THE REAL THING?

POLYCHROMY RESEARCH EMPLOYED IN AUTHENTICITY STUDIES OF ETRUSCAN *PINAKES* IN THE NY CARLSBERG GLYPTOTEK

(Con le tavv. XL-XLIV f.t.)

INTRODUCTION

This article presents an interdisciplinary investigation assessing the authenticity of seven fragmented Etruscan *pinakes* in the collection of the Ny Carlsberg Glyptotek in Copenhagen. As a precaution, to avoid biased results, the study was carried out blind. The artefacts were examined by a classical archaeologist performing a stylistic assessment, a paintings conservator analysing the painted decorations, and a physicist performing thermoluminescence (TL) dating and provenance determination. The technical and instrumental methods used for the analyses are described in *Technical assessment of the polychromy* and *Dating and provenancing of the terracotta* respectively.

Museum collections worldwide contain fakes many of which are made from terracotta. Authenticity is quite a fluent concept. Essentially, no object is a fake until intentionally paired with incorrect information with a view to making a profit or otherwise gain from the deception. There are several different ways to forge objects incl. copies of existing artefacts and imitation of a style observed in genuine pieces. The latter usually involves copying from different examples which is termed 'pastiche'. Another approach is to alter genuine artefacts tailoring them to the contemporary demands for increased profit. Such alterations include e.g. added engravings and restorations deceptively covering serious damage. Furthermore, artefacts created without the intention of deceit may intentionally be passed off as something else by someone else and thus enters the realm of forgeries. If, however, the person who pure-heartedly matches the artefact with the wrong context and succeeds in convincing others to share his belief, this does not constitute an actual

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case of forgery (Jones 1990, pp. 11-16; Craddock 2009, pp. 6-17). Whether intended to deceit or not, artefacts placed in the wrong context are a serious obstruction to our understanding of ancient cultures. It is of great importance that we keep authenticity issues in mind when assessing archaeological finds.

[S. B. H.]

Etruscan *pinakes*

The Etruscan terracotta plaques – so-called *pinakes* – usually stand in the shadow of the more famous and well-known Tarquinian wall painting and have not received much attention in scholarship. Many are still, more or less, unpublished or only briefly mentioned in catalogues and textbooks on the Etruscans (Pieraccini 2011). This lack of attention may be due to the fact that the relatively few fragments in existence are scattered among museums worldwide, challenging comparative studies.

However, they are among the most intriguing artefacts of the Etruscan culture. The Etruscan *pinakes* are painted terracotta plaques moulded from heavy, gritty clay, belonging to the period from the last third or second half of the sixth century and the first decades of the fifth century BCE (Roncalli 2006, p. 37; Gaultier - Chatziefremidou - Haumesser 2013). The majority bear painted figurative decoration, sometimes indicated by underlying incised sketches. The motifs include warriors, charioteers, processions, women and men, and creatures such as sphinxes and gorgons. Their subject matter is often considered mythological and difficult to interpret (Steingräber 2006).

The plaques were originally mounted in rows and the decoration thus tends to be arranged in continuous narrative friezes, composed of multiple plaques. Roncalli identifies three types of decorative schemes (Roncalli 2006, p. 31):

1. The figured area is distributed on a series of plaques (at least two), probably topped by a separate set, intended for the upper crowning frieze.
2. The painted surface is limited to accommodating a figured area and an upper frieze.
3. The entire frieze is concentrated on a single set of plaques, which includes a triple internal partition consisting of a base, a figured area, and an upper frieze.

The *pinakes* with known provenance have all been discovered in the surroundings of the Etruscan town of Cerveteri, and they appear to have been a phenomenon restricted to this particular area. Perhaps Pliny is in fact referring to Caeretan *pinakes* in his description of ancient painting (*nat.* XXXV 6): «There are in existence at Caere, some paintings of a still higher antiquity. Whoever carefully examines them, will be forced to admit that no art has arrived more speedily at perfection, seeing that it evidently was not in existence at the time of the Trojan War» (translation: J. Bostock).

The *pinakes* have been claimed to have been used to decorate the walls of chamber tombs, as a local variation of the wall-paintings typically decorating the Etruscan chamber tombs at Tarquinia in particular. The phenomenon was thought to be caused or inspired by the lesser capacity of the rough Caeretan tufa as a substrate for wall-paintings (Roncalli 2014, p. 243). Some scholars have even considered their chief function to be funerary (e.g. Del Chiaro 1983). This interpretation is primarily caused by the discovery in the nineteenth century of a number of very well-preserved *pinakes* from Caeretan tombs. Among the most famous examples are the Boccanera plaques, named after their finders, the Boccanera brothers. The group consists of five plaques depicting two opposing sphinxes and two male and seven female figures, dated to *c.* 560-550 BCE. The plaques were discovered in 1874 in a chamber tomb in the Banditaccia necropolis at Cerveteri. Another very famous example is the so-called Campana plaques from *c.* 530 BCE, discovered in 1845 in a chamber tomb in the Banditaccia necropolis by Marchese G. P. Campana. The find consisted of five plaques rendering a row of men approaching an altar. What is particularly interesting with regard to this find is that the plaques appear to have been modified to fit the architecture of the tomb: thus, according to Steingräber «certain structural details suggest that these plaques had adorned some other space, perhaps even the dwelling of the deceased, before they found a second and final home in the tomb» (Steingräber 2006, p. 124). Haynes explains that the plaques are cut at the top edge, which suggests their reuse in the tomb (Haynes 2000, p. 219). Furthermore, the scene is incomplete; originally it consisted of additional plaques, not included in the tomb (Gaultier - Chatziefremidou - Haumesser 2013). This particular example illustrates that the *pinakes* were re-used in the tomb. This is not too surprising considering their portable nature. In contrast to traditional wall-paintings, *pinakes* can easily be dismounted from the wall, transported, and remounted in a second location.

The use of *pinakes* in secular contexts is supported by more recent finds made during the twentieth century in the settlement and sanctuary areas of ancient Cerveteri. This is, for example, the case for the famous *pinax* with a depiction of a warrior, discovered in 1963, as well as the fragments found along with it, which were recovered from a well in the Quartaccio area at Ceri (just south of Cerveteri). Furthermore, a number of fragments now in the archaeological museum of Cerveteri (Roncalli 2006, nos. 13-21) are from the suburban sanctuary of the Mola valley while two fragments (Roncalli 2006, nos. 22-23) originate from the settlement area (Roncalli 2006, p. 30). Also, the *pinax* fragments from the excavations of the 'Scarico' at the Vigna Parrocchiale (which belonged to buildings dismantled for the construction of a Late Archaic temple) seem to confirm the use of *pinakes* not only for the temple decoration, but also for decorating the interior walls of the most prestigious homes (Roncalli 2006, p. 30). Fragmentary *pinakes* with depictions of warriors have also been discovered in the area of the shrine of Hera at Cerveteri (Steingräber 2006, p. 124). Due to these finds, it is therefore reasonable to raise the question as to whether the *pinakes* were in fact made for funerary use. Roncalli has thus argued that the *pinakes* recovered from tombs such as the Campana plaques (which had cuts and adjustments to make them fit the funerary architecture), the Boccanera plaques, and the *Tegola Dipinta* originally adorned the interior walls of temples and aristocratic residences rather than tombs (Roncalli 2006). Thus, the funerary origin, albeit secondary, of at least the *pinakes* recovered in the nineteenth century, cannot be supported by the more recently recovered examples of known provenances (Roncalli 2006, p. 30).

The question of authenticity

When dealing with Etruscan artefacts, especially of terracotta, one needs to be aware of the forgeries of Etruscan antiquities. Unfortunately, they are not uncommon. Among the most famous Etruscan forgeries are the three "Etruscan warriors" in the Metropolitan Museum of Art (Craddock 2009, pp. 197-199): a study carried out by von Bothmer and Noble, found that the warriors were forged. The large scale terracotta warriors were lacking vent holes necessary for firing major clay artefacts in one piece. Vent holes are present in all large, genuine Etruscan terracotta artefacts (von Bothmer and Noble 1961). Furthermore, chemical analyses were carried out, concluding that the forgers had misunderstood the kiln technology of the ancient Etruscans. Spectrographic examination showed high concentrations of manganese in the black glazes of all three examined artefacts. Not having encountered manganese black on terracotta artefacts of Etruscan origin before, von Bothmer and Noble believed that all Etruscan terracotta artefacts were made according to the three-step firing procedure used, for instance, for Attic vases. Thus, noting that the black glazes were based on manganese rather than ferric oxide and that the terracotta had not been subjected to a three-stage firing, von Bothmer and Noble were absolutely certain when denouncing the warriors as fakes (von Bothmer and Noble 1961, pp. 12, 21-22). Although later studies have shown manganese black to be a rather common pigment for Etruscan terracotta artefacts incl. antefixes (Schweizer - Rinuy 1982; Brøns - Hedegaard - Sargent 2016) there is no doubt that the terracotta warriors are indeed fakes. The terracotta *kore* in the Ny Carlsberg Glyptotek is another example of falsification. In a letter of 1958 from Harold W. Parsons to a Mr. Rorimer it is identified as a forgery, sculpted by a man by the name of Alfredo Fioravanti (von Bothmer and Noble 1961, pp. 15-16). Fioravanti worked together with the (in) famous Riccardi family, who had a workshop crafting Etruscan forgeries during the late nineteenth and early twentieth century (Craddock 2009, p. 197).

With regard to the Etruscan *pinakes*, several examples of forgeries have turned up in museum collections during the last century (Pieraccini 2011, p. 55). Roncalli has argued that the two *pinakes* in the Boston Museum of Fine Arts (inv. nos. 62.362 and 62.363) are forgeries (Roncalli 1969). Furthermore, Steingräber has expressed suspicion that a *pinax* from an American private collection is a fake (Steingräber 2006, p. 123). In the above examples, the suspicion is prompted by stylistic elements, which, however, can be difficult to determine definitively. Other forgeries of Etruscan *pinakes* have been revealed by the use of thermoluminescence (TL): a *pinax* from the Antikensammlung at the University of Bern, two from Munich (the so-called Arkesilas and Troilos *pinakes*), and one from a private collection in Basel have been revealed to be of modern origin, specifically made in the 1960s (Fleming - Jucker - Riederer 1971, pp. 162-163). As part of the same study, thermoluminescence dating was carried out on the Campana plaques and the Boccanera plaques mentioned above. The TL examinations showed that the Campana plaques belong to the period from 745 to 225 BCE, while the Boccanera plaques were dated to the period around 570 BC (+/– 269 years) (Fleming - Jucker - Riederer 1971, pp. 154-155). Finally, the idea that the Ceri *pinax* was false started circulating in the late 1960s and early 1970s. It has, however, proven to be genuine (Roncalli 2006). This illustrates how easily the study of Etruscan *pinakes* is contaminated by forgeries, necessitating constant evaluation of authenticity in order to prevent forged material from misleading scholarly research.

The question of authenticity is further complicated by the fact that many of the *pinakes* in museums as well as private collections derive from clandestine excavations and were sold on the international antiques market, in particular during the 1970s. Only a few have a certain provenance (Roncalli 2006, p. 15; Pieraccini 2011).

The *pinakes* from the Ny Carlsberg Glyptotek

In 1977, the Ny Carlsberg Glyptotek acquired a group of seven Etruscan *pinakes* from the international art and antiquities market. According to the museum records, the *pinakes* originate from Cerveteri, but are without exact provenance. However, based on the similarities in style, form, and subject matter of the many finds from the city area of Cerveteri, Roncalli suggests that the *pinakes* from the Ny Carlsberg Glyptotek also originate from the urban area of Cerveteri. This is supported by the many clandestine visits to the area of the ancient city of Cerveteri (Roncalli 2006, p. 30). However, it has also been suggested that the *pinax* HIN 798 possibly comes from the area of Temple B at Pyrgi (Roncalli 2006, p. 30).

HIN 793, 794, and 795 belong to the same original set of *pinakes*, as indicated by the shared upper band, the use of the same colours, type of clay, and thickness. It appears that the fragments originally belonged to a single narrative frieze. The fragments from NCG are reconstructed as three incomplete panels (Christiansen - Winter 2010, p. 175).

HIN 793

Measurements: H 34.5, W 36.5, Th. 2.5-3.4; H 14.5, W 15.3, Th. 3.5.

Date: *c.* 490 BCE.

Terracotta: light red clay (Munsell 2.5YR 6/6) with many inclusions.

Preservation: fragment of a painted *pinax* consisting of nine joining fragments and a non-joining fragment.

Decorative border: above and below are three narrow parallel bands in red, white, and black.

Motif: cream white slip as background for a motif, which has disappeared apart from a yellowish blotch. Along the upper edge is painted a band of red lozenges, each with a black dot in the centre.

HIN 794 (Odysseus and Teiresias?) (*pl.* XL *a*)

Measurements: upper part: H 23, W 19; H 8, W 13; H 9.8, W 15; H 4, W 8.8, Th. 2.5-3.5. Part with figures: H 38, W 36, Th. 2.8-3.

Date: *c.* 490 BCE.

Terracotta: light red clay (Munsell 2.5YR 6/6) with many inclusions.

Preservation: fragmentary painted *pinax*. Upper part: four barely joining fragments. Fragments with figures: five joining fragments.

Decorative border: along the upper edge is a painted band of red lozenges, each with a black dot in the centre. Above and below are three narrow parallel bands in red, white, and black.

Motif: a beardless naked male in profile to the left. His right arm is extended to the left towards a figure of which only a black hand and lower arm are preserved. The black hand is holding out a golden chain or necklace. D'Agostino has suggested that the motive depicts Odysseus and Teiresias (D'Agostino 1991, pp. 232-233). According to Roncalli, it is beyond doubt that the *pinax* depicts a so-called *nekyia* (a rite in which ghosts were summoned and questioned about the future). The man bent towards the smaller black figure, which emerges from the ground in front of him, is unparalleled in ancient depictions of communication with the underworld. His left leg is raised as if to rest his foot on a rocky outcrop, his left arm hangs down the left thigh, while his right arm is raised, as he is leaning in as if listening. As argued by Roncalli, Odysseus is usually depicted with beard and *pilos*, and the scene thus might as well depict another hero such as Theseus (Roncalli 2006, p. 39).

HIN 795 (*pl.* XL *b*)

Measurements: H 33, W 21, Th. 2.4-2.6.

Date: *c.* 490 BCE.

Terracotta: light red clay (Munsell 2.5YR 6/6) with many inclusions.

Preservation: fragmentary painted *pinax* consisting of five joining fragments.

Decorative border: above and below are three narrow parallel bands in red, white, and black.

Motif: part of male figure in dark brown outline. Only the face with forehead and hair and an upright left hand are preserved. The depicted male is wearing a wreath. Along the upper edge is a painted band of red lozenges, each with a black dot in the centre.

HIN 796 (warriors) (*pl.* XLI *a*)

Measurements: H 53, W 34, Th. 3.2-3.5.

Date: *c.* 520 BCE.

Terracotta: reddish yellow clay (Munsell 5YR 6/6) with many inclusions.

Preservation: left and central part of a painted *pinax*.

Motif: at the top is a broad band with two parallel bands. Below is a scene with two warriors to the left. The foremost (and best preserved) warrior wears a Corinthian helmet with a high crest. On his left arm he is holding a circular shield covering his body. He is raising a spear with his right hand. To his proper left is another warrior of whom only the rim of his shield is preserved.

HIN 798 (The Judgement of Paris? Atalante and Meleager?) (*pl.* XLI *b*)

Measurements: H 68.5, W 53, Th. 2.6-3.1

Date: *c.* 525 BCE.

Terracotta: light reddish brown clay (Munsell 2.5YR 6/4) with many inclusions.

Preservation: upper part of painted *pinax* consisting of eleven joining fragments.

Decorative border: along the upper edge is a broad band consisting of a hook meander with red and black bands. Above and below is a red and white and white and black band respectively.

Motif: the scene shows three human figures and a dog. From proper right to left, a woman facing proper left, dressed in chiton and a red mantle, which is drawn up over her head. She is grasping her garment in her left hand. In front of her is another woman also facing proper left. The woman has long black hair and is wearing a loose, transparent mantle, which leaves her naked body visible. She is facing towards a man on whose shoulder she is resting her hand. The man, who is facing the two women, is dressed in a short, red tunic and a short mantle. In his left hand he is holding a spear. Behind him is a sitting dog. As argued by Christiansen and Winter, the scene might depict the judgement of Paris. The half-naked woman might be Aphrodite, the woman behind her Hera, and the man Paris, prince of Troy (Christiansen - Winter 2010, p. 174). Alternative interpretations of the motive include Atalante and Meleager (Roncalli 2014, p. 243).

HIN 799 (lower part of human body) (*pl.* XLII *a*)

Measurements: H 17, W 19.5, Th. 2.6/7.

Date: 500-480 BCE.

Terracotta: light reddish brown to light red clay (2.5YR 6/4-6/6) with many inclusions.

Preservation: central part of a narrow painted *pinax*. The original edges are preserved on the left and right sides.

Motif: a figure preserved from waist to ankle, turning towards the proper left. The depicted person is wearing greaves or boots. The person wears a thin garment as indicated by fine, vertical, wavy lines. Over this and down his back are heavier folds, which might belong to a mantle. Behind his left leg, the edge of an object (perhaps a shield) is barely visible. To the right is an indeterminated object.

HIN 800 (Herakles) (*pl.* XLII *b*)

Measurements: H 9, W 13, Th. 2.

Date: 500-480 BCE.

Terracotta: light reddish brown clay (Munsell 2.5YR 6/4) with many inclusions.

Preservation: fragment of the right side of a narrow painted *pinax*. The original edge is preserved on the right side of the fragment.

Motif: upper part of a male – probably Herakles – turned to the proper right. He has curly locks above his forehead while the rest of his head is covered by a lion skin whose front paws are tied on his chest. The figure wears a short-sleeved garment under the lion skin.

Archaeological comment

When considering questions of authenticity it is relevant to consider the time of acquisition. The *pinakes* in the collections of the NCG were bought in 1977 and 1978 and are without known provenance. The majority of *pinakes* appeared on the international art market during the 1970s. It has been pointed out that this coincides with Francesco Roncalli's publication *La lastre dipinte da Cerveteri* from 1965, which introduced the Etruscan *pinakes* to a wider audience. Suspicion has therefore been raised that many of these artefacts were in fact fakes (Roncalli 2006, p. 15).

Etruscan *pinakes* are usually of homogenous, rectangular shape averaging 125 cm in height, 55 cm in width and 3 cm in thickness (Pieraccini 2011, p. 56). Thus, with regard to the measurements, the *pinakes* from the NCG, they all appear to conform to the overall measurements of known *pinakes* from museums worldwide. Due to their fragmented state, their original height and width is difficult to ascertain, but their thickness is always measurable. The NCG examples range in thickness from 2.5 to 3.5 cm, which conforms to the thickness of other known genuine museum examples. However, this is not sufficient as an indication of their authenticity, since also *pinakes* proven to be false adhere to these measurements. The forged *pinax* from Bern, for example, has a thickness of 3.2-3.3 cm. HIN 799 is unusual since it has a very narrow shape of only *c.* 20 cm, which stands remarkably out from the typical width of Etruscan *pinakes* of about half a metre. HIN 799 most likely belongs together with HIN 800 which has the same measurements, type of clay, colours, and stylistic traits. It has been suggested that the fragments functioned as revetment plaques surrounding an opening such as a doorway or a window (Christiansen - Winter 2010, p. 190). Thus, neither of these two specimens is a typical example of Caeretan *pinakes*: something which should be kept in mind in their assessment.

All of the compositions are painted on a whitish ground layer. Except in the case of HIN 799 and 800, the ground layer is largely left exposed forming the background colour in the depicted scenes. This reflects the common practice in Etruscan *pinakes* and wall paintings. Likewise, all of the depicted figures are outlined in black and the rest of the paint schemes are primarily based on yellow, red, and brown. This is generally in keeping with Etruscan painting tradition, which in the Orientalizing Period (seventh and early sixth centuries BCE) mainly included red, yellow, brown, and black, while the Archaic Period saw the introduction of a richer palette of colours, including blue and green (Steingräber 2014, pp. 96, 104).

With regard to the motives on the *pinakes* from NCG, the majority appears to conform to motives in genuine Etruscan art. For example, the warrior depicted on HIN 796 fits well with Etruscan imagery such as the so-called warrior-*pinax* from Ceri. Similarly, Herakles (in Etruscan *Hercle*), as depicted on HIN 800, is a popular subject in Etruscan art. The scene depicted on HIN 798 is interpreted as the Judgement of Paris (Christiansen - Winter 2010, p. 174), which is not unprecedented in Etruscan art: the Boccanera plaques as well as a fragmented *pinax* in Villa Giulia (Roncalli 1965, no. 43) have been interpreted as depicting the same Homeric scene. The only *pinakes* from NCG, which appear to differ from typical Etruscan imagery, are the group consisting of HIN 793, 794, and 795. The two men depicted on these specimens are rendered with very pale, almost white skin, which is highly unusual for Etruscan art. In Etruscan art a fixed type of colour-coding was employed rendering women with fair skin and men with darker, reddish skin. This is evident in other Etruscan *pinakes*, and is also true for terracotta statues, architectural decoration, and the wall-paintings in the chamber tombs of the Etruscan necropoleis where there is a clear division between men with darker skin and women with lighter skin (e.g. Del Chiaro 1984, p. 119). A further curious aspect is the small, black hand, holding what might be a necklace, depicted on HIN 794. Depiction of human skin this dark in colour is unusual in Etruscan art of the Early Archaic Period, although not unprecedented. As an example, Africans with black skin are rendered on Etruscan antefixes[1]. Africans become a popular motive in art from the second half of the fourth century BCE onwards (Gilotta 1985, p. 85)[2]. However, so far black skin has not been attested in Etruscan painting. Thus, whereas the iconography of HIN 796, 798, 799, or 800 does not raise suspicion, the unusual rendering of skin colour in HIN 794 throws suspicion to the authenticity of the group HIN 793-795.

[C. B.]

Technical assessment of the polychromy

Methodology

The seven fragmented *pinakes* forming the core of the investigation were first examined visually. The techniques employed include microscopy with a Leica M651 surgical microscope (max 40 ×), ultraviolet fluorescence (UVF) examination, and technical imaging by means of infrared reflectography (IRR), and visible-induced luminescence (VIL) imaging. With the standard of reference in mind, the investigation was extended with a UV and VIL imaging survey of the rest of the *pinax* fragments within the collection of the Ny Carlsberg Glyptotek[3]. All visual observations are supported by photographic documentation.

After the visual examination and technical imaging, handheld energy-dispersive X-ray fluorescence (HH-EDXRF or HH-XRF) was performed directly on the surface of the artefacts. Informed by the non-invasive analyses, sample material was then collected for

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[1] E.g. an antefix depicting the head of an African man of unknown provenance, Munich, Antikensammlungen, no. 5431. Andrén 1940, p. 498, 1,7, pl. 157, 534. Another antefix depicting an African man from Cerveteri, Louvre, no. 4797. Andrén 1940, p. 51, 3,10, pl. 18, 58. A final example is the antefixes depicting the heads of African men from Temple B at Pyrgi. *Santuari d'Etruria*, p. 133, no. 6-7 (F. Melis).

[2] In particular in plastic vases from the fourth century BCE, e.g. Karlsruhe, Badisches Landesmuseum, no. 73/129; New York, Metropolitan Museum of Art, no. 03.3.1. For Africans in Etruscan art, see also *EAA* V (1963) s.v. *Negro* (G. Becatti); Beardsley 1929.

[3] HIN 797, 822, 823, 825-829, 830, 833, 834, 836, 837, and 839-842.

cross-sections, Fourier transform infrared spectroscopy (FTIR), and gas chromatography mass spectrometry (GC-MS).

Ultraviolet fluorescence (UVF)

When utilising radiation just beyond the visible part of the electromagnetic spectrum, it is possible to access material aspects which are invisible to the naked eye. High-frequency radiation within the UVA range (340-400 nm) has a fluorescing impact on a variety of materials. UV examination forms an important part of the preliminary investigation of archaeological artefacts revealing the presence and distribution of fluorescent materials. These include a vast number of organic adhesives and surface coatings of original as well as secondary origin. It is worth noting that the fluorescence only hints at the nature of the fluorescent material. It is not possible to determine the chemical composition of a given material based on fluorescence alone (Bridgman - Gibson 1963; de la Rie 1982a-c; Verri *et al.* 2008).

The UVF recordings were made using a Harolux lamp with eight Philips TL-D 18W Blacklight Blue lamps (340-400 nm) and a Canon EOS 5D Mark II camera fitted with a Tiffen Haze 2A UV-blocking filter. The images have been edited using Adobe Photoshop Lightroom 2.7 and Adobe Photoshop CS6.

Infrared reflectography (IRR)

Near-infrared radiation (NIR) (0.75-1.4 µm) can be particularly useful for revealing preliminary sketches, underdrawings, and compositional changes that lie beneath visible paint layers. The degree of penetration depends on the thickness of the paint layer(s), the type of paint used, and the wavelength of the radiation. The longer the IR wavelengths and the thinner the paint layers, the easier it is to penetrate to the underlying layers. Besides revealing details beneath the surface, IRR may reveal equally important information on the composition and painting process by registering top layers which appear opaque in the IR images due to infrared absorption. Most of the IRR-related findings are related to infrared absorption of black chalk, bone black, and other carbon black pigments (Bridgman - Gibson 1963; Faries 2005).

The IRR was carried out by Riccardo Buccarella from the National Gallery of Denmark using two Hedler halogen 1000W lamps and an Osiris camera with an InGaAs array with an operation wavelength of 0.9-1.7 µm. The recordings are made at a distance of 85-100 cm from the decorated surfaces of the *pinakes*. Each recorded image consists of a BMP image measuring 4000 × 4000 pixels (c. 30 × 30 cm at 300 dpi) at a magnification of 0.8-0.9 × necessitating a series of parallel recordings for larger surfaces. The BMP images have been converted into TIFF files and stitched using Adobe Photoshop CC.

Visible-induced luminescence (VIL)

Some materials absorb visible light and reemit it as radiation in the NIR part of the electromagnetic spectrum. This phenomenon is termed VIL or NIR luminescence.

The pigments Egyptian blue ($CaCuSi_4O_{10}$), Han blue ($BaCuSi_4O_{10}$), Han purple ($BaCuSi_2O_6$), cadmium yellow (CdS), and cadmium red (CdS· CdSe) all show very strong VIL properties (Bridgman - Gibson 1963; Verri 2009). Since the Han pigments are only found on Chinese artefacts from the Warring-States Period (475-221 BCE) and the Han Dynasty (208 BCE-220 CE), and the cadmium pigments were only synthesized in the early nineteenth and early twentieth century respectively, Egyptian blue is the only one of the strongly NIR luminescent pigments employed in the Mediterranean area in antiquity. Although the pigment was widely used in antiquity it is only rarely found on artefacts from later periods (Eastaugh *et al.* 2004, pp. 76, 78-79, 153-154, 181). The IR emission exhibited by Egyptian blue is unusually intense. In fact, it is the strongest emission ($\Phi EM = 10.5\%$) known for a molecule-level chromophore emitting in the 800-1,100 nm range ($\lambda_{max} = 910$ nm). This makes Egyptian blue ideal for VIL imaging allowing detection of single pigment grains, even when concealed by surface coatings or patina (Verri 2009; Verri *et al.* 2010).

In this study, VIL imaging was carried out using two Excled LED RGB lamps ($\lambda_{max} = 470$ nm, 525 nm, and 629 nm) and a Canon 40D camera modified by removing the internal IR-blocking filter. The lens was fitted with a Schott RG830 visible-blocking filter with an approximate IR sensitivity range of 800-1,000 nm (Accorsi *et al.* 2009). A Labsphere Spectralon 75% reflectance standard was included in each recorded image for the evaluation of the presence of luminescence. The VIL images have been edited using Adobe Photoshop Lightroom 2.7 and Adobe Photoshop CS6.

Handheld X-ray fluorescence (HH-XRF)

HH-XRF is widely used in the field of archaeometry and is described in detail in numerous publications (e.g. Longoni *et al.* 1998; Glinsman 2005; Shugar - Mass 2012). Within the field of polychromy research, HH-XRF is a useful tool to gain preliminary impression of the different pigments used. Polychromy consists of mixtures of pigments, binders, and fillers applied in layers onto a substrate. The chemical composition as well as the thickness differs between the layers *and* within the individual layer. The average thickness of each layer can measure anywhere between 100 µm and a few mm. The inherent complexity of polychromy limits the usefulness of HH-XRF. First and foremost, the depth of the scans poses an issue. Depending on the specific analyser used and the density and elemental composition of the polychromy, the scans can penetrate up to a few mm into the structure. This means that each XRF data set may represent the combined signal of the different paint layers as well as the substrate. Another important issue is the fact that the method cannot detect elements lighter than magnesium, and that it is less sensitive to the lightest of the elements which it can detect. This means that a significant proportion of the elements usually constituting paint layers is either not detected or only partially so resulting in a rather disproportional impression of the constituents of the polychromy. Furthermore, the polychrome areas are often smaller than the area covered by the X-ray beam. In these cases, the data obtained predominantly inform us about the area surrounding the actual area of interest. However, despite its limitations, HH-XRF is a most useful tool affording fast, easy, and non-invasive insight into the polychromy.

By scanning for major element concentrations it is generally possible to identify the inorganic pigments present.

The analyses were carried out using an Innov-X Alpha-8000 LZX HH-XRF spectrometer. The instrument was held in hand for elemental analysis directly on the painted surfaces of the *pinakes*. The terracotta substrates were also analysed and used as a reference for the polychromy data. The X-ray beam covering an area of ~ 2 cm^2 (1.5 × 1.3 cm) was frequently calibrated at a stainless steel target. The analyses were carried out using standard and LEAP settings measuring 2 × 60 sec. on each selected area. The absorption peaks were automatically identified, followed by conversion from absorption to elemental concentration and subsequent data reduction using the Innov-X software. The limit of detection was defined at < 100 $\mu g\ g^{-1}$.

Cross-sections

In order to compare the stratigraphy and constituents of the polychromy, samples representing each of the colours within the individual paint scheme were collected for cross-sectioning. Since HIN 793, 794, and 795 clearly belong to the same decoration, samples were only collected from HIN 794. In total 29 samples were collected: four samples were collected from HIN 794, seven from HIN 796, and six from HIN 798, 799, and 800 respectively. All samples, each the size of a pin head, were collected from fractured areas limiting the damages caused by sampling to a minimum. The samples were removed with a scalpel which was thoroughly cleaned with acetone prior to each sampling. They were stored in glass containers until processed. Each sample was placed in an EasySection mould and embedded in Struers Serifix polyester resin. After hardening, the resin-embedded samples were polished manually from one side first with SiC paper of increasing fineness (800-4,000 grains/cm^2) on a Struers Knuth-Rotor 3 polishing machine and then with Micro-Mesh polishing sheets (6,000, 8,000, and 12,000 grains/cm^2). The finished cross-sections were examined with a Leica DM2500 M optical microscope (max 100 ×) in bright field (BD), dark field (DF) and UV. All observations were documented with a Canon EOS 5D Mark II camera mounted on the microscope.

Fourier transform infrared spectroscopy (FTIR)

Commercially available since 1969, FTIR is widely described in the literature (e.g. Mills - White 1994, pp. 20-22; Smith 1995). Within polychromy research the technique is mainly utilised for the identification of organic binding media. However, it also informs us of inorganic compounds in the sample material. FTIR spectroscopy, predominantly, provides information on the functional groups. The insight offered is thus limited to the class of chemical components in the sample material. Unfortunately, the IR spectrum of complex mixtures contains so many individual bond absorptions that these easily overlap and merge into broad envelopes (Meilunas - Bentsen - Steinberg 1990; Pilc - White 1995).

Similar to the samples for cross-sectioning, samples representing each of the colours within the individual paint scheme on 794, 796, and 798-800 were collected for analysis. In addition, the ground layer and the terracotta substrate were also sampled. Seeking to analyse the colours individually, the samples were removed by scraping rather than cutting in order to minimise contamination from underlying layers. All samples were collected with a thoroughly cleaned scalpel from damaged areas, and stored in glass containers until processing. The analyses were performed with the assistance of Mette Øgaard Thorsgaard at laboratory of the Danish School of Conservation. A Perkin Elmer Spectrum One FTIR spectrometer was used for the analysis. The measuring wavelength range was 4,000-650 cm^{-1}, the resolution 4.00 cm^{-1}. A background spectrum was measured for each specimen. Each absorption spectrum is based on four individual scans. The spectra have been interpreted by non-computerised comparison with known references.

Gas chromatography mass spectrometry (GC-MS)

First developed in the 1950s, GC-MS is described in a vast number of publications (e.g. Mills - White 1994, pp. 169-195; Hübschmann 2009). It is a specific test. Thus, rather than merely indicating a category of substances, it positively identifies the substance(s) present in the sample. Applying GC-MS, it is often possible to identify trace elements previously thought to have disintegrated beyond identification. Within the field of polychromy research, the method is used for the identification of potential remnants of organic binding media and surface coatings.

Two minute samples were collected from the ground layer, one from HIN 794 and one from HIN 796, for GC-MS analysis. In order to avoid contamination, the scalpel blade was thoroughly cleaned with acetone prior to each sampling. The sample material was kept in glass containers until processing. The analyses were performed by Mads Christian Christensen at the laboratory of the National Museum of Denmark. Prior to the actual analysis, each sample was prepared by alkaline hydrolysis and acidification and extracted with ether. The ether extract was then methylated with diazomethane and analysed with a Bruker Scion 456-GC-MS system for potential remnants of oils, resins, and waxes. The samples were not analysed for potential contents of proteins.

Results and discussion

Thoroughly examining the terracotta slabs, there are no obvious signs hinting at forgery; there is no suspicious discolouration on the fractures of the terracotta which would have indicated that the slabs were broken before firing (von Bothmer - Noble 1961, p. 14; Fleming - Jucker - Riederer 1971, p. 145). Likewise, there are no traces of paint on broken surfaces or inside fractures in the pictorial plane which would have strongly suggested that the slabs were broken prior to decoration (von Bothmer and Noble, 1961, p. 14). Abrasions and breaks appear quite worn and all surfaces of fracture correlate between the pictorial layers and the terracotta substrate.

Neither the seven *pinakes* forming the basis of the article nor the numerous other fragments surveyed as a part of the investigation exhibit strong fluorescent properties when exposed to UV radiation. The white areas on HIN 793-795 did, however, exhibit weak, yet observable, fluorescent response. The fluorescence from remnants of root marks and adhesives from modern conservation treatments was more distinct. The least well-preserved of the fragments of HIN 798 thus shows a very weak fluorescence due to consolidation of the paint layer. Neither microscopy nor UV examination has revealed any other repairs, alterations or additions to the paint layers[4].

Preparatory drawings, incisions, and corrections

Under magnification and in raking light, preparatory drawings in the form of incisions and painted lines become more apparent on most of the *pinakes*. Such preparatory measures are considered a common, if not compulsory, feature of Etruscan *pinakes* (Roncalli 1965, p. 47; Fleming - Jucker - Riederer 1971, p. 145). Most of the drawing on the artefacts in question appear to consist of horizontal lines. Thus, HIN 793-796 and 798 seem to be guided mainly by the horizontal band at the top of the depicted scenes. The paint layers tend to obscure the incisions and can make it difficult to discern them. On HIN 796 it is difficult to ascertain whether the horizontal bands at the top are incised or not. However, other features including the two shields and the eye of the warrior are clearly incised with a thin, sharp tool. On HIN 800 a single horizontal line crosses the surface at the top of the eye of the depicted male figure. This line could either have been made by pressing a string into the freshly applied ground layer or by incising with a sharp tool (Steingräber 1985, pp. 84-87). In the case of HIN 799, only the lower part of the original motive survives which makes it impossible to tell whether the design was guided by one or more preparatory lines at the upper part of the composition.

The composition of HIN 798 has clearly been spontaneously corrected which is a feature very often encountered in Etruscan *pinakes* and wall paintings (Fleming - Jucker - Riederer 1971, p. 145; Steingräber 1985, pp. 84-85). Aided by IRR, spontaneous corrections have also been discovered underneath the paint layers on HIN 800. Several lines at the proper right of the depicted figure indicate that the head, if not the entire figure, was repositioned a few times moving the figure further to the proper left of the composition.

Ground layers

The light-coloured ground layers, which in most cases also serve as the background colour, differ between the examined artefacts. HIN 793-795 have very thick, very smooth grounds which appear almost waxy to the touch. The rest of the *pinakes* have thin, relatively dry grounds with linear tool marks which seem to come from the application.

[4] When the *pinakes* were acquired by the Ny Carlsberg Glyptotek in 1977, the then museum restorer Aksel Theilmann wrote a very brief, joint condition report on them. The report mentions that the fragments were mounted with an adhesive soluble in acetone. Theilmann has enclosed photographs whereon he has marked the breaks which he believed to be genuine. However, he does not specify what he means by 'genuine'. Two breaks on HIN 793 and two on HIN 794 have not been marked. According to the conservation records, later conservation treatments have been limited to detaching and remounting.

Comparing the cross-sections, the differences become even more apparent: the surface of the terracotta slab of HIN 794 does not seem to have been treated with diluted clay like the rest of the examined *pinakes*. The practice of adding a finishing slip to terracotta surfaces is known from other painted Etruscan artefacts such as antefixes (Winter 2009, pp. 507, 519-520; Brøns - Hedegaard - Sargent 2016, p. 30). However, it is uncertain whether this is to be considered obligatory for all terracotta artefacts of Etruscan origin.

The cross-sections also emphasise the divergence exhibited by the ground layers: the ground of HIN 794 has been applied in at least five individual layers (*pl.* XLIV *b*), whereas the ground of the other *pinakes* consists of a single layer (*pl.* XLIV *a*). With each applied layer roughly measuring the same, the total thickness of the ground layers is about four times larger in the cross-sections from HIN 794 than in the rest of the examined specimens. Interestingly enough, the more time-consuming approach of applying multiple ground layers does not appear to be an improvement of the decoration technique. On the contrary, the ground layers in the samples from HIN 794 easily become detached from the terracotta substrate, a tendency which is not paralleled by the samples from the other *pinakes*.

Consulting the data from the HH-XRF analysis (*table* 1), it appears that the suggested constituents of the ground layers were available to the Etruscans. There are, however, clearly chemical differences between the compositions of these preparatory layers. The ground layers of HIN 793-795 are calcium-based with rather minute additions of chlorine and phosphorous. The rest of the analysed ground layers appear to be based on mixtures of potassium and calcium. Based on the detected amounts (ppm), the ratio between potassium and calcium is 5:1 for HIN 796, 3:1 for HIN 798, and 1:1 for HIN 799 and 800. In addition, the ground layers on HIN 799 and 800 contain significant amounts of sulphur and phosphorous corresponding to *c*. 8.5:1 and *c*. 11:1 of the detected calcium content. The ground layers of HIN 796 and 798 also contain sulphur and phosphorous but in much less significant concentrations.

Paint layers

The paint layers applied on top of the light-coloured grounds also differ in appearance. The painted decoration on HIN 793-795 seems to have been carried out in a fairly fluent medium, apparently free hand. The rest of the examined *pinakes* have been decorated using a more viscous paint and with more attention to detail. This difference becomes obvious when comparing features such as the bands sloppily executed at the top of HIN 793-795 with the hook meander board meticulously rendered on HIN 798. The difference attests to the approach rather than the skill of the craftsman.

Judging from the cross-sections, the paint layers are fairly similar and do not raise any suspicion regarding thickness and grain sizes. There are only a few examples of colour mixtures and none of superposition of layers for chromatic effects. Although the former appears more common than the latter, both practices of colour mixing have

	Area	Colour	P	S	Cl	K	Ca	Mn	Fe	Co	Cu	Zn	Pb
HIN 793-5	Terracotta	Terracotta	0.077	0.212	-	1.78	4.957	0.039	3.506	-	0.003	0.006	0.007
	Background	White	0.128	0.540	0.325	-	11.505	0.096	3.79	0.045	0.003	0.009	0.006
	Skin	Beige	0.133	0.43	0.207	-	11.842	0.114	5.616	-	0.002	0.009	0.006
	Decorative band	Red	0.26	0.5	-	0.845	6.84	0.117	7.794	-	0.003	0.009	0.005
	Black hand	Black	0.118	0.605	0.297	0.295	8.958	4.453	6.22	-	0.003	0.009	0.006
HIN 796	Terracotta	Terracotta	-	0.514	-	-	1.888	1.173	3.761	-	0.004	0.008	0.013
	Background	Beige	0.075	-	-	2.933	0.54	0.055	4.124	0.033	0.003	0.008	0.008
	Helmet	Pale orange	0.081	-	-	2.708	0.45	0.154	4.562	0.033	0.009	0.008	0.01
	Shield and arm	Red	0.079	-	-	2.356	0.478	0.139	5.108	0.022	0.004	0.005	0.013
	Crest	Purple	0.074	-	-	1.766	0.532	0.181	4.731	0.029	0.004	0.007	0.09
	Spear	Brown	0.056	-	-	1.59	0.484	0.105	4.165	0.048	0.005	0.008	0.015
	Shield	Black	0.093	0.07	-	1.502	0.812	5.291	5.904	-	0.007	0.021	0.014
HIN 798	Terracotta	Terracotta	0.038	0.081	-	2.202	1.125	0.123	3.323	0.028	0.002	0.004	0.012
	Background	Beige	0.078	0.051	0.037	1.965	0.578	0.035	4.366	0.031	0.003	0.005	0.012
	Skin (male)	Yellowish brown	0.13	0.628	-	1.534	1.644	0.644	5.943	0.042	0.009	0.013	0.011
	Hair (male)	Yellow + black	0.124	0.021	-	1.593	0.46	1.076	6.258	-	0.002	0.005	0.009
	Chiton and hair	Red	0.59	0.062	-	1.301	1.821	0.596	10.997	-	0.005	0.01	0.06
	Dog	Black	0.1	0.868	-	0.914	1.879	1.468	4.857	-	0.007	0.01	0.011
HIN 799	Terracotta	Terracotta	0.064	0.199	-	2.629	1.401	0.083	3.792	0.031	0.004	0.007	0.013
	Background	White	0.29	0.461	0.034	2.699	3.612	0.086	3.959	0.04	0.009	0.011	0.01
	Skin	Pale beige	0.319	0.155	-	1.933	3.652	0.296	4.307	0.042	0.008	0.017	0.028
	Garment	Beige	0.353	1.184	0.038	2.475	3.905	0.294	4.318	0.031	0.01	0.013	0.012
	Garment	Red + white	0.368	0.737	0.073	1.698	4.458	0.515	6.611	0.032	0.007	0.019	0.017
	Contour	Black + white	0.39	0.675	0.239	0.56	6.521	0.427	3.83	0.035	0.009	0.027	0.015
	Background	Grey	0.346	0.515	-	1.064	3.440	1.405	4.573	-	0.013	0.013	0.052
HIN 800	Terracotta	Terracotta	0.356	0.966	0.225	2.267	3.345	0.091	4.503	0.042	0.005	0.014	0.011
	Background	White	0.221	0.256	-	3.099	2.309	0.052	3.964	0.06	0.007	0.012	0.018
	Skin	Pale beige	0.314	0.431	-	1.553	3.841	0.097	4.231	-	0.005	0.013	0.016
	Lion skin	Red	0.363	0.558	-	1.723	4.154	0.385	9.689	-	0.008	0.024	0.022
	Contour	Black + white	0.381	0.461	-	1.363	3.54	1.032	5.333	0.021	0.007	0.02	0.035
	Sky	Bluish grey	0.285	0.625	0.03	1.739	4.41	0.417	3.949	0.043	0.033	0.018	0.015

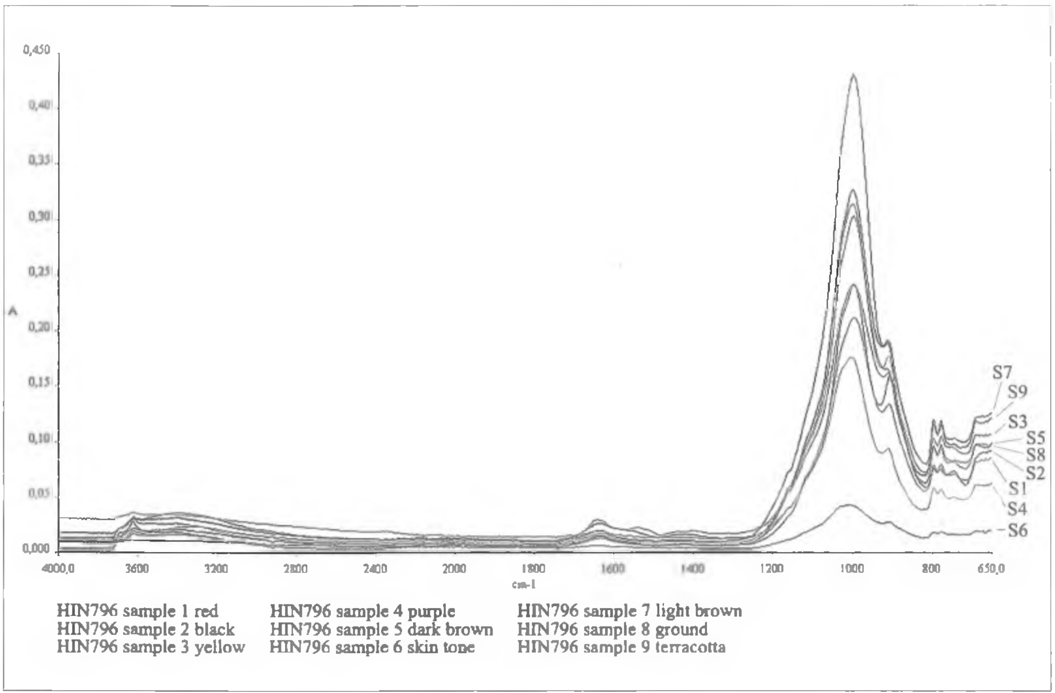
table 1 - X-ray fluorescence (XRF) results (wt%) listing all detected major and minor elements as well as trace elements with relevance to this particular study. In cases where the same hue has been analysed in different areas on the individual *pinax*, the mean is presented. A dash indicates that the concentration of a given element is below the detection limit.

been identified on Etruscan architectural terracotta elements incl. panels, antefixes, and a *pinax* from Ceri dated to 520-510 BCE (Bordignon *et al.* 2007a, p. 95; Bordignon *et al.* 2007b, pp. 257-258; Brøns - Hedegaard - Sargent 2016).

The elements detected by HH-XRF analysis (*table* 1) only point to constituents regularly employed in Etruscan painting. The palettes all appear to be based on earth pigments containing varying concentrations of iron and manganese. Apart from the different yellow, red, brown, black, and purple earth tones, Egyptian blue also formed part of the pigment selection for HIN 799 and 800 (*pl.* XLIII *a* and *b*). In both instances, the blue pigment is used for the background colour surrounding the depicted figure. On HIN 799 the pigment seems to be included in a pigment mixture, whereas it has been applied in more concentrated form for the rendering of the blue sky on HIN 800. The pigment was first identified by VIL imaging. XRF analysis attests to a raised concentration of copper in the background colours on both *pinakes*. In the case of HIN 800, the presence of minute blue grains has also been confirmed by microscopy in situ as well as in the cross-section representing the area. Egyptian blue was widely used in Etruria where it was employed alone as well as in pigment mixtures and superposing techniques of varying complexity (Brøns - Hedegaard - Sargent 2016; Brøns - Skovmøller - Sargent forthcoming). Interestingly, the widespread use of Egyptian blue in Etruria has only been rediscovered in recent years. In other words, this knowledge was not available to the forgers imitating ancient techniques in the 1970s. Since Egyptian blue was not readily available at that time, it is quite unlikely that it would have been used by default. Thus, the presence of Egyptian blue strongly indicates that HIN 799 and 800 were produced in the Mediterranean area in antiquity.

Binders

Affected by the deteriorated state and gritty nature of the sample material, it was not possible to produce clean, easily decipherable spectra with FTIR spectroscopy. The spectres are characterised by rounded peaks as would be expected for degraded materials. Interestingly, the sharpest of the spectra are the ones representing the ground and paint layers of HIN 794. Furthermore, the spectra obtained are dominated by clay minerals overlapping and absorbing the peaks of other compounds potentially including organic binding media. However, in the cases of HIN 796 and 798-800, there is a very strong correlation between the samples of terracotta, ground, and paint layers from the same artefacts (*graph* 1). This indicates that the ground and paint layers are based on the same clay as the terracotta. This is in keeping with recent studies of Etruscan polychrome terracotta artefacts which suggest diluted clay as the binder for painted decorations. The studies also propose that a two-stage firing process has been used for the polychrome terracotta artefacts; the first firing of the clay at a temperature in excess of 800°C and a second firing of the painted terracotta performed at temperatures no higher than 300°C fixing the pigmented slips to the terracotta substrate (Bordignon *et al.* 2007a, p. 87; Brøns - Hedegaard - Sargent 2016, p. 52). All of the pigments identified in this study are sufficiently heat-resistant to withstand the temperature suggested for



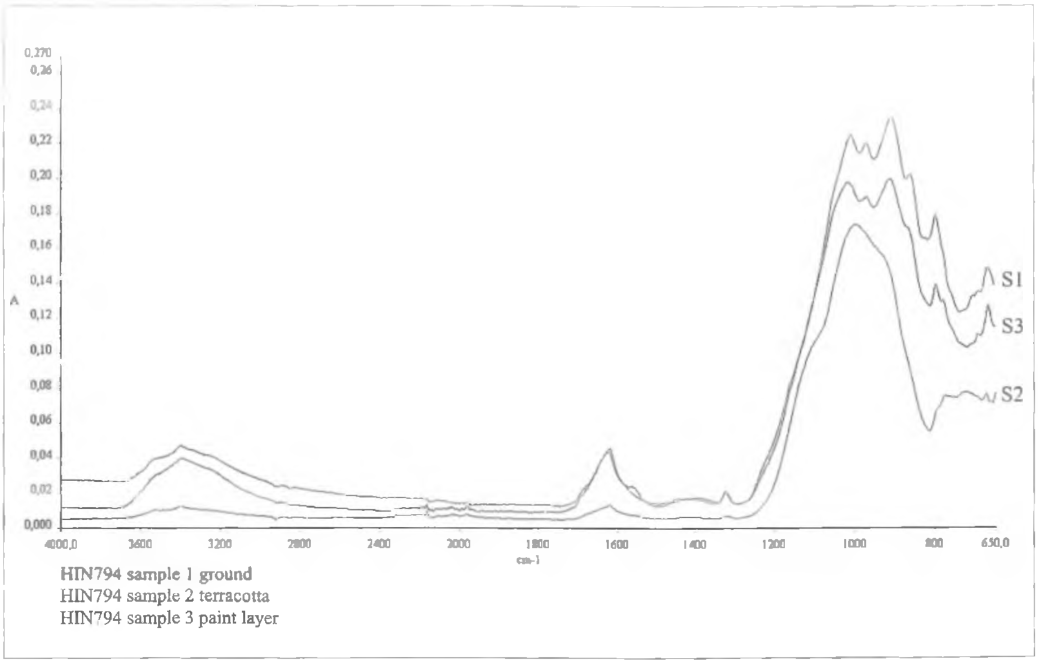
graph 1 - Fourier transform infrared spectroscopy (FTIR) absorption spectrum showing the strong similarities between the composition of the terracotta, ground layer and paint layers of HIN 796 (S = Sample).

the low-temperature firing[5]. However, this does not suffice to determine whether or not the *pinakes* were subjected to a two-step firing process.

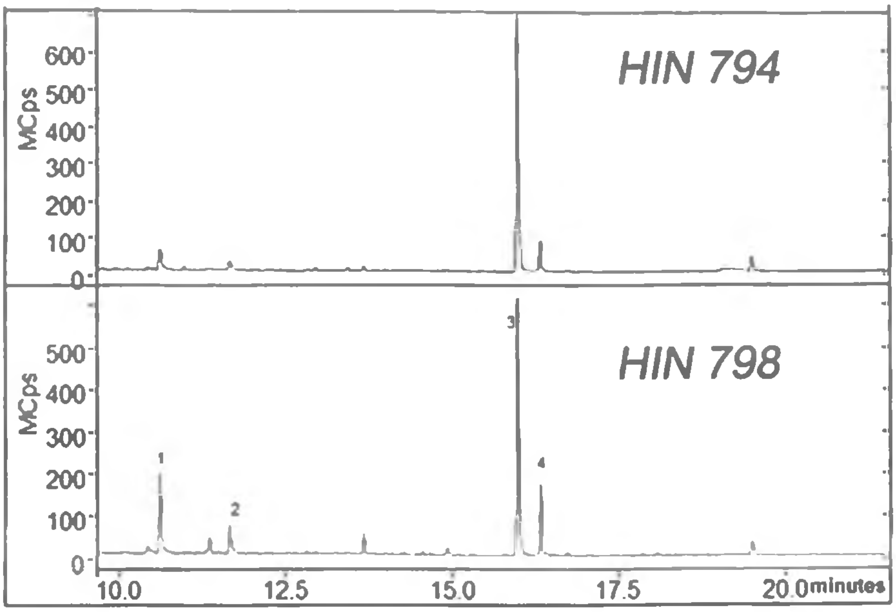
In the case of HIN 794 (also representing HIN 793 and 795) there is less correlation between the terracotta and the applied layers (*graph* 2). The ground and paint layers do appear quite similar. However, it should be noted that the meagerly applied paint layers proved difficult to sample. Thus, the sample material collected from the painted decoration is very likely to contain a significant amount of material from the ground layer beneath it. Despite their reduced legibility, the spectra for the ground and paint layers do show some peaks which could be indicative of a proteinaceous binding medium. However, comparing the spectrum with known references, it has not been possible to find a positive match. The GC-MS analysis performed on samples from the ground layer of HIN 794 and 798 did not identify any organic binding media (*graph* 3)[6]. However,

[5] Ochre is the most heat-sensitive of the identified pigments. When exposed to strong heat, the pigment changes from yellow goethite to red hematite. At *c.* 300°C goethite is completely transformed into hematite.

[6] Using GC-MS, phtalic, azelaic, and palmitic acid as well as minor amounts of fatty acids with 12, 14, and 16 carbon atoms have been detected in both samples (HIN 794 and 798). According to Christensen's report, phtalic acid does not occur in traditional binding media but is an important component in alkyd paint and plasticisers. Azelaic acid is a by-product from unsaturated fatty acids, which occur in e.g. plant oils and palmitic acid, and occurs in a wide range of fats and oils of both vegetable and animal origin. The ratio be-



graph 2 - Fourier transform infrared spectroscopy (FTIR) absorption spectrum illustrating the dissimilarities between the terracotta and the ground and paint layers of HIN 794 (S = Sample).



graph 3 - Chromatogram plots from the gas chromatography mass spectrometry (CG-MS) analysis. 1. dimethyl phthalate; 2. dimethyl azelate; 3. internal standard; 4. methyl palmitate. In addition, traces of saturated fatty acid methyl esters at 11.5, 14, and 15 minutes.

since the GC-MS analysis does not include protein analysis, it does not exclude the potential presence of a detectable amount of one or more proteinaceous binders in either of the two specimens.

Summary

In sum none of the examined *pinakes* shows obvious signs of falsification and there are no anachronisms among the identified constituents. HIN 796, 798, 799, and 800 all bear strong resemblance to other examined genuine Etruscan artefacts regarding application and choice of materials. In particular the antique origin of HIN 799 and 800 can be attested with great certainty due to the use of Egyptian blue.

The group HIN 793-795, however, differs remarkably from the other examined *pinakes*. In fact, the materials and manner of application of the ground layers bring medieval practices to mind. Medieval treatises describe the manner of applying layer upon layer of gesso to the substrate, thereby obtaining a smooth surface for gilding and painting. The medieval gesso consists of gypsum or chalk mixed with animal glue usually made from hides (e.g. Broecke 2015, pp. 150-155). Futhermore, the thinly applied paint layers of the *pinax* group in question also differ from other Etruscan examples. The mismatch between the overly thorough application of the ground layers and the sloppy execution of the painted decoration is rather conspicuous.

[S. B. H.]

Dating and provenancing of the terracotta

Methodology

Thermoluminescence dating

As the process forms part of countless archaeometric studies, the technical details of TL dating is described in a vast number of publications (e.g. Aitken 1985). In order to properly date terracotta artefacts using TL, it is necessary to know: 1. the dose of ambient radiation accumulated in the terracotta since firing; and 2. the dose accumulated per year. Since the annual dose rate depends on the environment wherein the terracotta has been buried or stored, artefacts without known provenance cannot be dated accurately. When attempting to date such artefacts, the annual dose rate has to be estimated which in turn yields less reliable results. However, even when dependent on estimated dose rates, TL dating can easily distinguish between recently produced and ancient terracotta artefacts. Besides the challenges described above, there are also sources of error related to the sample material. Since the surface of the terracotta has been exposed to more

tween the detected components does not correspond to the ratios in degraded oil-based or alkyd-based paints. Besides azelaic and palmitic acid, degraded oil paint usually contains stearic acid. Thus, although the identified substances do occur in oil-based paint, they cannot reasonably be ascribed to binding media. The presence of the identified compounds may be related to contamination from cleaning or surface treatments.

radiation than the core material, sampling is carried out by slow drilling. Although the first material from the sampling spot is discarded, there is a risk of contamination of the sampled core material with dust from more superficial areas. Furthermore, the sampled material is very sensitive to radiation including visible light which can easily affect the TL signature.

A sample was drilled out from the side, parallel to the pictorial plane, of each of the *pinakes* HIN 793, 794, 795, 796, 798, 799, and 800. The sampling was carried out under a black cover using a slowly revolving, electrical drill. The first material from each sampling spot was discarded ensuring that the samples were taken from areas which had not been exposed to light. It should be noted that the depth of the drillings differed: in the case of HIN 795, the first sample was exposed to light and a new one was drilled from the same hole resulting in quite a deep sampling spot about 2-3 cm into the terracotta slab. The double procedure also means that this particular sample is the least prone to contamination of all of the samples collected for TL dating. Due to the thinness of HIN 799 and 800, drilling was done slightly more carefully in these instances resulting in less deep sampling spots from *c.* 0.5 cm into the terracotta substrate.

The samples were sealed in aluminium foil and sent to the laboratory. They were unpacked in a darkroom, weighted, and mounted in a TL-DA-12 thermoluminescence reader manufactured at Risø National Laboratory, Denmark. The results of the TL measurements were subsequently used for both TL dating and provenancing. Each sample was first heated to 200°C and annealed for 30 sec. at 200°C, after which the sample was heated to 400°C while the light emission was recorded. The tops of the signal (at *c.* 340-400°C) were used for the TL dating. After the acquisition of the palaeosignal the sample was irradiated three times each followed by an identical acquisition of the light emission as described above. The radiations were made for 30, 60, and 120 sec. under a *c.* 1 GBq ^{90}Sr beta-source. The precise activity of the source was determined at the time of insertion and the precise activity is calculated at any one time thereafter using exponential decay with the known half-life. The dose-equivalent is determined by the regeneration method using the activity of the source at time of measurements. Following the TL measurements, each sample was pressed into a solid pellet using *c.* 12 kbar pressure. The pellet was first used for measuring potassium and silicon using an ARTAX-800 micro-XRF. The XRF spectrum was acquired as the accumulated spectrum from *c.* 100 points and the international standard reference material SRM NIST614 glass was used as calibration standard. Typically the relative standard deviation (RSD) of the potassium measurements was 0.2% and 0.4% for the silicon. After this, the concentrations of uranium and thorium were determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) measurements on the pellets. The ICP-MS was a Bruker Aurora M90 utilizing a CETAC LSX-213G2 laser ablation unit. The ablated area was 25 μm wide and c. 2 mm long. SRM NIST612 was used for calibration and using the thorium/silicon and uranium/silicon ratios. The absolute thorium and uranium concentrations were then calculated using the silicon concentration determined by the XRF. The collected uncertainty of both the thorium and uranium was better than 10% RSD.

The dose equivalents were calculated using the regeneration method and the software developed by Rainer Grün (Grün 1994). The received dose was assumed to originate from three sources: 1. cosmic radiation; 2. radiation from the object itself; and 3. radiation form the surroundings. The cosmic radiation was assumed to be 150 ± 30 mGy s^{-1}. The radiation from the object itself was calculated using the determined concentration values of uranium, thorium, and potassium measured on each sample. An average density of 1.9 ± 0.1 g cm^{-3} was used in the calculations for all samples. The grain diameter was assumed to be 200 ± 100 mm. The radiation from the surroundings was assumed to be zero due to the special original position of the *pinakes*. No hydrofluoric acid (HF) etching was performed in order to correct for possible alpha radiation received by the surface of the sample grains. No mineral separation has been performed. An alpha efficiency of 0.1 ± 0.01 was used, as it is assumed that most of the minerals are feldspars. A water saturation of 2wt% is assumed. Partly because of these approximations, partly because of the inherent uncertainties of the TL method, the reported ages can only be considered as approximate. A summary of the parameter used in the calculations are listed in *table* 2.

Alpha-efficiency	0.1 + 0.02
Density	1.9 ± 0.1 g/cm^3
Cosmic flux	150 + 30 μGy y^{-1}
Beta attenuation correction	Yes
Surrounding sediment	Zero radiation
Grain size	200 ± 100 μm
Alpha dosimetry	No HF etching has been applied
Mineral separation	No mineral separation has been applied

table 2 - Parameters used in the calculations of the thermoluminescence (TL) dates.

Provenance determination

The provenancing method used is described in detail by Rasmussen (2001) and has been applied to more than 50 locations in Denmark, France, Italy, Greece, Israel, and Argentina (e.g. Rasmussen 2001, 2003, 2008, 2011; Rasmussen - Kristensen 2001-2002; Rasmussen - Lund 2004; Petersen *et al.* 2005; Rasmussen - Hjermind 2006; De La Fuente *et al.* 2010; Rasmussen - Sørensen 2011; Mortensen *et al.* 2011). The method consists of measuring two material parameters of the ceramic material: the magnetic susceptibility and the thermoluminescence sensitivity. The magnetic susceptibility is measured on a Kappabridge KLY-2 susceptibility-meter built by Geofysika, Brno. The measurements are done by subjecting the sample to a low intensity alternating magnetic field at 910 Hz introduced by a set of Helmholtz-coils surrounding the sample. In this way the magnetic domains of the ferro-, ferri-, and diamagnetic minerals are forced back and forth through a hysteresis loop. The magnetic susceptibility is defined as the ratio between the external magnetic field (H) and the induced magnetization in the sample (J). The induced magnetization can be deduced from the drop in the external field, which is measured by a second set of smaller pick-up coils surrounding the sample. This measuring technique leaves the samples completely unharmed – it is not exposed to light, heat, or any mechanical stress, and due to the low relative intensity of the external magnetic field any permanent magnetization is left unaltered in the sample. The second parameter is the thermoluminescence sensitivity, which is measured on the TL equipment described above. The TL sensitivity signal is acquired after the second irradiation of the sample (for 60 sec.). Following this irradiation the sample is read for its TL signal after first annealing it at 200°C for 30 seconds and then heating to 400°C while the light intensity is measured. The measured light curve of the 30 second irradiation was integrated from 202 to 235°C and the number corrected for various parameters such as machine drift, sample size, and the precise irradiation dose. The final result reflects the number of electron traps per mg of ceramic material. The two parameters, the magnetic susceptibility and the TL sensitivity, are plotted against each other in a log-log diagram. It is our experience that differences in clay provenance almost invariably show up as different locations of the points in this plot, examples of which are described in the references above.

Results and discussion

Thermoluminescence results

The dates are listed in *table* 3 and shown in *graph* 4, where the one sigma uncertainties (covering 66% of the probability) are marked as error bars. When comparing the earliest proposed dates for the artefacts, only a few of them would appear to belong to the Etruscan Archaic Period. HIN 793 and 794, which have received the earliest dates of the examined terracotta slabs, would seem to date from the Middle Ages. However, the age gap suggested by the analysis may be due to contamination or radiation of the sample material from HIN 793 and 794. There appears to be a correlation between the depth of the sampling spot and the proposed date: the deeper the sampling, the earlier the dating. The risk of contaminated results can be reduced by taking more samples from the same object for comparison.

CHART sample nos.	NCG inv.nos.	TL date (BP)
KLR11014	HIN793	1099±152
KLR10972	HIN794	1516±211
KLR11015	HIN795	1731±243
KLR10973	HIN796	2752±414
KLR10974	HIN798	2090±391
KLR10975	HIN799	1822±249
KLR10976	HIN800	1770±251

table 3 - Thermoluminescence (TL) dates based on the assumption that the radiation from the surroundings has been negligible.

As mentioned above the calculation of the ages is based on the assumption that the radiation from the surroundings is negligible. This would be a correct assumption if the *pinakes* had been mounted on the walls of temples or secular buildings from production till sampling. However, this assumption also requires that the *pinakes* have been buried or stored in an environment of low potassium, uranium, and thorium concentrations. This would be the case if they had been surrounded by sediments of limestone, marble, organic material, etc. However, the assumption will be invalid if the *pinakes* have been buried among e.g. granite and clay. As the find contexts of these artefacts are unknown, the said assumption regarding the surrounding radiation is based on the scenario considered to be the most likely.

Provenancing results

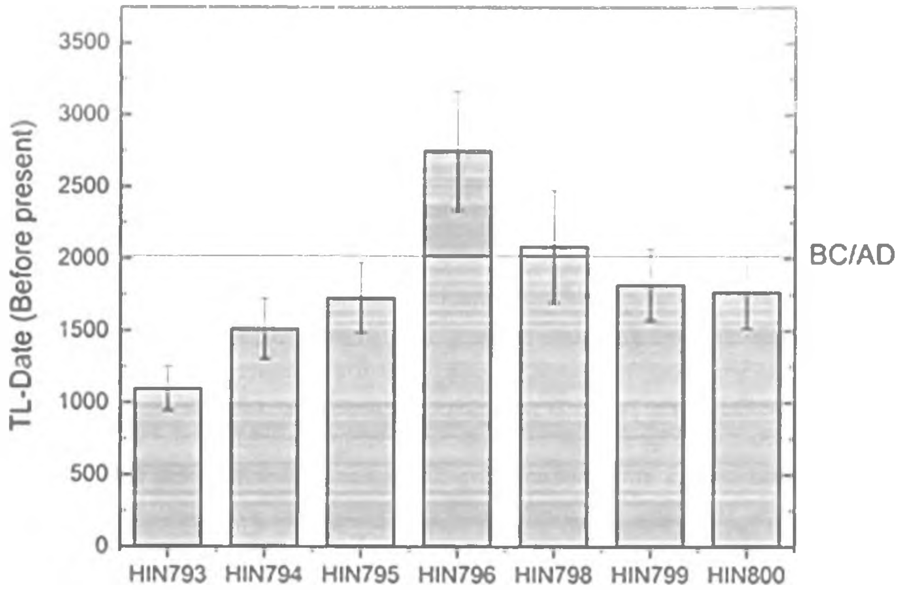
The results of the provenancing in *graph* 5 show that HIN 799 and HIN 800 have a slightly different clay provenance than the rest. It should be noted that the clay provenance is entirely independent from the TL dating results.

[K. L. R.]

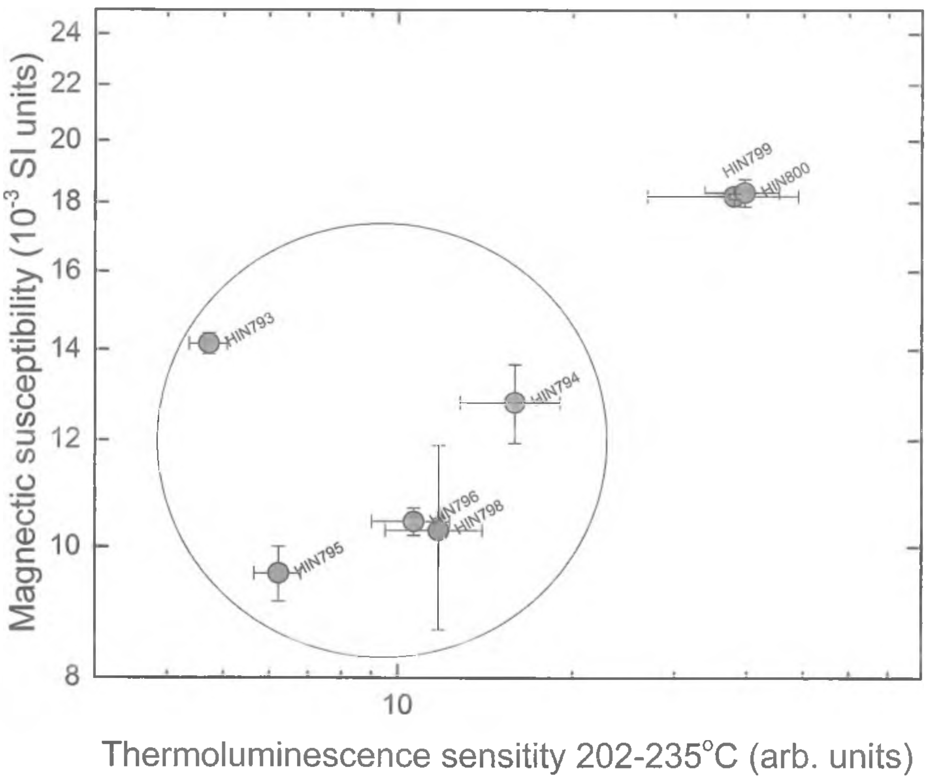
Joint assessment

Assessing the authenticity of the examined *pinakes*, a few other possibilities need to be taken into consideration. Obviously, there are the possibilities of the individual *pinax* being either all genuine or completely fake. Consulting the TL results, it can be concluded that none of the terracotta slabs is of recent manufacture. Furthermore, according to the provenance determination, it is reasonable to assume that they are all made from local clay from the Etruscan region. However, that does not necessarily establish their genuineness as Etruscan artefacts.

The uncertainties concerning the chemical environment of the find spots are reflected in the rather large margins in the TL results, thus permitting dating many centuries after the Etruscan culture had ceased to exist. This calls for an assessment of a possible later date of manufacture for the terracotta slabs. Comparing the suggested dates for HIN 793-795 there is quite a stretch. In fact, HIN 793 and 795 are so far apart that they do not overlap allowing for a common dating of the group. However, the strong, visual resemblance between the three slabs in terms of measurements as well as clay colour and composition suggests more contemporary dates of manufacture. Considering that the dating of each slab is based on a single, susceptible sample, it is therefore quite likely that the rather late dates are caused by contamination. Still, the TL results could suggest an early medieval date of manufacture. However, assessing the iconography and style, the parallels are found in examples from Etruria, ancient Greece, and Rome. Apart from the multiple ground layers on HIN 793-795, there are no other technical traits to suggest a medieval origin. It would appear that this particular type of painted terracotta slabs is a purely Etruscan tradition never adopted by any other culture.



graph 4 - Thermoluminescence (TL) results. The one sigma uncertainties are marked as error bars.



graph 5 - Provenancing results.

Considering the iconography, technical features, as well as the dating and provenancing results, it can be stated with reasonable certainty that HIN 796, 798, 799, and 800 are genuine Etruscan *pinakes*. The group HIN 793-795, however, encompasses too many, too curious dissimilarities to be readily accepted as Etruscan artefacts. As mentioned above, the terracotta slabs appear to fit the profile in terms of age and geography, and are certainly not of recent manufacture. The problems all lie in the painted decoration. In fact, comparing the iconographic and technical observations, these differing artefacts appear to be part ancient, part modern. Thus, we would argue that the ancient terracotta slabs were decorated, broken, and patinated in the 1970s in order to meet the demand of the international art and antiques market. It is interesting to note the measures taken to ensure that the decorated fragments would pass for genuine Etruscan artefacts. Aware that TL dating would reveal recently produced terracotta as fake, ancient, possibly Etruscan, slabs were chosen. The motifs are kept very simple avoiding the iconographic risks of copying existing scenes and constructing new ones. It would seem that the forger has consulted medieval treatises, the most ancient descriptions available, in order to obtain a credible expression. The palette is kept as simple and safe as possible by restricting it to white, black, red, and yellow earth pigments. The fact that the fake *pinakes* were accepted as genuine tells us that they were consistent with the contemporary knowledge of Etruscan art. The intensive research conducted since the late 1970s has granted a more detailed insight into Etruscan pictorial expressions and painting techniques which are much more advanced than hitherto believed. Thus, what gives away the artefacts is a lack of knowledge of iconography and decoration techniques, but also the primitive expression which mirrors a modern attempt to replicate Etruscan artefacts supposing the culture to be more primitive than it was. This study serves to emphasise the importance of including polychromy studies when assessing the authenticity of painted artefacts.

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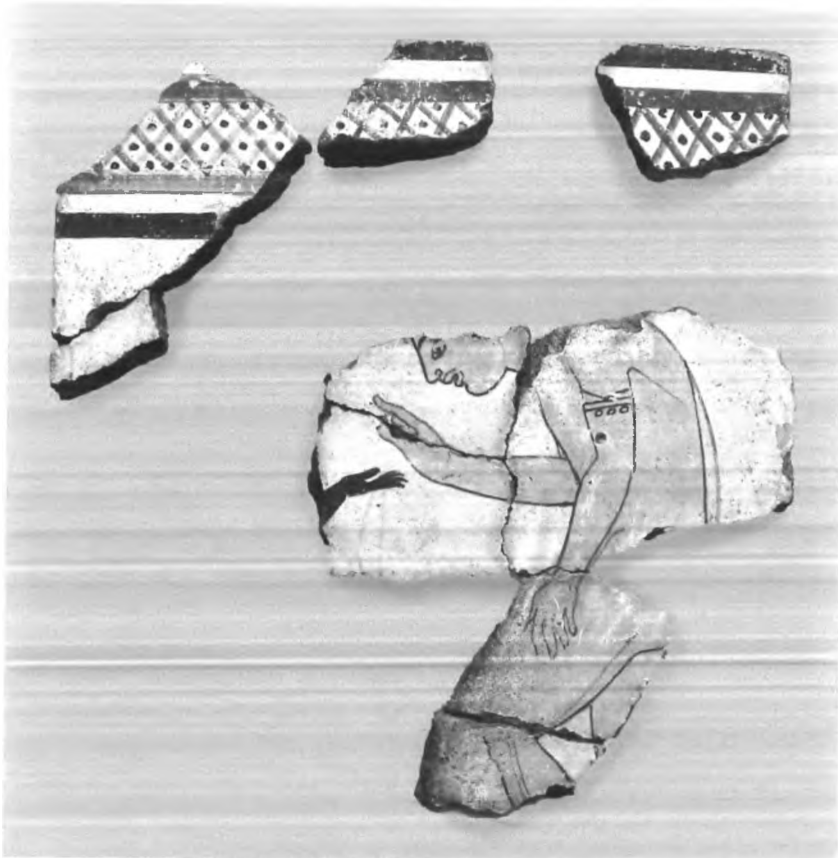
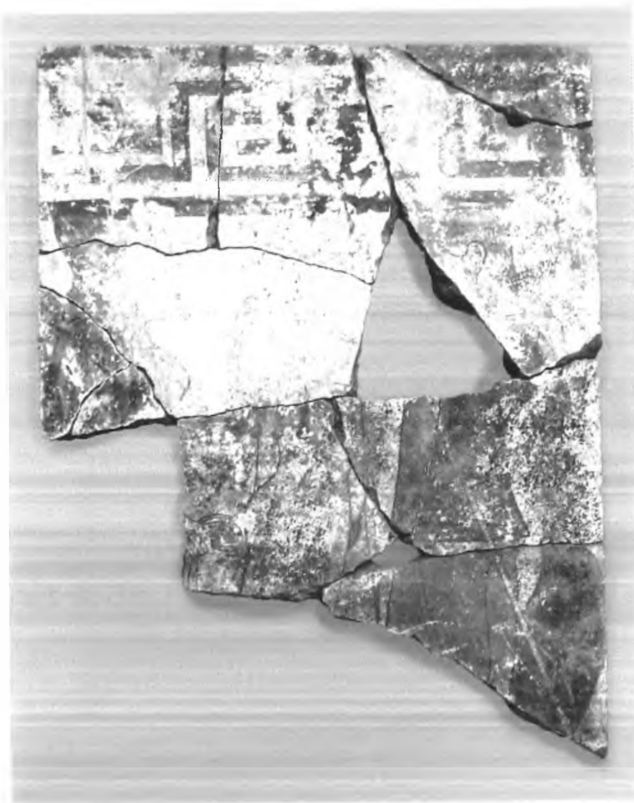


a

b

Copenhagen, Ny Carlsberg Glyptotek. *a)* HIN 794; *b)* HIN 795.

a



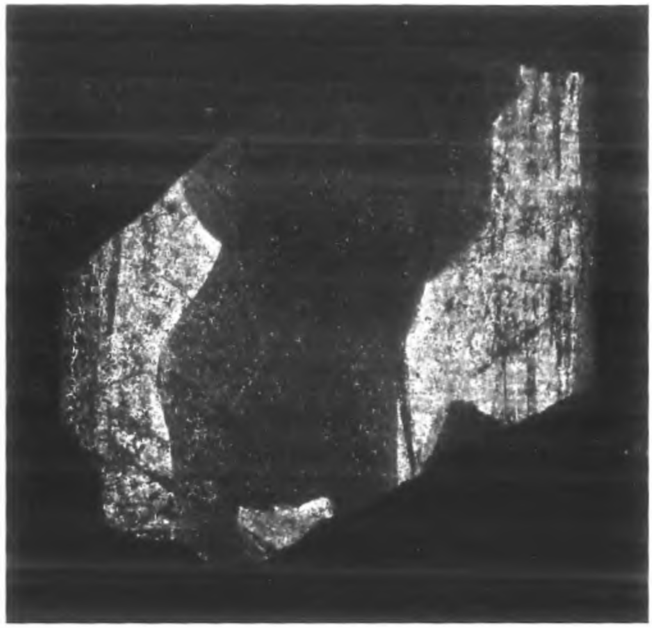
b

Copenhagen, Ny Carlsberg Glyptotek. *a*) HIN 796; *b*) HIN 798.

a

b

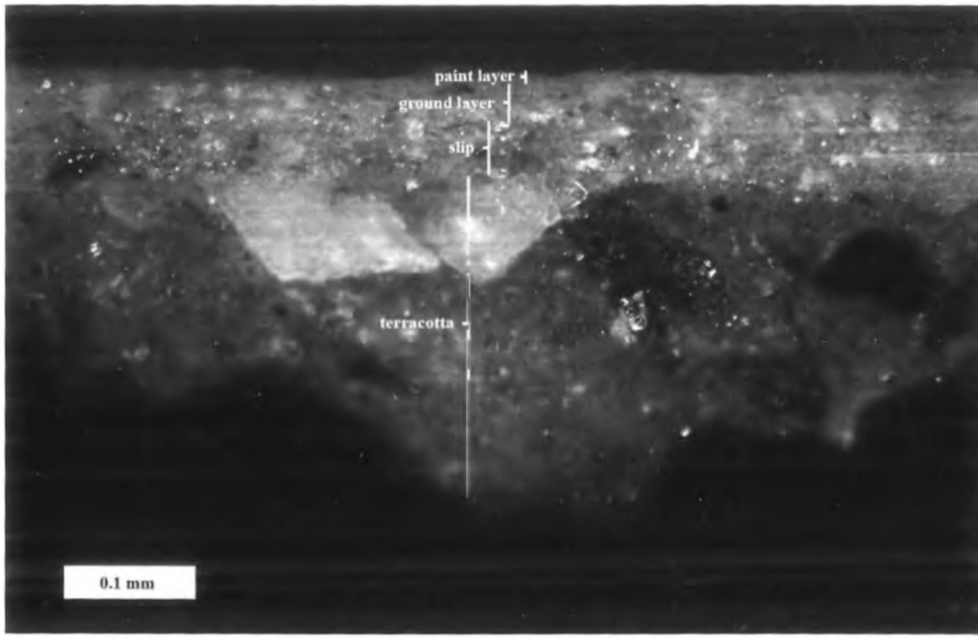
Copenhagen, Ny Carlsberg Glyptotek. *a*) HIN 799; *b*) HIN 800.



a

b

a) Visible-induced luminescence (VIL) image of HIN 799 showing the distribution of Egyptian blue; *b*) Visible-induced luminescence (VIL) image of HIN 800. The concentration of Egyptian blue is quite high in the upper part of the decoration which indicates that the background was painted a vivid sky blue.



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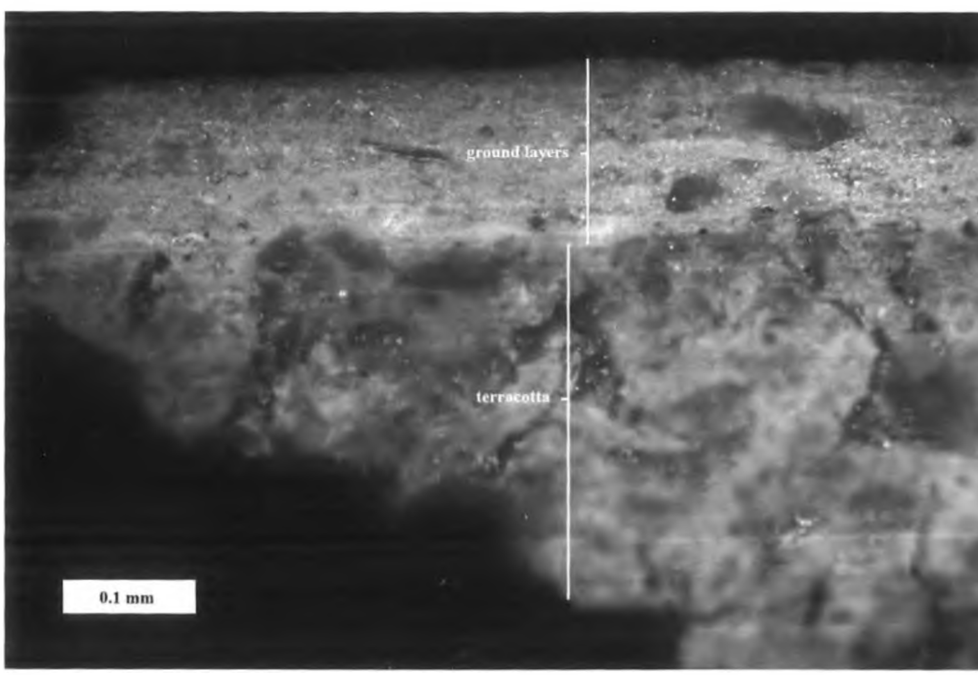

b

a) Micrograph of a cross-section representing the red paint layers on HIN 799. Dark field (DF), original magnification 20×; *b*) Micrograph of a cross-section representing the white background on HIN 794. Dark field (DF), original magnification 20×.