολύχρωμοι Θεοί. Χρώματα στα αρχαία γλυπτά. Έκθεση του Εθνικού Αρχαιολογικού Μουσείου σε συνεργασία με την Γλυπτοθήκη του Μονάχου και το Goethe Institut της Αθήνας. in: Pub: National Archaeological Museum in Athens in Collaboration with the Glyptothek in Munich and the Goethe Institut in Athens. 2007, pp. 25–41. (In Greek). Available online: <https://www.jstor.org/stable/4390680> (accessed on 31 October 2024).
44. Frantzi, G.; Maridaki, A.; Papakonstantinou, E.; Verri, G.; Sotiropoulou, S.; Brecolaki, H. The Revelation of the Decorative Pattern on the Coffered Ceiling of the Porch of the Karyatids in the Erechtheion. In *Archaeology of Colour: Technical art History Studies in Greek and Roman Painting and Polychromy; Meletemata 87*; Brecolaki, H., Ed.; Athens, Brepols Pub: Ghent, Belgium, 2024; p. 49.

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.