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Deceiving Colours

Scientific Imaging and Chemical Analysis of Polychrome Campana Plaques in the Ny Carlsberg Glyptotek

Abstract

This study presents the results of examinations of the polychromy of three Campana plaques in the Ny Carlsberg Glyptotek, Copenhagen. The study combines scientific imaging with chemical analysis: the preliminary information on the materials present extracted from the multispectral images are followed up by identifications based on vibrational spectroscopy and other chemical analyses. This has revealed significant information about their original polychromy. The insights gained go far beyond information that can be obtained by visual examination with the naked eye alone, or even with a microscope. The examinations have shown that some parts of the polychromy are original, while other parts belong to a modern restoration that took place sometime during the 19th century. The ancient pigments identified on the plaques include red ochre, yellow ochre, carbon black, gypsum, kaolin, lead white, Egyptian blue, cinnabar, and vanadinite, while the modern restorations include chrome yellow and shellac. The present study has thus provided us with information on the ancient appearance of these artefacts, but, just as importantly, it has exposed what is ancient and what is in fact modern restoration, which is obviously of paramount importance to our understanding of the plaques original appearance.

Introduction: Campana Plaques and Polychromy Research

The polychromy of ancient artefacts is an expanding field of research. Polychromy research is an interdisciplinary endeavour, involving different scientific capacities including archaeology, conservation, and the natural sciences. The focus has primarily been on Greco-Roman marble sculpture and grandiose architecture,[1] wall-paintings,[2] as well as more remarkable artefacts, such as the famous mummy portraits from Roman

1 E.g. Liverani et al. 2004; Brinkmann et al. 2010; Østergaard – Nielsen 2014. For Roman architectural polychromy, see particularly Zink 2014 and 2019.

2 See e.g. Cuni 2016 and references therein.

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Egypt.[3] Until recently, however, terracotta artefacts have been relatively overlooked. This is fortunately starting to change, with studies focusing on Etruscan architectural decoration,[4] and Hellenistic figurines and statuary.[5] Relatively little attention has been paid to the polychromy of Campana plaques though: only one scientific study has been published so far. It identifies the pigments used for the polychromy of nine fragments (eight with visible polychromy) of Campana plaques from the Palatine Hill, Rome.[6]

That so few studies focus on examinations of polychromy and the identification of pigments is surprising, since many of these artefacts in fact show clear traces of their original colours, which presents an intriguing opportunity to identify the pigment palette used for their decoration, and thus provide deeper insights into their production and original appearance. Perhaps the colours have not received much attention because it is an established fact that the plaques were painted, and the polychromy is not considered to particularly transform their appearance, nor is there an element of surprise in the contrast, unlike, for example, when the colours of a seemingly white marble sculpture are revealed. Several publications do give limited descriptions of the polychromy if preserved, although this has not always been done accurately.[7] The present study seeks to fill this gap in research by examining the polychromy of three painted Campana reliefs in the collections of the Ny Carlsberg Glyptotek in Copenhagen.

Campana Reliefs in the Ny Carlsberg Glyptotek

The NCG holds a small collection of 18 Campana reliefs and one fragment.[8] They were all acquired in the period between 1899 and 1907, and the majority are without exact provenance. The collection represents various genre motifs, known from other Campana plaques, including a Nilotic scene, Victory sacrificing a bull, Dionysiac scenes, the goddess Ceres, and scenes with satyrs. The reliefs are generally well-preserved, but only three display visual traces of polychromy and were therefore chosen for further analyses.

Campana Relief Depicting Satyrs Picking Grapes (IN 1708: Fig. 1)

The relief depicts two squatting satyrs, who are picking grapes on either side of a grape vine in the centre. They put the grapes in two baskets placed on the ground before them. The satyr to the left is young, while the satyr to the right is older. They both wear a cloak, or perhaps a panther skin or a *nebris*, but are otherwise naked. An ornamental palmette frieze crowns the figure frieze.[9]

3 E.g. Svoboda – Cartwright 2020.
4 E.g. Bordignon et al. 2007a; Bordignon et al. 2007b; Brøns et al. 2016a; Brøns et al. 2016b;
5 Jeammet 2010; Bourgeois – Jeammet 2014; Bourgeois – Jeammet 2020; Buisson et al. 2014.
6 Tarquini et al. 2020.
7 As an example, in the catalogue of the Ny Carlsberg Glyptotek (Østergaard 1996), only some of the colours of IN 1701 and IN 1708 are described, while the blue background is not even mentioned.
8 Poulsen 1949, cat. 93–110; Østergaard 1996, cat. 180–197.
9 The plaque belongs to Rauch's variant 5: Rauch 1999, cat. 576.

Fig. 1 Campana plaque, Ht.: 32 cm. W.: 35 cm. Copenhagen, Ny Carlsberg Glyptotek, Inv. IN 1708.
Image: CC BY-NC-ND 4.0 (O. Haupt).

Polychromy: The skin of the satyrs is painted red and there is yellow/orange paint on the cloaks and on the grapes in their hands, in their baskets, and on the vine. There are remains of black paint on the baskets and in the hair of the satyrs. Moreover, there are extensive remains of blue paint on the background.

Acquisition and parallels: The relief was acquired at an auction of the collection of Louis Saulini at the Hotel Sangiorgi (Palazzo Borghese) in Rome in 1899.[10] According to the catalogue, the lot included three identical reliefs, all with traces of colour. In addition to the relief in the NCG, numerous identical reliefs are known.[11] Several of them have no traces of their original colours, but a relief from the National Museum in Denmark has well-preserved polychromy, which overall adheres to the same colour scheme as the one in the NCG. Additionally, a relief now in Moscow is described as polychrome: the satyrs are painted yellow and red, the baskets and grapes yellow.[12]

10 Catalogue 1899, lot. 247.

11 See Rauch 1999, 101–105. 177–187 nos. 456–628. Examples include: National Museum of Denmark, no. Abb 307. Breitenstein 1941, 846 (acquired in Rome in 1860–61); British Museum, London, no. D536 and D537 (acquired in 1805); Martin von Wagner Museum, Würzburg, no. H 2677; Pushkin Museum, Moscow (previously in the Staatliche Museen, Berlin, no. 3609).

12 Rohden – Winnefeld 1911, 300.

Campana Relief Depicting Satyrs Treading Grapes (IN 1701: Fig. 2)

In the centre of the scene are two young satyrs, both clad in a panther skin or a *nebris*, treading grapes. To the left of the satyrs is another young satyr dressed in a skin and playing the flute. To the right is an old satyr carrying a basket. An ornamental palmette frieze crowns the figure frieze.[13]

Polychromy: The skin of the satyrs is painted red. The hair of the three youngest satyrs is painted brown. The panther skins of the satyr to the far left and of the old satyr to the far right are painted yellow, while the panther skins of the two satyrs in the middle are painted blue. The double flute and the grapes are painted yellow, while the old satyr's basket is painted red and yellow. There is yellow paint as well as a little red paint on the horizontal moulding separating the figure scene from the palmette frieze above, and extensive remains of white paint on the background.

Acquisition and parallels: The relief was acquired at an auction of the collection of Louis Saulini at the Hotel Sangiorgi (Palazzo Borghese) in Rome in 1899.[14] According to the catalogue, the lot included five identical reliefs, three of which have traces of colour.[15] Besides the relief in the NCG, several identical reliefs are known.[16] Two of the known identical reliefs are now in the collections of the National Museum of Denmark[17] and the Pushkin Museum, Moscow.[18] Both reliefs have well-preserved polychromy, which adhere overall to the same colour scheme as the one in the NCG. In particular, the one in Moscow has a similar polychromy, while the relief in the National Museum is more subtle in its colours, which appear faded.

Campana Relief with *palaestra* Scene (IN 1929: Fig. 3)

The relief depicts five statues in an architectural setting consisting of a *porticus* with six fluted Corinthian columns. The two central and larger columns support a triangular pediment with a depiction of two hippocamps holding a shield. A frontal statue of Hercules wearing a lion skin and holding a club stands in this central *intercolumnium*. A *porticus* with four columns supporting a frieze and an architrave is shown to the left and right. Statues of athletes are standing in the four *intercolumnia*. To the left are two pugilists. To the right is an athlete scraping oil off his body, and a victor crowning himself and holding a palm leaf in his left hand. The scene depicts a *palaestra*. The

13 The plaque belongs to Rauch's variant 2a. Rauch 1999, cat. 675.

14 Catalogue 1899, lot. 248.

15 The museum has two of the reliefs from this lot: IN 1701, which is included in this study, and IN 1707, which depicts a similar scene with satyrs treading grapes. The type corresponds to IN 1701, but there are differences in the details and the crowning row of palmettes is missing. Moreover, it has no traces of its original polychromy.

16 See Rauch 1999, 106–113. 188–199 nos. 629–811.

17 National Museum of Denmark, no. Abb 231. Breitenstein 1941, no. 856. Acquired from King Christian VIII, who received it as a gift from Campana in Rome. Rauch 1999, cat. 674.

18 Previously in the Staatliche Museen, Berlin, inv. no. 3610. Rauch 1999, cat. 667.

Fig. 2 Campana plaque, Ht.: 31 cm. W.: 43 cm. Copenhagen, Ny Carlsberg Glyptotek, Inv. IN 1701.
Image: CC BY-NC-ND 4.0 (A. Sune Berg).

Fig. 3 Campana plaque, H.: 39 cm. W.: 39.5 cm. Ny Carlsberg Glyptotek, Inv. IN 1929.
Image: CC BY-NC-ND 4.0 (A. Sune Berg).

central part of the relief may be regarded as rendering a Hercules temple or an *exedra* in the *porticus*.[19]

Polychromy: The background behind the athletes directly to the left and right of Hercules, as well as above the wreath above him, are yellowish. There are traces of yellow paint on the pediment above and on the hippocamps. Both hippocamps have minor traces of purplish paint in their hair. There are also traces of purple paint on the semi-circular architecture above the athlete scraping off oil and on the head of Hercules' club. Hercules' lion skin has some remains of yellow paint. The polychromy is most well preserved on the lower part of the relief; the horizontal moulding, as well as the statue and column bases, have white paint and there are clear remains of blue paint on the background behind the athlete to the far left, behind Hercules, on the column to the right of Hercules, and behind the athlete to the far right.

Provenance: Reliefs with identical motifs have been recovered in the Gardens of Sallust in Rome and are presumably made in the same mould. They probably all come from the same building, possibly a *palaestra* connected to a bath complex.[20]

Acquisition and parallels: The relief was acquired by Carl Jacobsen in 1902 via the German archaeologist Paul Arndt (1865–1937) for the price of 350 Lire excluding transport. In a letter from Arndt to Jacobsen, he mentions that five or six identical reliefs have been recovered.

There are numerous known identical parallels to the relief in the NCG.[21] Many of these reliefs have traces of polychromy. Overall, the individual reliefs appear to follow the same colour scheme as the relief in NCG: for example, the background behind the five statues is alternating blue and yellow. The two most central arches above the frieze are dark red, and the hippocamps yellow, as is Hercules' lion skin. However, a relief in Dresden has a somewhat different colour scheme:[22] the area over the garland above Hercules is in this relief painted red instead of yellow, and the two most central arches are white instead of red, while the two outermost arches are red rather than white. So, although the polychromy of the individual reliefs at first impression appears the same, there are minor differences.

19 Østergaard 1996, 282.

20 Perry 1997, 43; Østergaard 1996, 282. See also the contribution by R. Sporleder in this volume, p. 355.

21 Kunsthistorisches Museum, Vienna, no. V 1895; Allard Pierson Museum, no. 451; Musée du Louvre, no. CP1500 / S4488; Museum of Fine Arts, Boston, no. 03.883; Albertinum, Dresden, no. Z2141; Staatliche Antikensammlung, Munich, no. SL273; Sammlung Archäologischen Instituts der Universität Heidelberg, no. C XII (fragment); Sammlung August Kestner, no. 118 (fragment) and 1421 (fragment); Staatliche Museen, Berlin, no. TC 8814; Pushkin Museum, Moscow, no. AT 3700 (previously in the Staatliche Museen, Berlin, no. 8739). American Academy, Rome, Norton-Van Buren Archaeological Study Collection no. 000136. See Perry 1947, 43 and Reinhardt 2016a, 251 n. 55 for individual parallels and further references.

22 <https://skd-online-collection.skd.museum/Details/Index/640938> (31.03.2022).

Experimental Methods

Imaging Techniques

Multispectral imaging was performed with a Canon EOS 5D Mark IV camera body and a Canon EF 50 mm f/2.5 Compact Macro lens. The camera was modified by removing the infrared and ultraviolet radiation blocking filter in front of the sensor. The following filters were used for image acquisition: XNite CC1 from MaxMax.com for visible light photography (VIS), XNite CC1, PECA 916, and Tiffen Haze 2E for ultraviolet induced visible fluorescence imaging (UVF), as well as a Schott RG830 for infrared photography (IRR) and visible light induced infrared luminescence imaging (VIL). A Midwest Optical Systems BP324 filter yielded ultraviolet reflectance (UVR) images. Light sources employed were incandescent tungsten lamps, Excled LED RGB lamps (470 nm, 525 nm, and 629 nm), and Hoenle UVASPOT 400/T lamps filtered with a Schott UG2A glass. In addition, the X-Rite Color Passport 2, Target-UV™ from UV Innovations, and a 99% Spectralon® diffuse reflectance standard were used.

X-Ray Fluorescence (XRF) Spectroscopy

XRF spectra were acquired with a handheld Bruker Tracer 5^{i} equipped with a Rhodium tube. Two measurements at 15kV, 15 µA, with no filter, and 40 kV, 7 µA, with a Ti/Al filter, were taken for each location optimising the detection of low and high Z elements respectively. The data were processed with the Bruker Artax software *Spectra*, Version 8.0.0.476.

Fourier Transform Infrared (FTIR) Spectroscopy

A ThermoFisher IR spectrometer equipped with an MCT detector and coupled to a microscope (Continuum) was used to record infrared spectra of microsamples. The samples were pressed between two diamond windows and measured in transmission mode. Resulting spectra were compared with reference libraries.

Raman Spectroscopy

Raman spectra were acquired with a WITec alpha300R Confocal Raman Microscope equipped with two lasers emitting at 532 nm and 785 nm. The excitation laser power was on the order of 1 to 5 mW. A Zeiss EC Epiplan-Neofluar 50x lens and 300 and 600 g/mm gratings were used. The data were processed with WITec Project Five software, version 5.0.15.55, and compared with reference spectra.

Scanning Electron Microscopy Coupled with Energy Dispersive X-Ray Analysis (SEM-EDX)

A Hitachi S-3400 N SEM equipped with an energy-dispersive spectrometer (EDS) was used for the microstructural analyses. The spectrometer is a Bruker Quantax 200 EDS system with two Peltier-cooled XFlash silicon drift detectors. The detectors have an active area of 20 mm^2 each. The system allows the detection of low-energy X-ray photons so that even boron (Z = 5, Kα = 0.182 KeV) can be detected. The observations were performed in variable pressure (VP) mode on non-coated polished sections, and analyses were related to internal virtual standard profiles. The acquisition varied between 200 and 600s live time.

Cross-Sectional Analysis

Samples for cross-sectional analysis were mounted in Technovit 2000 LC resin cured with blue light (Technotray Power). A two-step process was used for including a label, resulting in 8 mm cylinders. Images of the polished cross-sections were recorded with a Leica research microscope in bright field mode with crossed polarising filters and under UV illumination detecting the induced visible fluorescence.

Results

IN 1708

Comparison of the visible light photograph with the UVF image (Fig. 4, a and b) shows that the yellow-orange grapes in the baskets, in the hands of the satyrs, and hanging on the tree exhibit a strong orange fluorescence. The same behaviour under UV illumination is observed for large areas of the skin of the two satyrs. FTIR analysis identifies the fluorescing material as restoration paint containing shellac, which is in agreement with the orange colour of the fluorescence. Additionally, the pigment chrome yellow (lead chromate, $PbCrO_4$) is detected in the shellac-based paint by both FTIR and Raman spectroscopy, clearly identifying these areas as modern restoration (see further below). Primarily in the grapes, but also in some areas of the skin of the satyrs, the restoration is applied in a dot pattern only visible in the UVF image (Fig. 5). The terracotta plaque, once broken in two pieces, is glued together with an unidentified material fluorescing in a turquoise colour, as can be seen in the vertical crack to the right of the grape vine. The blue background and the ornamental palmette frieze at the top of the relief fluoresce weakly in a greenish colour while the baskets, the grape vine leaves, as well as the original skin colour of the satyrs show no UV-induced fluorescence.

A paint cross-section from the shellac treated area of the calf of the left satyr is illustrated in Figure 6. Three layers are visible. On the bottom, the terracotta substrate is recognisable with its red inclusions. Then a red paint layer follows on top, and the final layer is an unpigmented highly fluorescing shellac layer. This stratification shows that, in this case, the shellac served as a coating rather than a binding medium, possibly to match the surrounding area of original paint in gloss. Additional cross-sectional analysis shows that there is no ground layer in the original ancient polychromy, which agrees with observations through close examination of the plaque under the stereo microscope.

The VIL image detects the distribution of Egyptian blue applied to the relief (Fig. 4, c). As the pigment emits light in the near infrared spectral region upon excitation with visible light, the VIL image is white in locations where the pigment is present and

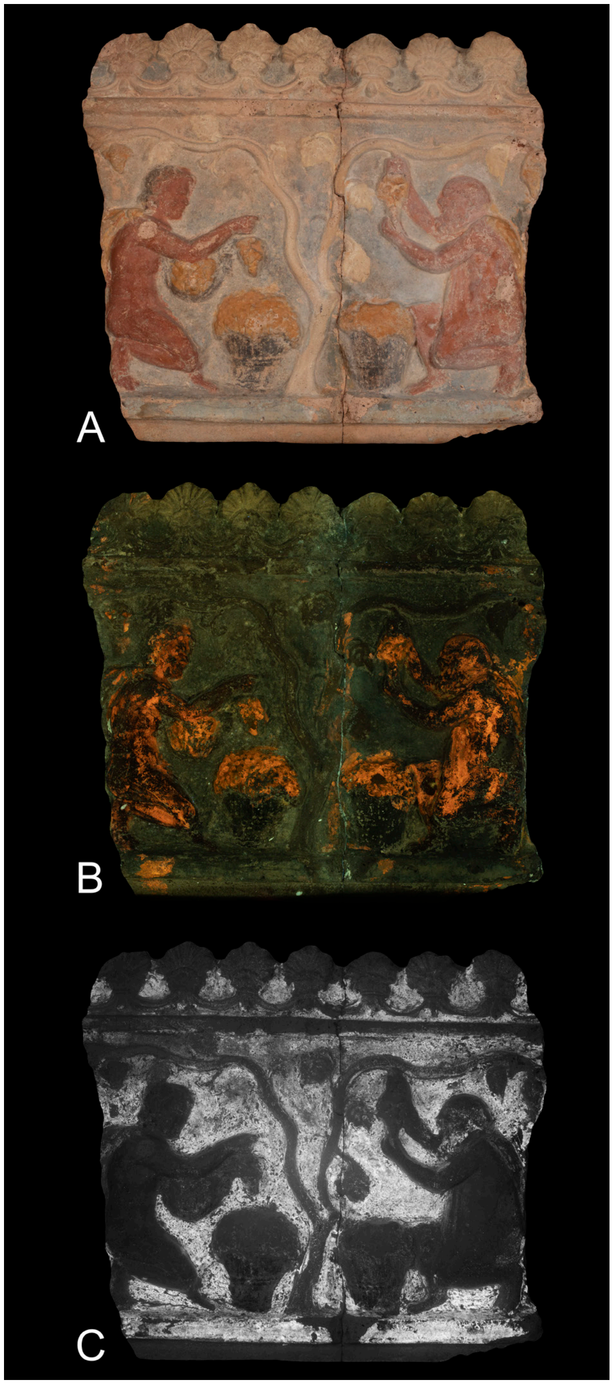

Fig. 4, a–c Campana plaque IN 1708: a) visible light photography; b) UV-induced visible fluorescence image; c) visible light induced infrared luminescence (VIL) image.
Images: CC BY-NC-ND 4.0 (J. Stenger).

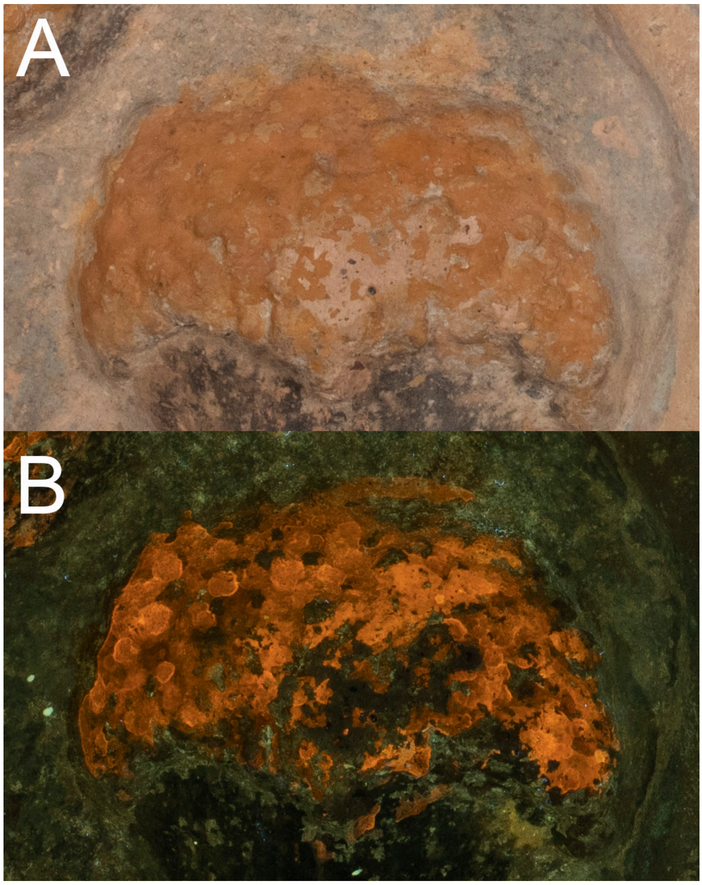

Fig. 5, a. b Campana plaque IN 1708, detail of the basket: a) visible light photography; b) UV-induced visible fluorescence image.
Images: CC BY-NC-ND 4.0 (J. Stenger).

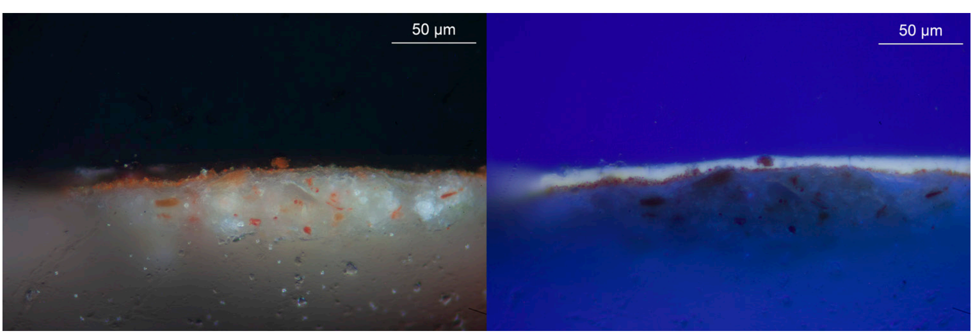

Fig. 6 Campana plaque IN 1708. Optical microscopy of a cross-section taken from the calf of the left satyr in an area of strong orange fluorescence. Visible light using bright field illumination and crossed polarising filters (left) and UV-induced fluorescence (right).
Images: CC BY-NC-ND 4.0 (J. Stenger).

black where it is absent. Egyptian blue covers almost the entire background of the satyr scene, as well as the background of the palmette frieze. Additional use in lesser concentrations can be seen in the beard of the older satyr to the right and in the two cloaks worn by the satyrs. The cream-coloured leaves of the grape vine appear mostly homogeneous when observed by the naked eye. However, the VIL image illustrates that the paint includes Egyptian blue (Fig. 7), which means that the leaves were rendered with variation within single leaves and would possibly originally have appeared more greenish. Additional IRR and UVR imaging gave no further information about materials or production technique, but excluded the use of carbon-based black.

FTIR and Raman spectroscopy provide further information on the pigments present in the paint and is complemented by semi-quantitative XRF measurements. For the blue background, the presence of Egyptian blue is confirmed, and gypsum and lead white are also detected. The paint used for the black baskets contains gypsum, calcite, and kaolin. The black colourant itself was not identified. The infrared photograph (not illustrated here) shows little absorption, suggesting that a carbon-based pigment is not present. Carbon black was also not detected in the Raman analysis. One could speculate that the black colourant might be a manganese oxide-based pigment. For the red skin colour of the squatting satyrs, the XRF spectrum is very similar to the unpainted terracotta, suggesting the presence of an earth pigment such as red ochre. The yellow-orange restoration paint contains gypsum, calcium sulphate anhydrite, and lead white, in addition to chrome yellow.

The cream-coloured grape vine and leaves show the surprising presence of vanadium in the XRF analysis (Fig. 8).[23] To further investigate the presence of this unusual chemical element, a cross-section of a mounted paint sample from the lowest hanging leaf was analysed using optical microscopy and SEM-EDX (Figs. 9 and 10). The elemental mapping shows that vanadium correlates with lead and chlorine, suggesting the presence of vanadinite, a rare mineral with the formula $Pb_5(VO_4)_3Cl$. Although vanadinite occurs as crystals that are often red, the streak of this mineral is white to pale yellow and light brownish yellow.[24] In agreement with this information, a comparison of the elemental maps and optical microscopy shows that the vanadinite in this case is also yellow. Blänsdorf reports experiments grinding red vanadinite crystals to a powder and observing a colour change towards yellow and brownish yellow, indicating that the colour difference is related to the changing particle size.[25] Additional Raman measurements detect a strong and spectrally broad vibration around 823 cm^{-1}, a shoulder just below 800 cm^{-1}, and a group of bands centred around a 321 cm^{-1} vibration. Comparison with a vanadinite reference spectrum[26] confirms this identification.

23 The chemical element vanadium was first discovered on this object during a demonstration of a handheld X-ray fluorescence instrument. The vanadium Kα signal at 4.95 keV is clearly not being confused with the iron escape peak which could be present but would be expected at 4.66 keV (6.40 keV Fe Kα – 1.74 keV Si Kα). In addition, the vanadium Kβ signal at 5.43 keV confirms the identification of the element.

24 <https://www.mindat.org/min-4139.html> (31.03.2022).

25 Blänsdorf 2015.

26 Solecka et al. 2018.

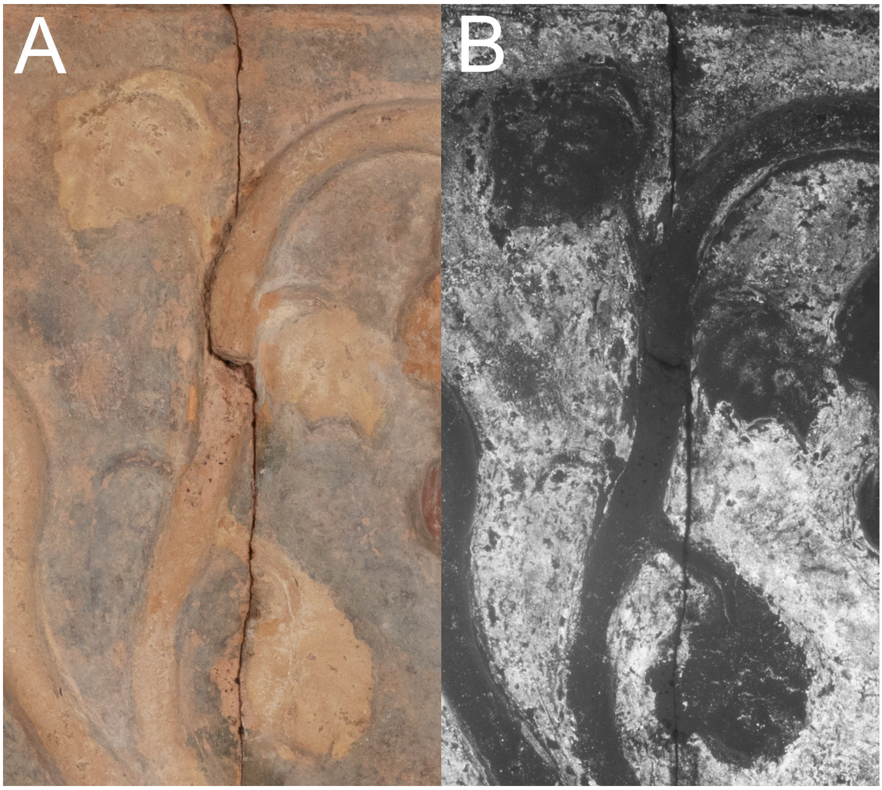

Fig. 7, a. b Detail of three leaves on the grape vine in IN 1708 in visible light (a) and in the visible light induced infrared luminescence (VIL) image (b).
Images: CC BY-NC-ND 4.0 (J. Stenger).

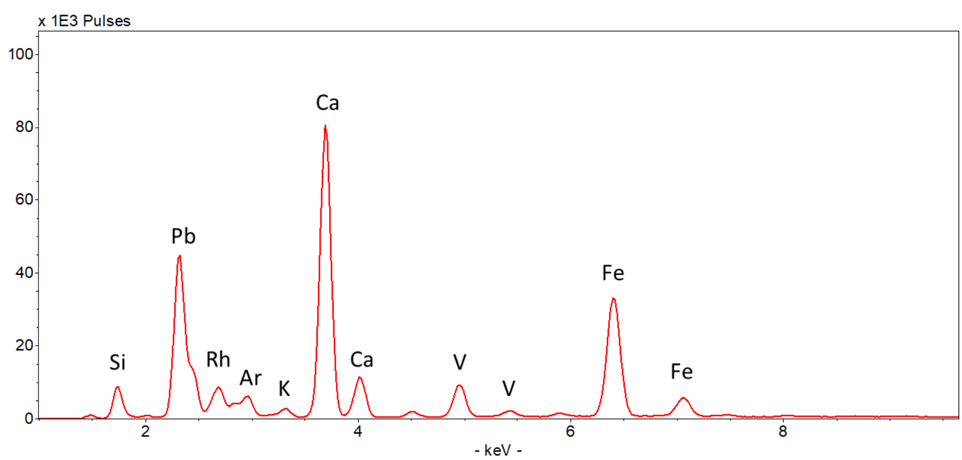

Fig. 8 The XRF spectrum of the cream-coloured leaf in IN 1708 showing the presence of vanadium.
Image: CC BY-NC-ND 4.0 (J. Stenger).

Fig. 9 **A paint cross-section from the lowest leaf in IN 1708 shows yellow vanadinite. The area marked red was subject to elemental mapping in the SEM, see Figure 10.**
Image: CC BY-NC-ND 4.0 (J. Stenger).

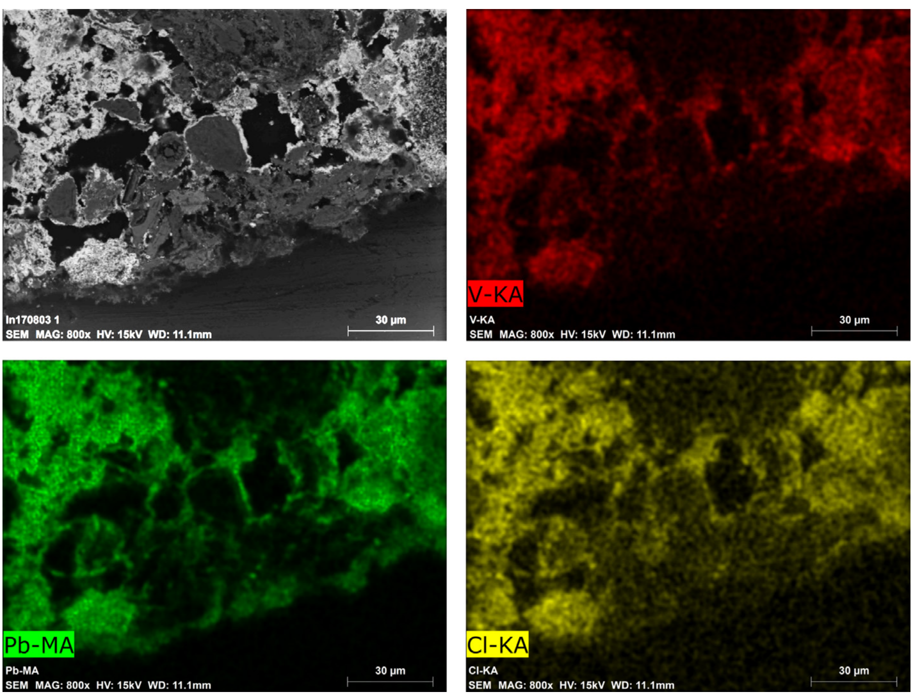

Fig. 10 **A backscatter SEM image of the area marked red in Figure 9, upper left. The elemental maps (red, green, and yellow) show a correlation between vanadium (V), lead (Pb), and chlorine (Cl).**
Image: CC BY-NC-ND 4.0 (J. Bredal-Jørgensen).

In addition to vanadinite, the area of the cream-coloured leaf also contains gypsum, calcium carbonate, quartz, and augite $(Ca,Na)(Mg,Fe,Al,Ti)(Si,Al)_2O_6$, a common silicate mineral which comes in a variety of colours from brown-green, black, green-black, brown, or purplish brown. These analytical chemistry findings, together with the detection of Egyptian blue in the VIL image, suggest that the original colour of the leaves was rendered through a deliberate mixture of green, blue, and yellow pigments. The current cream-coloured appearance is likely due to a colour change since the application in ancient times (see more below). Its underlying process remains an unsolved question for now.

Apart from the shellac in the restored areas, no signals stemming from binding media are detected except for hints in FTIR spectra towards the possible presence of an oxalate, which might result from biological activity degrading the organic binder, which was not detected.[27]

IN 1701

The Campana relief IN 1701 has many similarities to the terracotta discussed above (IN 1708) including subject matter, palette, preservation state, and restoration aspects. Again, the UVF image (Fig. 11) uncovers extensive restoration easily recognizable by the orange fluorescence characteristic of shellac, whose presence is confirmed by FTIR. Here the modern inpainting is mostly limited to the skin colour of the satyrs, with a few additions in other areas. It again exhibits a dot pattern in the application, as in IN 1708, next to some broad brushwork, suggesting that the same restorer treated both objects. In contrast to IN 1708, the background here is painted not blue but white, with the pigment identified by FTIR as calcium carbonate (calcite and aragonite) with small amounts of gypsum. This white background shows a strong greenish fluorescence, presumably from an unidentified binder.[28] The infrared spectrum shows, however, no trace of a binding medium. The areas of paint loss in the background, the original red skin and the brown hair of the satyrs, as well as most of the orange areas on the cloak, the ornament below the palmette frieze, and the grapes show no UV-induced visible fluorescence at all. On the other hand, some locations of terracotta loss, for example on the right foot and the left thigh of the left satyr, show a weak greenish fluorescence (Fig. 12, a and b). This could be an indication of the presence of a consolidation material.

A strong VIL signal attesting to the presence of a large amount of Egyptian blue can be seen in the blue panther skins of the two central satyrs. Moreover, weaker VIL signals are attested in the beard of the older satyr to the right, on the cloak of the left satyr, and on the double flute he is playing, indicating the use of a paint mixture including considerable quantities of Egyptian blue (Fig. 12, c).

27 Rampazzi 2019.

28 It is unlikely that the fluorescence is related to a surface coating, since there is an exact correlation between the white paint and the fluorescence.

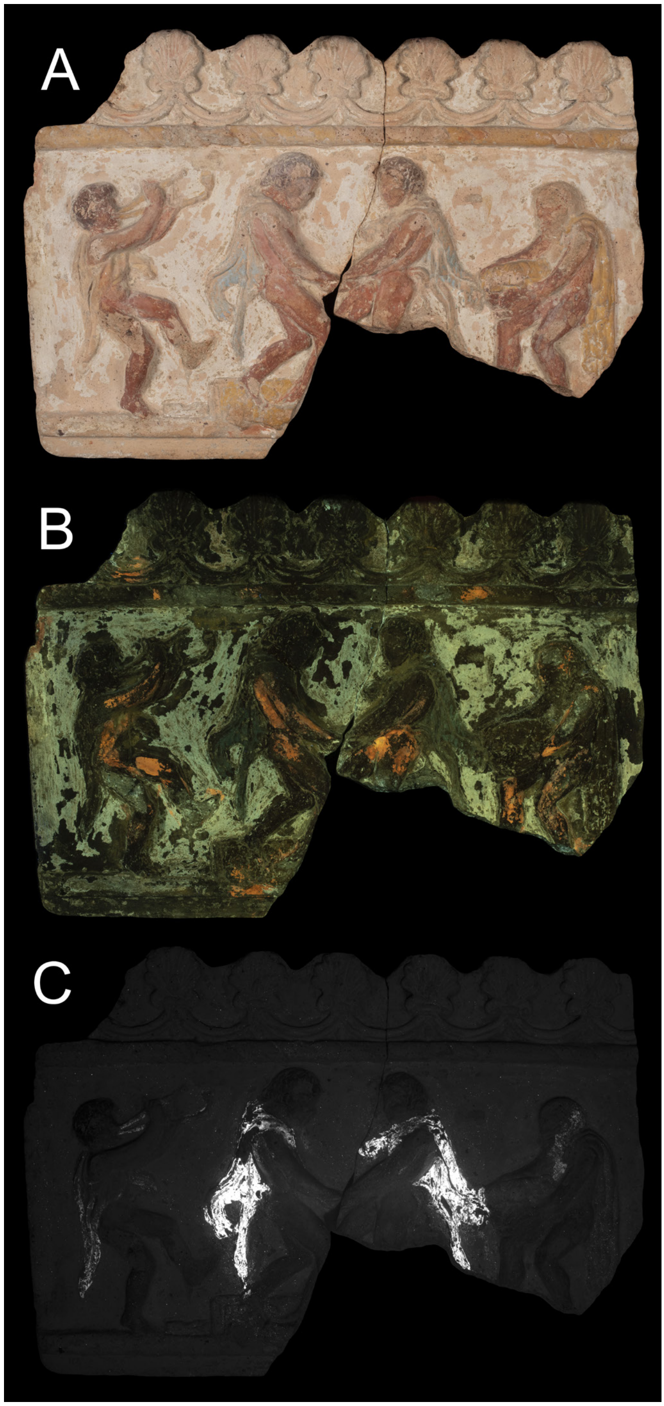

Fig. 11, a–c Campana plaque IN 1701: a) visible light photography; b) UV-induced visible fluorescence image; c) visible light induced infrared luminescence (VIL) image.
Images: CC BY-NC-ND 4.0 (J. Stenger).

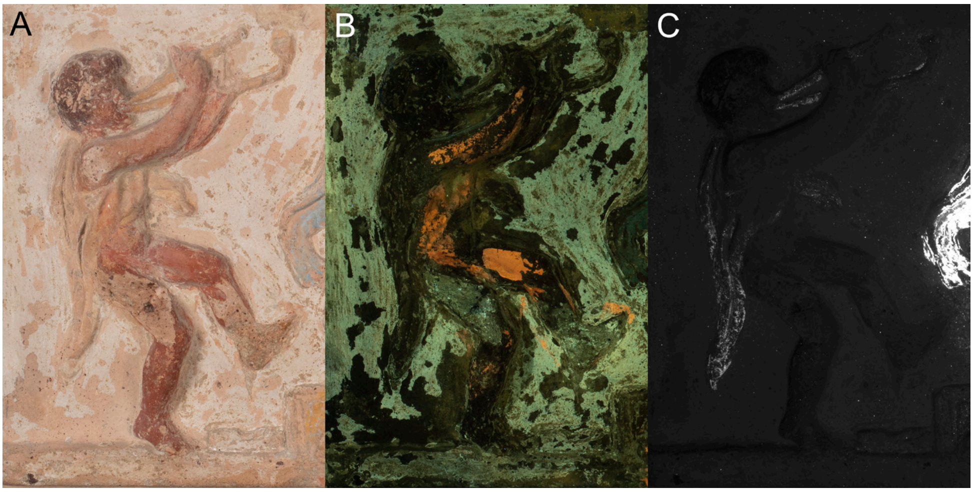

Fig. 12, a–c Campana plaque IN 1701, detail of the satyr to the far left: a) visible light photography; b) UV-induced visible fluorescence image; c) visible light induced infrared luminescence (VIL) image.
Images: CC BY-NC-ND 4.0 (J. Stenger).

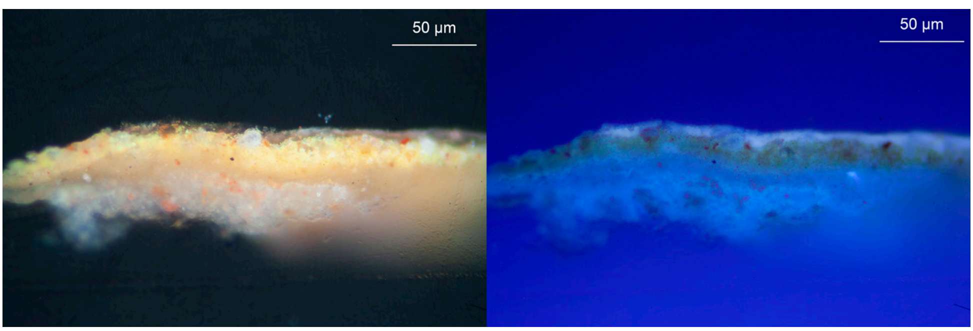

Fig. 13 A paint cross-section from IN 1701 in the area of the yellow grapes. Visible light using bright field illumination and crossed polarising filters (left) and UV-induced fluorescence (right).
Images: CC BY-NC-ND 4.0 (J. Stenger).

The blue was confirmed as Egyptian blue by Raman spectroscopy, and attested together with carbon black, gypsum, calcite, and albite ($NaAlSi_3O_8$), a common feldspar mineral with a white streak. In the areas of the yellow horizontal ornamental frieze above the scene, the yellow grapes, and the yellow cloak, kaolin and calcium carbonate are attested, suggesting that a yellow ochre was used as the colour giving pigment. Moreover, XRF analysis suggests the use of cinnabar, vanadinite, and red ochre for the skin colour of satyr to the far left.

Figure 13 shows a cross-section of the paint layers in the area of the yellow grapes to the lower left. The lowest layer is recognizable as the terracotta substrate with its red inclusions. The next layer is probably an ancient yellow ochre paint, followed by modern yellow restoration and a fluorescing shellac coating.

IN 1929

IN 1929 has some visible paint on its surface, but much less preserved polychromy can be detected by the naked eye compared to IN 1708 and IN 1701. The background areas of the two athletes right next to Hercules, as well as above the garland of leaves between the central two columns, are painted yellow. Blue paint is apparent at the base of the far-left athlete next to his feet, between Hercules' base and the adjacent left column, and on both sides of the legs of the far-right athlete. This evidence suggests an alternating colour scheme consisting of blue, yellow, blue, yellow, blue for the backgrounds of the five figures. The visible light photograph also illustrates remains of white paint on and below the column bases, as well as minor areas of white paint near the top of the pediment. Traces of purplish paint can be seen on Hercules' club, in the hair of the hippocamps, and on the architectural arch on the right.

Comparison of the VIS and UVF images (Fig. 14, a and b) shows that the white paint has a weak greenish fluorescence. Additional greenish fluorescence is seen in a material which is applied roughly diagonally from the upper left part of the plaque to the lower right. It is unclear if this greenish fluorescent material is original or modern. The highest intensity greenish fluorescence is seen on three bases and on one of the column capitals. Close examination of the UFV image shows a few rare spots of orange fluorescence, for example on the double torus of the left centre column's base (Fig. 15, b). On the bodies of the athletes and on the columns, there is a brownish fluorescence indicating additional paint residues, which are not visible under normal illumination. The shield held by the hippocamps exhibits some pink fluorescence, suggesting the presence of a red organic lake pigment (not illustrated).

VIL imaging shows a high signal in areas of blue paint, strongly suggesting the presence of Egyptian blue. Chemical analysis was not executed on this relief. Infrared luminescence in the entire background area of Hercules, and the far left and right athletes, confirms the alternating yellow-blue colour scheme. There is hardly any VIL signal in the yellow background for the two athletes adjacent to Hercules. The area that now appears yellow, above the central garland, is modulated with Egyptian blue into what could originally have been a more greenish hue (Fig. 14). Other areas of high infrared luminescence are the depressions of some of the architectural elements, and the lower part of the background of the pediment, suggesting that the two symmetrically arranged hippocamps are rendered as emerging from the sea. The linear ornaments framing the pediment seem to have a pattern of yellow in the depression, and blue mixed with white on the raised elements, suggesting an alternating blue-yellow sequence echoing the background areas of the figures. There appear to be two types of white paint, one mixed with Egyptian blue and one without.

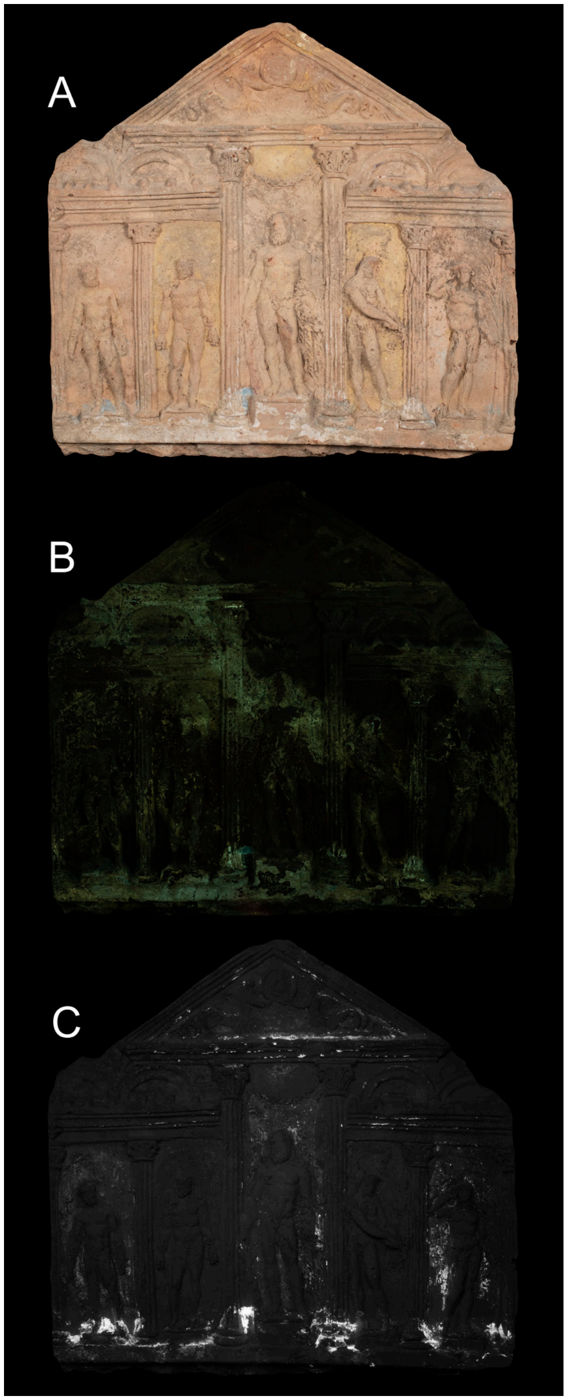

Fig. 14, a–c Campana plaque IN 1929: a) visible light photography; b) UV-induced visible fluorescence image; c) visible light induced infrared luminescence (VIL) image.

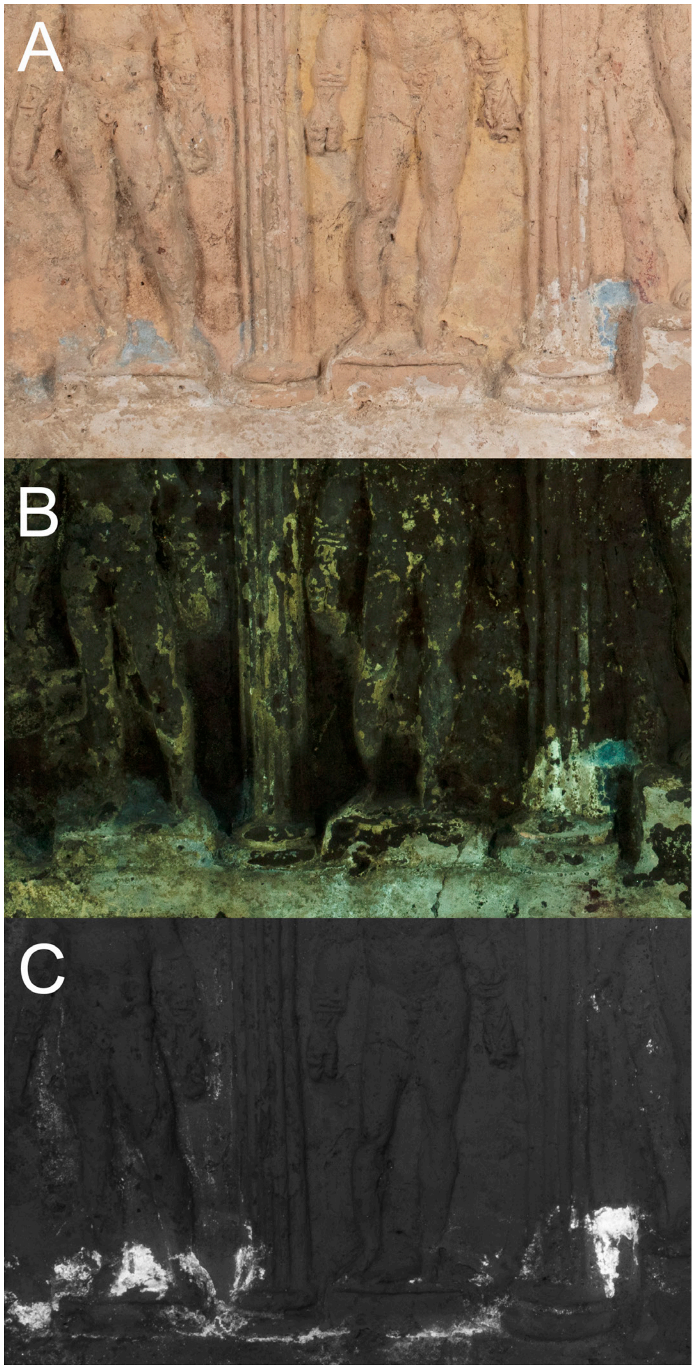

Fig. 15, a–c Campana plaque IN 1929, detail: a) visible light photography; b) UV-induced visible fluorescence image, contrast enhanced; c) visible light induced infrared luminescence (VIL) image.

Images: CC BY-NC-ND 4.0 (J. Stenger).

Ancient Pigments

Table 1 summarises the pigments that have been identified on the plaques IN 1708 and IN 1701. However, while some of them belong to the ancient polychromy, others are part of a modern restoration. In the following, we will first discuss the pigments which are part of the ancient paint layers, before moving on to the modern restorations.

Table 1 Overview of materials identified using FTIR, Raman spectroscopy, XRF, and SEM-EDX

Colour	IN 1708	IN 1701
White (background)	–	calcium carbonate
Blue	background: Egyptian Blue, lead white, gypsum	cloak: Egyptian blue, gypsum, carbon black, calcite, albite
Red (skin)	gypsum, calcium carbonate, kaolin, red ochre*	vanadinite*, mercuric sulphide*, red ochre*
Black (baskets)	gypsum, calcium carbonate	–
Cream colour (leaf and tree)	leaf: Egyptian Blue, gypsum, quartz, calcium carbonate, augite, vanadinite tree: vanadinite*	–
Yellow (ornament)	–	kaolin, calcium carbonate
Brown (hair)	not analysed	gypsum
Orange restoration	chrome yellow, lead white, gypsum, shellac	–
Red restoration	–	shellac, kaolin, calcium carbonate, gum, mercuric sulphide*

* Indication based only on XRF

The ancient pigments identified on the plaques include red ochre, yellow ochre, carbon black, gypsum, kaolin, lead white, Egyptian blue, cinnabar, and vanadinite. Several of these are very common in ancient polychromy, for example, the use of carbon black, as well as red and yellow ochres, which were used for painting since the early history of humankind.[29]

By comparison, the only scientific study carried out so far on the polychromy of Campana plaques identified yellow ochre, red ochre, lead white, a calcium-based white pigment, Egyptian blue, and *minium* (red lead) for the polychromy of nine fragments of Campana plaques recovered on the Palatine.[30] Overall, these findings fit well with the result of the current investigation of the plaques in the NCG, which has, however, revealed further pigments, adding to our knowledge of the palette used by the ancient

29 Eastaugh et al. 2004, 279 f.
30 Tarquini et al. 2019.

artists for this type of architectural decoration. Since so few studies of the polychromy of Campana plaques have been published, it is relevant to look for further comparisons, such as with Etruscan architectural decoration. Thus, a study of Etruscan antefixes has identified a somewhat similar, although more limited, palette consisting of red and yellow ochre, carbon black, manganese black, calcite, possibly kaolin, and Egyptian blue.[31]

Four of the identified pigments (Egyptian blue, cinnabar, vanadinite, and lead white) on the NCG plaques deserve more attention, either due to their fascinating history, their high price, or their rarity, and will therefore be discussed individually in the following paragraphs.

Egyptian Blue

Egyptian blue is a bright blue, crystalline pigment, possibly the earliest artificial pigment ever produced. Chemically, it is a calcium copper tetrasilicate compound ($CaCuSi_4O_{10}$), made by heating a calcium compound (such as powdered limestone and sand rich in calcium carbonate) together with copper and quartz.[32]

Egyptian blue is described by ancient authors, such as Vitruvius (*De Arch.* 7.11) and Pliny the Elder (*NH* 33.57), under the term *caeruleum*, meaning "colour of the sky".

As the world's oldest synthetic pigment, the use of Egyptian blue dates back at least to the first dynasty of Egypt (from circa 3000 BCE), possibly earlier.[33] Its latest production date and use is still debated, but it appears to decline in use sometime during the early Middle Ages. The latest known use of Egyptian blue pigment (to date) is documented on an Italian oil painting from 1524, painted by Giovanni Battista Benvenuto, known as L'Ortolano,[34] while in 2020, Egyptian blue was identified on a fresco by Raphael, the 'Triumph of Galathea', painted circa 1512 in Villa Farnesina, Rome.[35] As more artworks are examined, evidence will possibly emerge for its later use.

There appear to have been various ancient production centres for Egyptian blue.[36] During the Roman period, the pigment was produced around the Bay of Naples. Archaeological evidence dating to the first century CE has thus identified a production centre at Cumae, which is also attested by Pliny (*NH* 36.66).[37] Literary evidence, as well as finds of pigment pellets and crucible remains, complement this, suggesting that Egyptian blue was produced in Puteoli and Liternum in the Bay of Naples.[38] Furthermore, there is archaeological evidence for the production of Egyptian blue in the Kom Helul sector

31 Brøns et al. 2016a. See also Bordignon et al. 2007a and 2007b.

32 For a thorough description of the properties of Egyptian blue, see Nicola et al. 2023, 392.

33 The earliest attestation of Egyptian blue as a pigment appears to be from the carving of a bowl of the late Predynastic period, ca. 3300 BCE. Corcoran 2016.

34 National Gallery of Denmark, inv. no. KMSsp7. Bredahl-Jørgensen et al. 2011. For further evidence of the use of Egyptian blue beyond the Roman period, see Skovmøller et al. 2016 and Nicola et al. 2023.

35 Anselmi et al. 2020.

36 Egyptian blue was regularly produced in Egypt, e.g. in Memphis, where a major production centre has been identified. For a recent review, see Kovalev et al. 2023.

37 Caputo – Cavassa 2009; Skovmøller et al. 2016, 373.

38 Lazzarini – Verita 2015; Cavassa et al. 2010.

of the ancient city of Memphis, Egypt,[39] dated to the period between the third century BCE and the second century CE, possibly even later.[40]

Egyptian blue was an extremely widespread pigment, used for Egyptian, Mesopotamian, Etruscan, Greek, Cypriot, and Roman artefacts, and it appears to have been almost omnipresent during Antiquity.[41] Egyptian blue also appears to have been widely used for the polychromy of Campana plaques. Not only is it clearly attested on all three plaques examined here, primarily for the background, it is also identified on the fragments from the Palatine Hill, Rome, where it is used for the blue background of several of the examined fragments.[42] The use of the colour blue for the background is typical for these plaques, and traces of blue paint are often visibly preserved. Yet Egyptian blue was not only used for backgrounds, but also for other elements, such as the cloak of two of the satyrs on IN 1701. It is also used for paint mixtures, as in the greyish beard of the older satyr on IN 1708. Such paint mixtures including Egyptian blue were commonly used in Roman polychromy, as is attested, for example, for the skin and hair of Roman marble portraits.[43]

The choice of Egyptian blue for polychromy on Campana plaques is not surprising, since this particular pigment, as mentioned, was widespread and several production centres existed during Antiquity. Moreover, Egyptian blue appears to have been relatively cheap and readily available, in contrast to other ancient blue pigments such as azurite and particularly lazurite, which were harder to come by. In fact, so far, there are only a handful of attestations of the use of lazurite for ancient polychromy.[44] It is thus reasonable to assume that the blue colour generally used for painting Campana plaques is obtained using Egyptian blue.

In a separate study, four samples of Egyptian blue from IN 1708 were studied using lead isotope analysis, which can give insight into the provenance of copper-based materials, in which lead is usually present in traces. Such provenance information can reveal whether local or imported materials were used for producing pigments. In the case of the Egyptian blue from IN 1708, the results indicate that the Italian South-Eastern Alpine region is the most likely source area of the copper raw materials.[45] It is likely that copper ore from this region was transported to the Bay of Naples. However, Egyptian blue production in the Italian South-Eastern Alps or North Italian regions is also possible, perhaps associated with other pyrotechnological industries such as glass or metal working.[46]

39 Tite – Hatton 2007; Hatton 2005; Petrie 1911.
40 Nicholson 2003.
41 See Skovmøller et al. 2016 and references therein as well as the homepage <https://www.trackingcolour.com/> (31.03.2022).
42 Tarquini et al. 2019.
43 Skovmøller 2020.
44 See e.g. Brøns et al. 2020 and references therein.
45 Rodler et al. 2021.
46 Rodler et al. 2017.

Cinnabar (IN 1701)

Cinnabar (α-HgS), mercury sulphide, is a very toxic, naturally occurring mineral, which was used since Prehistory to produce a dense red pigment for painting, amongst other purposes. The elemental analysis of the red skin colour on IN 1701 shows a signal for mercury, a clear indication for cinnabar in this context. Interestingly, the mercury signal occurs in areas of original paint, as well as in locations characterised by the shellac fluorescence. Moreover, the red paint used to render the skin of the satyrs is probably composed mostly of red ochre, judging from the visual appearance and the XRF signal. Consequently, cinnabar is only present in low concentrations. The presence in both original and restored areas suggests that shellac served here as a coating, rather than a medium for the restoration colourant. The traces of cinnabar are still an interesting find and worth putting into context.

Generally, cinnabar occurs frequently in Roman art.[47] It has been widely attested in Roman wall-painting, for example, in Pompeii and Herculaneum,[48] but it is also identified in the polychromy of marble sculpture, including portraits and representations of divinities,[49] on sarcophagi,[50] and on the newly excavated marble reliefs from Nicomedia, to name just a few.[51] The pigment is identified on IN 1701, where it is attested on the red leg of the satyr dancing to the left.

A note on terminology is in order, since the term 'cinnabar' is used today to refer to the natural mineral form, while the synthetic form is normally termed vermilion.[52] Cinnabar is mentioned by ancient authors, although the terminology can be somewhat confusing. Thus, Greek authors, such as Theophrastus, refer to the pigment as *cinnabaris*. Roman authors use the term *minium*[53] for cinnabar, while the term *cinnabaris* is usually understood as referring to so-called dragon's blood, a red resin from the Dracaena tree.[54]

Cinnabar (termed *minium*) is recorded by Pliny (*NH* 35.12) among the so-called *colores floridi*, which were paid for by the client at his own expense, indicating a high cost for this particular pigment.[55] Pliny (*NH* 33.40) records the price of cinnabar as 70 sesterces per pound, that is, ten times more expensive than high quality red ochre

47 For earlier attestations in the Mediterranean area, see e.g. Brecoulaki 2014.

48 E.g. Knuutinen et al. 2007. See Bugini et al. 2000 for the attestation of cinnabar in a wall-painting from the Republican period in Brescia.

49 E.g. Verri et al. 2010; Skovmøller – Therkildsen 2015; Therkildsen 2012.

50 E.g. Bracci et al. 2020.

51 Abbe – Ağtürk 2019.

52 Synthetic mercuric sulphide, also known as vermilion, was not available in Antiquity: Eastaugh et al. 2004, 105; Gettens et al. 1993.

53 To make it even more confusing, the term *minium* is now used to designate red lead (Pb_3O_4).

54 Pliny 33.38: "The Greeks (…) give to minium the name of '*cinnabaris*', and hence the error caused by the two meanings of the same word; (…) This *cinnabaris*, too, is extremely useful as an ingredient in antidotes and various medicaments. But, by Hercules! our physicians, because minium also has the name of '*cinnabaris*', use it as a substitute for the other, and so employ a poison, as we shall shortly show it to be." (Translation: Bostock 1855).

55 "The florid colours are those which the employer supplies to the painter at his own expense; *minium*, namely, *armenium*, *cinnabaris*, *chrysocolla*, *indicum*, and *purpurissum*." (Translation: Bostock 1855).

from Sinope. The high price and exclusivity of the pigment is supported by the fact that cinnabar was not a locally occurring pigment, but would have been imported from Spain, for example, where mines in use since Antiquity are located at Almadén.[56] The use of cinnabar on a Campana plaque is thus somewhat surprising, considering the low cost of the substrate as well as the typical placement of these plaques at a considerable height. However, there appears to have been no correlation between the choice of substrate and the cost of pigments, as evidenced, for example, by the use of gilding for terracotta figurines.[57]

According to Vitruvius and Pliny, pure cinnabar (*minium*) was unsuited for painting outside, since it would turn black in the sunlight. Pliny states (*NH* 33.40): "To objects painted with minium the action of the sun and moon is highly injurious." However, he suggests a solution to this by protecting the paint with an oil or wax:

> "The proper method of avoiding this inconvenience, is to dry the wall, and then to apply, with a hairbrush, hot Punic wax, melted with oil; after which, the varnish must be heated, with an application of gallnuts, burnt to a red heat, till it quite perspires. This done, it must be smoothed down with rollers made of wax, and then polished with clean linen cloths, like marble, when made to shine."[58]

The cinnabar used for the polychromy of museum artefacts is generally well preserved. Cinnabar is very resistant to oxidation or acid rain, and the pigment is very stable and not soluble in water, acid, or alkaline solutions, which is why many ancient artefacts still have well-preserved, visible red colour.[59] However, as already stated by ancient authors, cinnabar is well-known for turning black, grey, or even brown, although this discolouration does not happen to all cinnabar-based paints.[60] The quality of the pigments is decisive for the reaction. Research into why cinnabar darkens points mainly to the influence of environmental factors, and in particular photosensitivity. Furthermore, the adjacent material, for example, other pigments, binding media, or substrates, can also affect the decomposition of the pigment.[61] Darkening of cinnabar can, for example, be caused by radiation, cleaning (as with laser), and as a reaction with halogens or to pigments, due to the choice of binding media or the influence of the substrates.[62] Such darkening of cinnabar is attested in several instances, particularly in Roman wall-paintings from Pompeii and Herculaneum, where cultural heritage

56 Ancient authors also suggest the coast of Asia Minor, e.g. Ephesos, and Colchis in the Black Sea as further sources for cinnabar. Theophr. *lap*. 58; Plin. *NH* 37.114; Vitr. 7, 9, 4.

57 E.g. Jeammet 2010; Brøns 2022.

58 Translation: Bostock 1855.

59 Nöller 2013.

60 Eastaugh et al. 2004, 105.

61 Nöller 2013.

62 Nöller 2013. For the alteration of cinnabar, see also Neiman et al. 2015.

professionals have reported the phenomenon of red paint layers darkening significantly after excavation.[63]

Vanadinite (IN 1708 and IN 1701)

Vanadinite is a rare crystalline mineral, which occurs in small quantities in the oxidation zone of lead ore deposits around the world. Its colour is usually red, red-brown, orange, and sometimes yellow.[64] The pigment is identified on both chemically-analysed Campana plaques: on IN 1701, the identification as a component of the red paint for the dancing satyr to the far left is based on semi-quantitative XRF analysis only. On IN 1708 it is present in the blue background to the far right on the plaque, on the tree stem, and on one of the creamy-white leaves of the tree. The creamy-white colour for the tree trunk and leaves is puzzling, since one would rather expect it to be painted in more natural colours, such as brown for the stem and green for the leaves. This raises questions of whether the paint may have changed its appearance since Antiquity. It has been shown that vanadinite may darken or lose transparency upon prolonged exposure to light,[65] which is not the case, however, for the Campana plaques under investigation here. The optical microscopy of the cross-section shows a light-yellow colour. The vanadinite on the stem and leaves is attested together with augite, which is green, brown, or black, and with gypsum and calcium carbonate which are all white, as well as slight amounts of Egyptian blue. Thus, we should possibly imagine the leaves as originally being painted in a light yellowish or greenish colour.

Among the pigments identified on the three Campana plaques, only the pigment vanadinite is a rare find, although it has been documented before in ancient polychromy: there are, so far, four cases among published studies of ancient polychrome artefacts in the Mediterranean area. Vanadinite has been identified on a Hellenistic marble statue of Artemis from the 'Maison des Cinq Statues' on Delos.[66] The pigment is used for the bright yellow border of the goddess' *chiton*.[67] It has also been identified in the yellow paint on a Hellenistic terracotta figurine from Amathus, Cyprus,[68] and on a Hellenistic marble stele from Macedonia.[69] In the latter case, the pigment is attested on the black background of the figure scene, which, according to Rouveret and Walther, was originally orange, but has now turned black due to an alteration/deterioration

63 Neiman et al. 2015; Cotte et al. 2006.; Knuutinen et al. 2007. Darkened cinnabar has also been detected on the belt of the famous Phrasikleia *Kore* in the National Archaeological Museum, Athens. Brecoulaki 2014; A. Karydas, 'The Marble Statue of Phrasikleia at the National Archaeological Museum: Report of the XRF investigation' (unpublished report 19/9 1999).

64 <https://www.minerals.net/mineral/vanadinite.aspx> (31.03.2022) and <https://www.mindat.org/min-4139.html> (31.03.2022).

65 Rouveret – Walther 1998.

66 Archaeological Museum of Delos, inv. no. A 4126.

67 Bourgeois – Jockey 2004, 177.

68 Courtois – Velde 1981.

69 Musée du Louvre, inv. no. MA 3643.

process of the vanadinite.[70] Finally, it has been attested in pigment mixtures used for a preparatory drawing (*sinopia*) underneath a Roman mosaic in Lod, Israel.[71]

Vanadinite has also been identified in the polychromy for artefacts outside the ancient Mediterranean area. We have been able to identify four published instances. Vanadinite has been attested in the yellow paint on early Islamic (9^{th} – 12^{th} century CE) painted stucco, wall paintings, and terracotta friezes excavated at Nishapur, north-eastern Iran,[72] and on a late Sasanian (224–651 CE) painted stucco fragment from Ghaleh Guri in Ramavand, western Iran.[73] Finally, there are two attestations in China, in a Han dynasty mural in Xi'an and on terracotta sculptures at Qin Shihuang's burial complex (circa 210 BCE).[74]

The attestation of vanadinite on a Campana plaque is thus quite exceptional. Three of the instances from the Mediterranean area are on Hellenistic statuary, while one is on a mosaic, which makes the identification of vanadinite on IN 1708 the first in Roman architectural decoration.[75]

Lead White (IN 1708)

The presence of lead white on one of the plaques deserves mention, due to its different use and chronology. Lead white is attested on IN 1708 in the blue colour of the background, and in the yellow/orange colour of the mantle of the satyr to the right. For the blue colour, its use is certainly ancient, since it is mixed with Egyptian blue. In the orange colour, however, it is mixed with chrome yellow, which identifies the paint as modern. This suggests that the lead white identified on the plaque was used in both the original polychromy and in the restoration. This is not necessarily surprising, since lead white has been claimed to be "the most important of the white pigments used in Europe from the Roman period onwards."[76] The pigment is widely attested in ancient polychromy, where it was commonly used as an undercoat to ancient polychrome marble artefacts, as well as for the paint layers.[77] In all three Campana plaques examined in this study, there is no evidence, either from microscopic investigation or cross-sectional analysis, for a ground layer. Hermann von Rohden and Hermann Winnefeld distinguish between four general techniques of decorating Campana plaques: 1) plaques covered in a white coating, which served as a substrate for polychrome painting, 2) plaques without a coating, where the paint was applied directly onto the terracotta substrate, 3) plaques covered in a thick milky-white coating, but with no additional paint, and, 4) plaques that remained entirely unpainted.[78] The three NCG plaques would thus

70 Rouveret – Walther 1998.
71 Piovesan et al. 2014.
72 Holakooei et al. 2018.
73 Holakooei et al. 2016.
74 Blänsdorf – Yin 2006.
75 See now also the contribution by B. Vak, K. Uhlir, M. Griesser and R. Iannaccone in this volume.
76 Eastaugh et al. 2004, 233.
77 Brecoulaki 2014, 15, n. 67.
78 It will be a task for future research to review these four categories defined long ago by Rohden – Winnefeld 1911, 27*, see also Reinhardt 2022a, 134 f.

belong to their type 2, without any white coating underneath the polychromy. Similarly, cross-sections were performed on one fragment from the Palatine, which showed that the blue paint was applied directly onto the terracotta substrate.[79]

Modern Restorations

Chrome Yellow

The presence of Chrome Yellow ($PbCrO_4$) is clearly anachronistic and can be attributed to modern restoration. The use of the rare mineral crocoite with the same chemistry can be excluded, since the pigment is dispersed in shellac as a binder (see below). Chrome Yellow was first introduced in the beginning of the nineteenth century.[80] It has good hiding power and hues between reddish and greenish yellow can be observed.[81] With light exposure, it tends to darken over time and turns brown. The poor lightfastness was improved significantly in the second half of the twentieth century by encapsulation of the pigment grains with silica.[82]

Shellac

Shellac, or lac, is a natural resin produced from the secretion of the insect *Laccifer Lacca,* native to Asia.[83] It was not a material available in the ancient Mediterranean. Since the 17th century, it has been used in Europe as a furniture finish, later as adhesive, a conservation material, and for pre-vinyl phonograph records. Bleached shellac was also used as a picture varnish.[84] Today the main producer is India. Shellac often has a typical UV induced orange fluorescence, but as Stappel rightly points out, the colour of the fluorescence can vary widely[85] so that it can only serve as a suggestion and not as a material identification. The clearly anachronistic presence of shellac easily identifies the restored areas. Its matching characteristic of application on IN 1701 and IN 1708 point to the same restorer. Since the two objects came from the same collection, and were bought at the same auction in Rome in 1899, it would not be surprising if a single individual was responsible for the treatment of both the artefacts to prepare them for sale.

Conservation History and Colour Reconstructions

As was often the case for marble sculptures, some Campana plaques may have been cleaned of their original polychromy when or before entering the art market in the 19th and early 20th century, catering to the taste of the period. At the same time though,

79 Tarquini et al. 2019, 8 fig. 10.
80 Kühn – Curran 1986.
81 Eastaugh et al. 2004, 99.
82 Kühn – Curran 1986.
83 Stappel 2001.
84 Southerland 2010.
85 Stappel 2001, 603.

it was well-known that terracotta figurines and reliefs, including Campana reliefs, were originally painted, as attested by the visible remnants of original polychromy on many of these artefacts. It even appears that, sometimes, a terracotta artefact with traces of ancient paint preserved was considered even more valuable than one without. Consequently, some ancient artefacts, including Campana reliefs, appear to have been painted, or the original polychromy at least supplemented, by the art dealers.[86] Thus, the polychromy, or some of it, may be modern, as was proven in this study for two of the examined plaques. This underlines the importance of thoroughly examining the polychromy and detecting possible colour restoration before drawing conclusions on its original appearance.

The clear distinction between ancient polychromy and modern restoration is key when carrying out colour reconstructions. Such colour reconstructions of Campana plaques are quite widespread.[87] This has partly to do with the fact that they are close to two-dimensional, making a colour reconstruction easier to carry out. Moreover, as said, many plaques have visible traces of polychromy, which makes a reconstruction tempting since less guesswork is involved.

An example is the colour reconstructions, carried out by Ingrid Töllner, of two intact Campana plaques in the collections of August Kestner. Plaster casts were made of the two reliefs, which were painted with commercially-available acrylic paints in a manner imitating the colours of parallel Campana plaques in other museum collections (based on colour photos).[88] However, the colour reconstruction of one of the Kestner Campana plaques, illustrating two satyrs harvesting grapes, is based on the polychromy of the Campana plaque IN 1708 in the NCG,[89] which has now been proven to have been largely repainted sometime during the late 19th century, before it was included in the museum collection. Thus, this reconstruction reflects the appearance of the plaque when it entered the art market, rather than its ancient appearance as part of the decoration of a Roman building.[90]

A further example is the colour reconstructions carried out by Karolina Michałowska of two Campana plaques in the National Museum in Warsaw: one physical reconstruction of a full-size copy of a fragment, and digital reconstructions (2D and 3D) of this same fragment, as well another fragment depicting a woman and a candelabrum.[91] Besides visual inspection with a magnifying glass, the two fragments were examined with VIL, attesting the use of Egyptian blue for the backgrounds.[92] Although

86 Blume 2016, 41.

87 See e.g. Siebert 2011, 29; Michalowska 2014; Bass – Flecker 2016, 10; Pensabene 2017b, pl. A.

88 Siebert 2011, 29.

89 Siebert 2011, 29. Museum August Kestner, inv. no. 1338.

90 A note should be made on the choice of acrylic paints for making reconstructions of ancient polychromy, which should be avoided due to their very different appearance, lustre, coverage etc. Preferably, paint mixtures including pigments and binding media, which were in use during antiquity, should be used.

91 National Museum in Warsaw, inv. nos. 199609 and 199607.

92 Michałowska 2014, 43. Unfortunately the VIL images were not reproduced in the publication, which makes it impossible to ascertain the extent of the blue pigments, as well as to confirm that the luminescence is in fact not due to contamination.

VIL is a good place to start, it is not sufficient to determine ancient appearance, since this method only detects one specific pigment.

The various attempts at colour reconstructions are based on visual traces of colour and comparisons with other examples, some of which may not entirely display their original polychromy. They thus run the risk of disseminating a polychrome appearance which is unrelated to the ancient expression.

A further note of caution, when reconstructing ancient polychromy, is required for the possible occurrence of colour alterations. Some ancient pigments may change colour/hue with time; cinnabar, Egyptian blue, and vanadinite have all been shown to turn dark/black under certain environmental circumstances. As argued by Neiman et al., ancient pigments may display shifts in hue, value or chroma, darkening or complete colour transformation.[93] This can result in visual disruption of the artefact, and it might also obscure the artist's intent and the original appearance. It can go so far that the colour alterations change the meaning of the piece.[94] In addition, the chemical processes underlying these changes might cause instability in the material integrity of the object. One can therefore only urge further scientific examinations of such plaques before carrying out reconstructive initiatives.

Conclusions and Future Perspectives

In the present study, scientific imaging in combination with chemical analysis is applied to the examination of Campana plaques. The preliminary information on the materials present, extracted from the multispectral images, are followed up by identifications based on vibrational spectroscopy and other chemical analyses. This has revealed significant information about their original polychromy. The insights gained go beyond information that can be obtained by visual examination with the naked eye alone, or even a microscope. This can provide us with information on how these artefacts were produced and painted, their ancient appearance, and possibly how they were valued in Roman times. Just as importantly, such scientific examinations can expose what is, in fact, ancient and what is modern restoration. As discussed above, this is of paramount importance to our understanding of their original appearance.

The perception of these artefacts as being less significant, or of lesser value due to their terracotta substrate and their association with architectural decoration is not entirely valid. It has thus been argued that the polychromy of terracotta artefacts was more limited than for marble artworks: "From the scarce analytical data that we possess to date, and the visual testimony of preserved paint layers, it seems that the palette of pigments applied to marble sculptures was much more varied than on terracotta artefacts and wall paintings."[95] The polychromy of terracotta artefacts generally tends to be considered as "less sophisticated", and it has been argued that, especially in the case of architectural terracottas, a narrower range of pigments was applied, possibly

93 Neiman et al. 2015, 916.
94 Neiman et al. 2015, 916.
95 Brecoulaki 2014.

because they were considered "too precious for such inferior material" or because they were unsuited for painting such artefacts.[96] However, this is contradicted by the identification of cinnabar, although admittedly only in traces, on one of the Campana plaques, as well as the varied use of different pigments, including the rare vanadinite as a component for the polychromy of two of the plaques (although we cannot entirely exclude the possibility that this inclusion is unintentional). Moreover, some Campana plaques, for example, the reliefs recovered at the Palatine, are indeed very finely painted.[97]

Hopefully, future scientific investigations can provide a deeper insight into the colour palette of these fascinating artefacts, which pigments and binding media were used, as well as how they were mixed or superimposed.[98]

A future avenue of research could be to compare the polychromy of identical Campana plaques, such as the type representing *palaestra* scenes, exemplified by IN 1929 examined in this study. Several identical plaques, but with a varied polychromy, exist in museum collections. Such examinations could reveal interesting information on whether these plaques were indeed identical. Moreover, it could provide insights into their production and the existence of individual workshops, as well as whether these artefacts were painted in the same workshops as, for example, marble sculpture. Finally, it is obviously of great interest how the polychromy of these plaques affected the overall architecture of Roman buildings.

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96 Michalowska 2014, 42.
97 See e.g. Pensabene 2017b.
98 Blume 2016, 44.

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For the works cited in this article, please refer to the comprehensive Bibliography at the end of the volume.

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