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The grand tour: a multi-analytical journey into the Palmela amphora of Panathenaic shape

O grand tour: uma viagem multianalítica pela ânfora de Palmela de forma Panatenaica

VERA MOITINHO DE ALMEIDA

Centre for Digital Culture and Innovation (CODA) & Transdisciplinary Research Center for Culture, Space and Memory (CITCEM), Faculty of Arts and Humanities of the University of Porto (FLUP), Via Panorâmica s/n, 4150-564 Porto, Portugal

Institute for Systems Engineering and Computers at Coimbra (INESCC), University of Coimbra, Rua Sílvio Lima, Pólo II, 3030-790 Coimbra, Portugal

vmoitinho@letras.up.pt

Abstract

The Greek vase collection of the Duke of Palmela arrived in Portugal around 1834 and included the only (pseudo-)Panathenaic amphora in a Portuguese collection. The European art market was flourishing but so were restorations, copies, and forgeries. After acquiring this vessel, the MNA decided to examine it technically. Authenticity issues were raised by computed tomography imagery and material analysis. Distinct analytical techniques confirmed the modernity of the extensive overlayers. However, recent ultraviolet induced visible fluorescence imaging suggests some areas may be black glass-ceramic – an ancient technique only rediscovered in 1942. In light of the latest evidence, it is argued that further testing will be required to clarify if this is an ancient vessel with extensive overlayers of modern interventions or a completely modern product. The archaeological and historical interest of this vessel renders it of particular value to critically reflect on distinct analytical techniques, restoration practices, and antiques collecting.

KEYWORDS

Authenticity
Black-figure
CT imaging
Forgery
Pottery
UV-induced visible fluorescence imaging

Resumo

A coleção de vasos gregos do Duque de Palmela entrou em Portugal c. 1834. Incluía a única ânfora (pseudo-)panatenaica numa coleção portuguesa. Na Europa florescia o mercado de antiguidades, a par com restauros, cópias e falsificações. Após a sua aquisição, o MNA decidiu examiná-la por tomografia computorizada e análise de materiais, o que levantou questões de autenticidade. Distintas técnicas analíticas confirmaram a modernidade de camadas de pintura. No entanto, imagens recentes de fluorescência visível induzida por ultravioleta sugerem que algumas áreas podem ser vitrocerâmica preta – uma técnica antiga apenas redescoberta em 1942. À luz das evidências mais recentes, argumenta-se que mais testes serão necessários para esclarecer se este é um vaso antigo com extensas camadas de intervenções modernas ou um produto completamente moderno. O interesse arqueológico e histórico deste vaso torna-se de particular relevância para uma reflexão crítica sobre as distintas técnicas analíticas, práticas de restauro e coleções de antiguidades.

PALAVRAS-CHAVE

Autenticidade
Figuras negras
TAC
Falsificação
Cerâmica
Fluorescência visível induzida por radiação ultravioleta

Introduction

The MNA 999.1.1 vessel

According to Rocha Pereira [1], the Greek vase collection of the first Duke of Palmela (Duque de Palmela), Pedro de Sousa Holstein (1781-1850), was originally assembled by his grandfather and father – Manuel de Sousa (1703-1759) and Alexandre de Sousa e Holstein (1751-1803), respectively. While diplomats in Rome and art collectors, they adhered to the growing fashion for ancient cultures and antiquities. At some point, Alexandre even obtained permission to excavate around the roman city of Ariccia, near Rome [2-4]. This was the period of the Grand Tour in the eighteenth and nineteenth centuries. The European art market was flourishing but so were restorations, copies, and forgeries. Amid this activity, the Duke of Palmela's collection arrived in Lisbon around 1834. It comprised eighteen vessels, which included what was thought to be the only Panathenaic amphora in a collection in Portugal, said to have been originally brought from Herculaneum and Pompeii [1]. In May 1998, this amphora, together with a lid, was eventually bought by the Portuguese National Museum of Archaeology (MNA), in Lisbon – it was given the inventory number 999.1.1 and from now on is referred to as MNA 999.1.1 (BAPD 9023288 [5]) (Figure 1 and Figure 4).

The Palmela collection was studied by Rocha Pereira [1] (repeated in all her subsequent publications [6-8]), who described this amphora as being a pseudo-Panathenaic one. Bentz [9, p. 188] and Morais [10] also published studies on this amphora. The description of this black-figured vessel has so far not been reported in much detail. A stylistic analysis of ornamentation, shape, and iconography led Morais [10] to date the vessel from between 550 and 475 BCE, and tentatively attribute it to the Leagros Group. According to Rocha Pereira [1], the lid seemed to belong to the vessel.

In 2018, the MNA decided to technically examine MNA 999.1.1 in order to draw up a conservation and restoration treatment plan for it. The pseudo-Panathenaic amphora was being promoted – it would soon leave the museum's depot to at last be exhibited to the public. Micro-samples of some of the materials were analysed at Hercules Laboratory, University of Évora, under optical microscopy (OM), micro-Fourier transform interferometer (μ-FTIR), and scanning electron microscopy and energy dispersive x-ray spectroscopy (SEM-EDS), although the analysis resulted in an incomplete report. In 2019, an x-ray examination through computed tomography (CT) scan was undertaken at IMI-art/Affidea, in Lisbon, to determine its integrity. For the first time, authenticity issues were raised both by CT imagery and material/elemental analysis. But internal issues at the museum's collections department halted the initial plan.

In early 2021, Prates and I gathered all the available data on MNA 999.1.1 and set up a small team to proceed with further investigations (for details see [11]). This included a fine analysis of specific morphological features, forming techniques, and painted layers through CT imagery. It is worth mentioning that, to our knowledge, this was the first study to use the CT radiodensity of surface painted layers to help investigate the authenticity of a Greek vessel. To determine the antiquity of the ceramic clay, dosimetry by luminescence semiquantitative protocols and mineralogical analyses by x-ray-diffraction were undertaken at Center for Nuclear Sciences and Technologies (C2TN-IST), University of Lisbon. The results dated the ceramic paste to a maximum of 1000 years, indicating it was not an ancient Greek vessel. However, it is relevant to note that the quartz from the samples was in poor condition and did not have enough absorbed dose (information reported at team meeting, 2021/06/15), while some alteration of the original luminescence signal could be related to the CT imaging process.

More recently, a new visual inspection was carried out to analyse distinct surface features, followed by ultraviolet (UV) induced visible fluorescence imaging to further investigate non-destructively colours and materials. These new findings raise the following question about the antiquity of the vessel: "Is MNA 999.1.1 an ancient vessel with extensive overlayers of modern interventions" or "is it a completely modern product?"

To answer this question, it is important to examine the full picture. The focus of this article is on the findings of direct relevance to the authenticity of MNA 999.1.1 vessel, with an emphasis on Vis, UV, and CT imagery. Furthermore, this investigation intends to shed light on nineteenth-century restoration practices, materials, and techniques, as well as the current interest in and demand for Mediterranean antiquities [12-15]. Thus, let us dare to further examine it.

Panathenaic amphorae

The Greater Panathenaia (Παναθηναια), a state religious festival, honoured Athena Polias, the patron goddess of Athens. While the Lesser Panathenaia was an annual event, the Greater was an extended and more magnificent event held once every four years, between the sixth century BCE and the third century CE, which included musical, gymnastic, and equestrian contests.

Large ceramic vessels containing olive oil from the sacred grove of Athena at Akademia were given as prizes in the Panathenaic Games. The *amphoreis Panathênaïkoi*, that is to say, the Panathenaic amphorae, could be highly valued as lasting symbols of mastery and excellence. Only workshops which had the capacity to produce a large number of vessels by leading potters and painters were awarded such highly lucrative contracts. These vessels had a distinctive form with broad body, narrow neck, and a small echinus foot. They received standard composition and decoration by talented vase-artists, usually depicting Athena *Promachos* advancing between columns, holding a shield, and brandishing a spear. Along one of the columns, the official inscription ΤΟΝΑΘΕΝΕΘΕΝΑΘΛΟΝ – i.e., *ton athenethen athlon*, meaning "One of the prizes from Athens" – is written. Later, in distinct periods, the archon's name or those of the treasurers and stewards of the games would be written too. The other side of the vessel would depict the event for which it was a prize.

Pseudo-Panathenaic amphorae – meaning, not prize amphorae but non-official imitations of the Panathenaic amphorae [16] – were produced in ancient times as well. They may have been used to commemorate a victory in a smaller contest, as an object of trade, or even as a souvenir.

Over the centuries, the Panathenaic amphorae have been much prized. As with other Greek vase types, they have been often heavily restored, replicated, and at times forged.

Primary forming techniques

The Panathenaic amphora is a special type of amphora shape. These vessels were not continuously curve (i.e., one piece) but were made in separate sections: neck/mouth, body – typically in one part, though Schreiber [17, pp. 85-86] identified a midsection join in a sherd indicating two parts – one foot, and two handles. All sections were wheel thrown, except for the handles which were made from coiled clay and then curved to the desired shape. When the clay was fairly firm but still mouldable, sections were joined by cementing them with slip at the neck/shoulder and at the body/foot. Handles were joined to the neck and shoulder, on opposite sides, also cemented with slip.

Likewise, lids were wheel thrown, made as separate pieces, fitted to measure, joined by cementing them with slip, and then turned. The lid itself was thrown upside down as an almost flat dish. It had a raised circular flange to fit inside the vessel's mouth, to keep it still and prevent the contents from spilling, and to seal the vessel. Knob handles could be thrown as solid pieces or made hollow – typical forms were the pomegranate and pine cone. According to Noble [18, p. 33], the lid was made "at the same time as the amphora so that it could be given a proper fit (…). During drying, the lid was left on the vase so it would shrink uniformly with the vase".

Black-figure technique

The Panathenaic amphorae were decorated exclusively with the black-figure technique, even long after the black-figure style had fallen out of fashion. The figures were initially painted on

unfired, leather-dry vases with a clay slurry (i.e., a thick slip made from mixing a refined version of the throwing clay with illitic clay), which turned to black glass-ceramic (BGc) [19] after firing. Unpainted areas were left to provide a background for further decoration. Both black and red paint were made of iron oxide, with the black having the addition of illitic clay enriched with iron oxide particles. Outlines and details were incised into the slip before firing, allowing the underlying clay to be seen through the scratches. Details – such as women's skin, hair, clothing, accessories, and ornaments – were often reinforced and highlighted with white (made from pure clay with the minimum amount of iron oxide) and red/purple colours. As Sparkes [20, p. 16] once provocatively described this style: "black men, white women, no spatial depth, one ground line, all foreground".

After painting, the vase was fired in a kiln in a complex three-stage firing process. The first firing was at a temperature of about 800 °C, in oxidising conditions. The clay and slip would fire red (iron oxide in the form of hematite or maghemite). Next, the temperature of the kiln was raised to about 950 °C for a very short time, in reducing conditions (oxygen removed; carbon-rich environment) [21]. The clay and slip would turn black (as the illite clays vitrified and the iron oxides changed to black magnetite or hercynite, and some soot was absorbed). The slip, now sealed from the oxygen, would become glossy black by vitrification thus resistant to any further changes. Finally, the vents of the kiln were re-opened to lower the temperature, and the oxidising condition was restored. Once more, the renewed oxidisation would turn the unpainted areas reddish-orange (as the iron oxides changed to red hematite), but the slip-covered areas would remain BGc. The entire process lasted approximately 6 to 10 hours and required great precision and skill from the craftspeople.

Methods

CT imaging

In cultural heritage research, there is a body of scientific literature on the use of x-rays to investigate ancient Greek pottery. In particular, x-rays are used to document the internal and external geometries of vessels, as well as their joints, fissures and fractures, ceramic paste structure, forming techniques, and restorations [11, 21-25]. Occasionally, forgeries have been detected through x-rays.

As mentioned before, MNA 999.1.1 was imaged by CT scan in 2019 at IMI-art/Affidea, in Lisbon (Siemens Somatom Definition AS 128, spiral tomography; 100 kV, 400 mA; 1330 slices, 6 mm thickness with 50 % reconstruction overlap, 0.35 pitch, square matrix 512 × 512 pixels [11]). To further test the CT radiodensity of surface painted layers, six black-figured fragments (of which three belonged to the same object) from Alcácer do Sal, stored at MNA, were CT scanned in 2021, following the same protocol (for details see [11]). The radiodensity of a material is measured by the amount of x-rays that pass through it. The greater the radiodensity of a material (i.e., the higher its atomic mass), the fewer x-rays pass through it. Radiodensity is represented in greyscale images and quantified in Hounsfield units (HU) – on a scale with 4096 values (12 bit), ranging from -1024 HU to 3071 HU, where (at standard pressure and temperature) -1000 HU is air and 0 HU is distilled water.

3D Slicer v4.11.0 software [26-27] was used for 3D reconstruction from multiple slice images, segmentation, and separation of the clay paste. Geomagic Wrap 2017 software (3D Systems) was used for post processing the 3D data and computing distinct measurements [26, 29]. ODEEG App Package software [30] was used to automatically calculate the maximum filling volume and to generate cross-section scientific illustrations.

UV and Vis imaging

Ultraviolet (UV) and visible (Vis) imaging techniques are widely used in cultural heritage research. The fact that many materials absorb invisible UV rays and re-emit light in the visible

spectrum enables them to be detected by the colours of UV light. UV-induced visible fluorescence and new Vis imaging were carried out at the National Museum of Archaeology, using an X-Rite ColorChecker (a standard colour reference target for camera calibration). The main features of the UV imaging system consisted of a near UV wavelength (365 nm) lamp, and a Canon EOS 550D camera, coupled with an AF-S Canon 18-135 mm f/3.5 lens and a Hama UV 0 filter.

All the aforementioned techniques have been used for several years and have provided valuable information for pottery studies.

Analysis and results

Shape and forming technique

Vessel

MNA 999.1.1 is a terracotta amphora of Panathenaic shape (Figure 1). It has an ovoid body, short neck, echinus mouth and foot, and almost cylindrical handles. Unlike neck-amphorae, the curve of the shape does not change radically between the neck and the shoulder. The wall thickness of the vessel is asymmetrical and uneven [11]. Table 1 displays some basic measurements of the vessel and the lid.

Figure 1. MNA 999.1.1 vessel views: *a)* obverse; *b)* left; *c)* reverse; *d)* right; *e)* top; *f)* bottom.

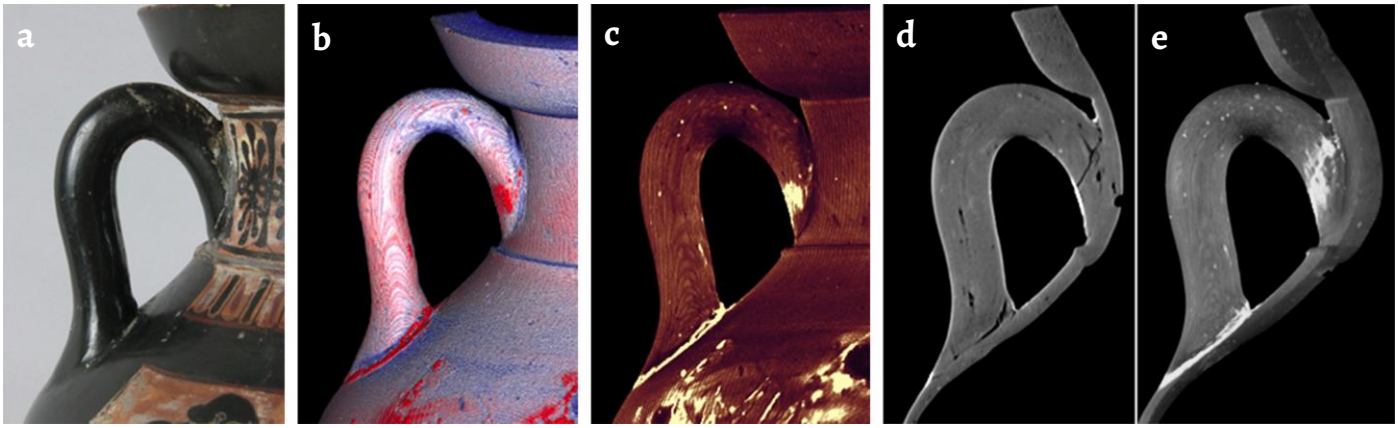

Figure 2. MNA 999.1.1 vessel, left handle (viewed from reverse): *a)* photograph of the black painted surface showing no visible signs of the restored fissures. CT imagery showing a material of high radiodensity added superficially to the upper oblique fissure and to the handle/shoulder joint fissure: *b)* 3D volume rendering; *c)* 3D cropped reconstruction; *d)* multiplanar reconstruction (MPR) sagittal view; *e)* maximum intensity projection (MIP) view (CT images: IMI-art/Affidea).

A close visual inspection of the surface of the vessel, confirmed by CT imagery, shows no clear evidence of any major fragmentation [11]. However, CT data reveals that a material of high radiodensity (possibly plaster) has been added beneath the visible black paint to repair some fissures in the left handle and at the handle and shoulder joints (Figure 2).

A few voids have a solid inclusion at their centre. The possibility of mineral aggregates or secondary mineral phases completely filling pristine pores during complex post-depositional transformations should not be ignored, as these may be wrongly identified as original inclusions [31]. Such inclusions can be intrinsic to the clay or added as temper. Likewise, some pores may in fact be negative interfaces, originating from the dissolution of the minerals forming the inclusions or from clay temper materials, such as the organic fibres which are burnt during the firing process. A comprehensive analysis of the clay fabric – to characterise its contents and distinguish original pores from negative interfaces (original or post-depositional) – is beyond the scope of this article so I use the generic term void.

Prates et al. [11] clearly demonstrate the following characteristics of this vessel: it was mainly wheel thrown; it is not a continuous-curve vessel; the neck/mouth, body, foot, and handles were separately made in sections that were joined by cementation with slip at the neck/shoulder, body/foot; and the handles were joined to the neck and shoulder on opposite sides. Some fissural air remnants can be still detected, especially at the joins between body/foot, handles/shoulder, and handles/neck. The primary forming technique was confirmed by: (1) the spiral pattern of ridges and grooves up and around the walls of the body, formed as the potter's fingers pulled the clay on the wheel; (2) the oblique orientation of elongated inclusions and voids in the clay paste/matrix; (3) and the orientation of inclusions and voids parallel to the walls (Figure 3). The oblique orientation and elongated shapes are characteristic of pulling the clay on a fast wheel [23]. The relatively narrow neck prevented the potter from removing the primary forming marks from the internal surface (which is not visible to the user). As for the handles, the elongated voids are centrally aligned and the orientation of inclusions and voids run parallel to the walls, clearly confirming that both were made from coiled clay and then curved.

Table 1. Basic measurements of MNA 999.1.1, from CT-derived 3D model. Note that the centre of the coordinate system is set at the centre of the 3D model's base. Weight of the physical vessel; Width refers to the maximum left-right distance (Figure 1b, Figure 1d) and length to the maximum reverse-obverse distance (Figure 1a and Figure 1c), while capacity refers to the maximum filling volume without dropping.

	Weight (g)	**Width/length** (mm)	**Height** (mm)	**Mesh volume** (mm^3)	**Max. filling height** (mm)	**Capacity** (cm^3)	**Mouth / lid diameter** (mm)	
							internal	**external**
Vessel	2678.7	233.3/234.2	361.9	1662539.4	357.2	6171.6	117.5	149.5
Lid	151.7	-	-	-	-	-	115.2	143.6

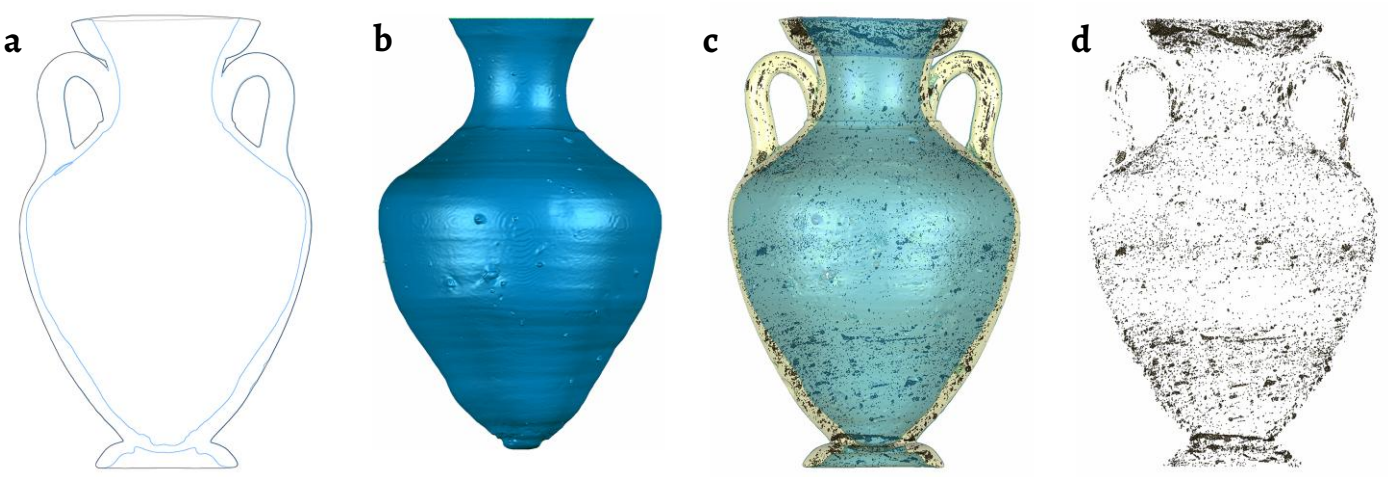

Figure 3. MNA 999.1.1 vessel: *a)* cross-section illustration automatically generated from the CT data, outer (black line) and inner (blue line) surfaces; *b)* 3D inner surface showing wheel marks (spiral pattern of ridges and grooves up and around the walls); *c)* 3D front view with transparency exhibiting voids (dark grey) in the clay fabric; *d)* voids in the clay fabric.

Lid

The lid (Figure 4 and Figure 5) has a circular shape, is almost flat, and has a hollow knob handle in a characteristic pomegranate shape. Underneath, a raised circular flange allows it to fit inside the vessel mouth to keep the vessel sealed and stop the contents spilling. In contrast to the vessel, the accompanying lid is considerably fragmented (for details on its state of preservation see [11]). The only mention of the lid in IPPAR's report nº 83 [32] notes that it had been glued with a cellulosic adhesive before its arrival at the museum. The CT imagery seems to confirm once again wheel throwing as the primary forming technique. The knob was made separately and cemented into place. The UV light revealed modern interventions that were not previously detected with the naked eye, such as repainted areas and other marks; black fluorescing filler used to fasten the sherds together; and modern overpaint and/or varnish fluorescing in a milky brownish-yellow tone, with some areas showing large brushstrokes.

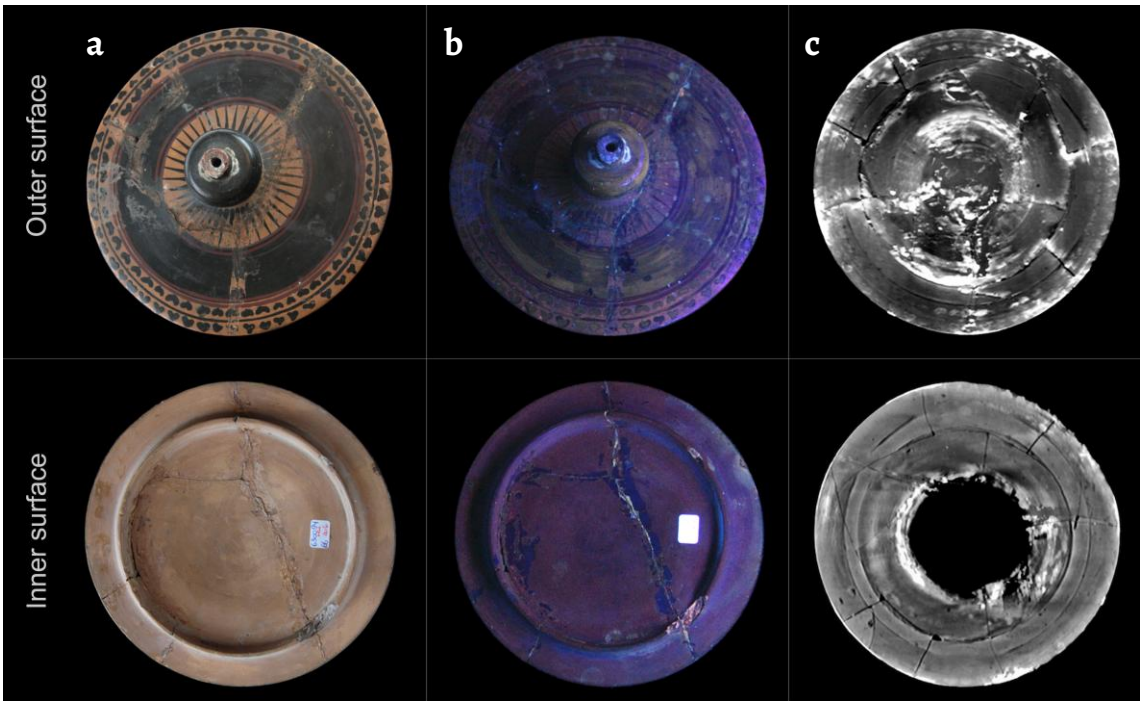

Figure 4. MNA 999.1.1 lid: outer (top) and inner (bottom) surfaces: *a)* visible; *b)* ultraviolet-induced visible fluorescence; *c)* computed tomography imagery (CT images: IMI-art/Affidea).

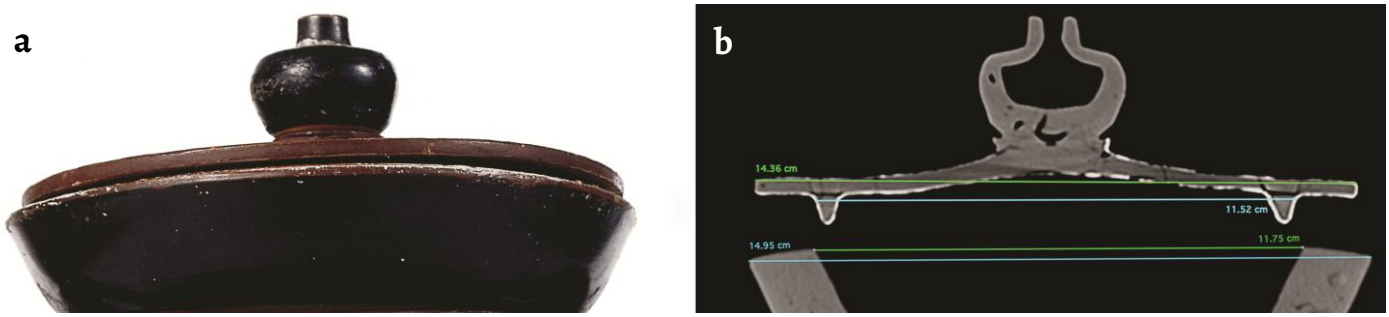

Figure 5. MNA 999.1.1 vessel mouth and lid: *a)* visible; *b)* computed tomography imagery showing how the lid fits onto the mouth of the vessel (CT image: IMI-art/Affidea).

As to whether the vessel and lid match, the geometrical features, acquired by CT scan, do not seem to match [11] (Figure 5): the lid does not entirely cover the upper surface of the vessel; the inner and outer diameters of the lid and vessel do not entirely fit (Table 1); and the horizontal edge of the lid does not completely fit the vessel's rim, which is tilted outwards. There is also a difference in the angle of the mouth's inner surface and the corresponding surface of the lid's flange, which prevents the lid from having a secure fit.

Surface decoration

Vessel

Designs black on red panels with incised and painted lines, with highlights in white and red (Figure 1). On side A (obverse), the panel continues up into the neck of the vase; on side B (reverse), the panel is separated from the neck of the vase by a black border. The neck has a double honeysuckle pattern, with a protruding ring and an alternating purple and black elongated tongue-pattern below. On the lower part of the body, there are two thin red bands on each edge of a broad black band, followed by a standard radiating elongated black pattern (of rays or leaves, perhaps) with a red band below. The outside of the foot is black, ending with a thin red band. A black band lines the inner surface of the mouth.

Side A depicts Athena *Promachos* (in the frontline of battle), in the typical striding, militant pose of the prize Panathenaic amphorae. She has a high-crested helmet that overlaps the tongues on the neck of the vessel with a tress or lock of hair over her shoulder. She wears an *aegis* covered with a vertical dot-pattern, with a snake-border on the back only, and a long *peplos*, belted at the waist. The *peplos* is patterned with small triplets of white spots and its folds are indicated by two broad bands down the centre and along the bottom with a wavy-pattern between the straight lines. She is short and stout; one foot is set forward and almost flat on the ground while the other is drawn back, heel raised. She wears a shield on one arm, with a central white drawing – it could be a *ketos* head [1], medusa, octopus, or lion head – and red spots on the antyx (border). The other arm is drawn back brandishing a spear. She is standing to the left, between two Doric columns.

Side B depicts a wrestling scene. In the middle, two nude red-bearded athletes engage in pankration (a combination of wrestling and boxing). The athlete on the left has his head covered by his opponent's head. To the left of the athletes, a red-bearded *brabeus* (adjudicator) stands watching; he is wrapped in his *himation*, which is decorated with small red spots, and holds a staff in one hand and three long stems in the other. On the right, a *paidotribes* (trainer) or *ephedros* (an odd contestant with a bye to the next round) looks on; he appears nude and beardless, with his right arm slightly raised and left hand on his hip. On the wall hangs a garment with folds depicted, and a pattern of small red spots and triplets of white spots. According to Rocha Pereira [1], this is quite a common scene on the back of Panathenaic amphorae.

The state of conservation of the vessel is generically and briefly described in IPPAR's report nº 83 [32], right after its arrival at the museum. The vessel was then "cleaned superficially (less

adherent crusts removed) with cotton swabs soaked in ionised water and scalpel, under a binocular magnifier" (author's translation from the original Portuguese).

Figure 1, Figure 6, Figure 7 and Figure 8 show that overall, the figures and pictorial decoration of the vessel are not finely executed, revealing less technical and artistic skill than expected from leading vase painters. Most incisions are rather crudely drawn. Some details on the wrestlers' legs are not incised but painted over with thin coloured clay lines. The shield decoration is coarse, and its interpretation is not straightforward. Athena's *aegis* is covered with an incised vertical dot pattern, instead of the usual scales. The skin of her arm is painted in white over a black silhouette, instead of inside contour lines. The capitals of the Doric columns are too high so there is not enough space to depict anything on top – cockerels are often shown on top of the columns, or other figures resembling statues. Moreover, neither column presents the standard inscription ΤΟΝΑΘΕΝΕΘΕΝΑΘΛΟΝ, as one would expect from an official Panathenaic amphora – though one should be cautious about concluding too much from this as inscriptions were sometimes added later [33]. The inner surface of the mouth is decorated with a black band, although BGc would be unnecessary for a lidded vessel.

A significant number of surface losses and paint delamination (i.e., flaking) can be visually observed. Most pits are spread over the external surface of the vessel, especially on the decorated panels, and suggest a mechanical procedure of indeterminate cause; in some cases it is not possible to rule out intentionality. The faces of Athena and the *paidotribes* (or *ephedros*) are entirely damaged; the face of the wrestler on the right-hand side of the panel is partially damaged, while the *brabeus*' face is fully preserved. Delamination has occurred on the body of the vessel, predominantly to what one would expect to be the natural (i.e., ancient) reddish colour of the clay, but on the black surface too. Delamination is an evident sign of modern intervention, as originally these colours were not painted, but obtained through the black-figure technique (see section "Black-figure technique").

The UV light enabled to detect certain materials and to visually differentiate surface areas (Figure 4, Figure 7 and Figure 8). As a reminder, the two main colours in the black-figure technique were obtained as follows: the reddish colour of the clay was made from iron oxide, and black from iron oxide and illitic clay. White was obtained from pure clay with the minimum amount of iron oxide. These (ancient) coloured surfaces and ceramic clay should appear dark under the UV light, without any fluorescence. Indeed, some black areas, such as the honeysuckle pattern on the neck and the black elongated-tongue pattern underneath, do not fluoresce at all. However, other black areas (e.g., mouth, rim, handles, sides of the body) fluoresce in a milky brownish-yellow tone and large brushstrokes become visible, suggesting modern overpainting and varnishing. Conversely, the white paint on Athena's skin (hydrocerussite, lead white) is highly fluorescent; the surface losses have been filled with modern plaster, which fluoresces here in rose tones, and shellac, which fluoresces in orange or yellow tones [34]. Shellac is a resin of animal origin that was commonly used in nineteenth century restorations as a filler, adhesive or varnish; it is brittle and deteriorates over time. The surface patina fluoresces too, but in greyish-green tones. Surprisingly, this patina is not natural and only seems to occur on the external surface of the vessel, which is visible to the user. It was actually produced with several materials and pigments, including Prussian blue and lead(II)-chromate (chrome yellow), in an attempt to give the appearance of ancient burial deposits and calcareous or salt-like crusts. However, some stains and marks may in fact indicate real surface damage, some of which may result from the ageing properties of the shellac used in modern retouching [12] or the *aqua forte* (nitric acid) used for cleaning ceramics [14, 35]. In contrast to the inner surface of the vessel, which seems better preserved (see supplementary material [36]), crusts run over at the external surface onto the decorated sections and pits.

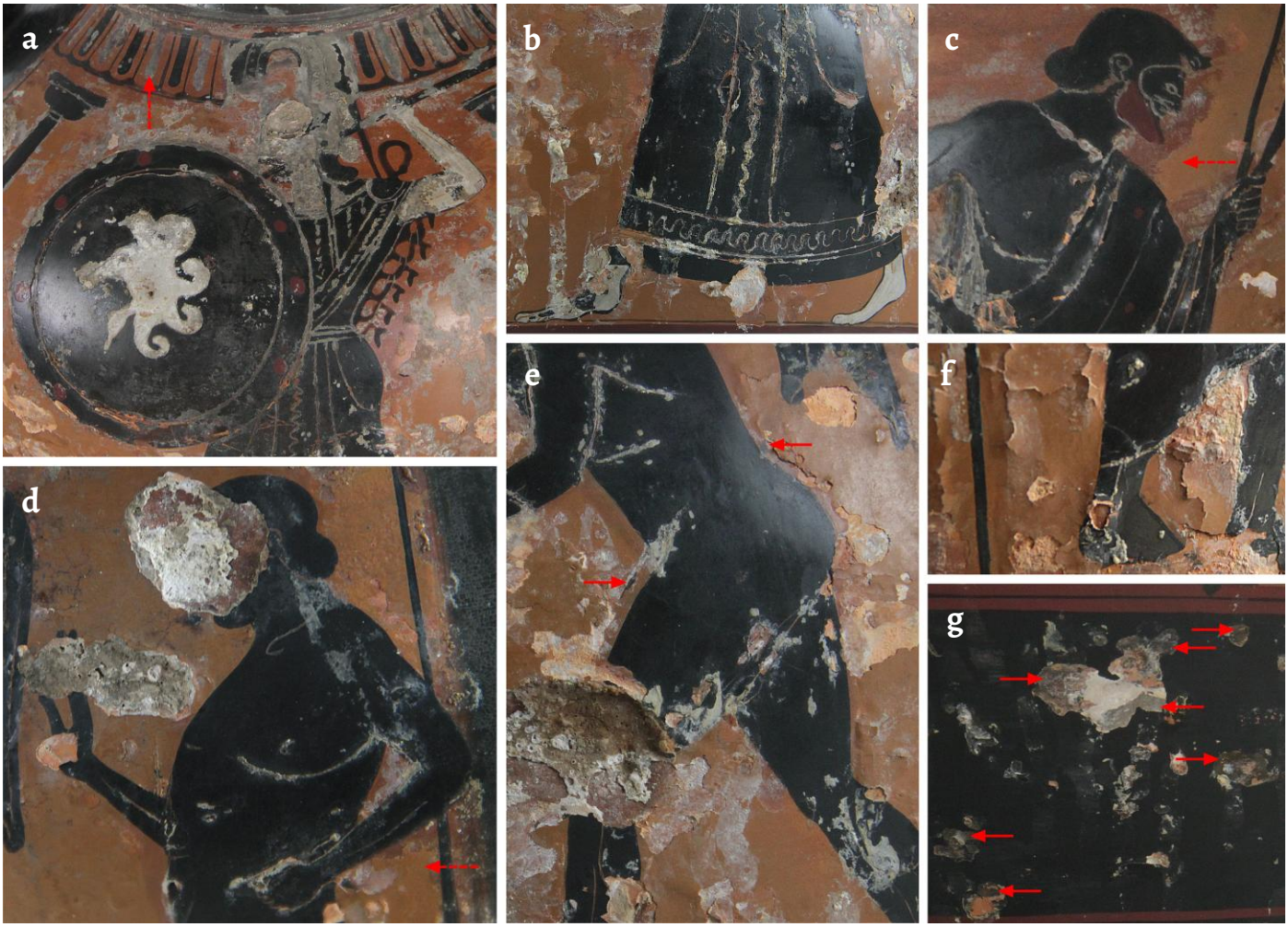

Figure 6. Details of the vessel illustrating figures and pictorial decoration not finely executed, surface losses, under (red arrows) and overpaint (dashed red arrows), and paint delamination. Side A panel: *a)* Athena's head and helmet damaged, *aegis* without the usual scales, arm painted in white over a black silhouette, coarse decorated shield, and capitals of the columns ending too high; *b)* Athena's *peplos* with crude incisions. Side B panel: *c)* overpainted background around the *brabeus*; *d) Paidotribes*' (or *ephedros*) right hand disproportionate; *e)* wrestler with crude incisions and overpainted details; *f)* paint delamination on and around the *brabeus*' feet. Lower part of the body: *g)* paint delamination revealing black colour underneath.

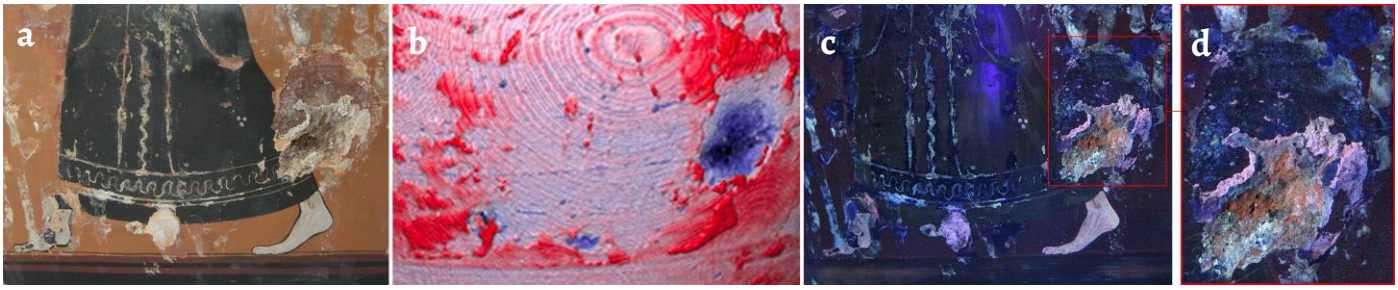

Figure 7. Side A panel, detail of Athena's feet and *aegis*: *a)* under visible light; *b)* CT 3D volume rendering showing a material of high radiodensity added superficially (in red); *c)* UV-light showing white paint on skin, *peplos* fluorescing in orange tones, and modern materials fluorescing in distinct colours; *d)* detail of pit filled with modern materials. The exposure, gamma correction, and sharpness of the UV images have been adjusted for higher readability of some features (CT image: IMI-art/Affidea).

The CT scan undoubtedly detected surface losses and fissures, while revealing large areas covered with a material of high radiodensity (plaster, possibly to smooth over surface irregularities) and overpainted layers – which may represent "severe limitations on the CT analysis of any underneath ancient Greek paint, like the black-figure technique" [11, p. 266]. In contrast, the experimental study carried out by Prates et al. [11] on a small set of fragments from Alcácer do Sal indicated that: (a) fired iron oxide has low radiodensity; and (b) the thin slip layers, difficult to access due to the curved shape of the clay wall, can go easily undetected by CT scan.

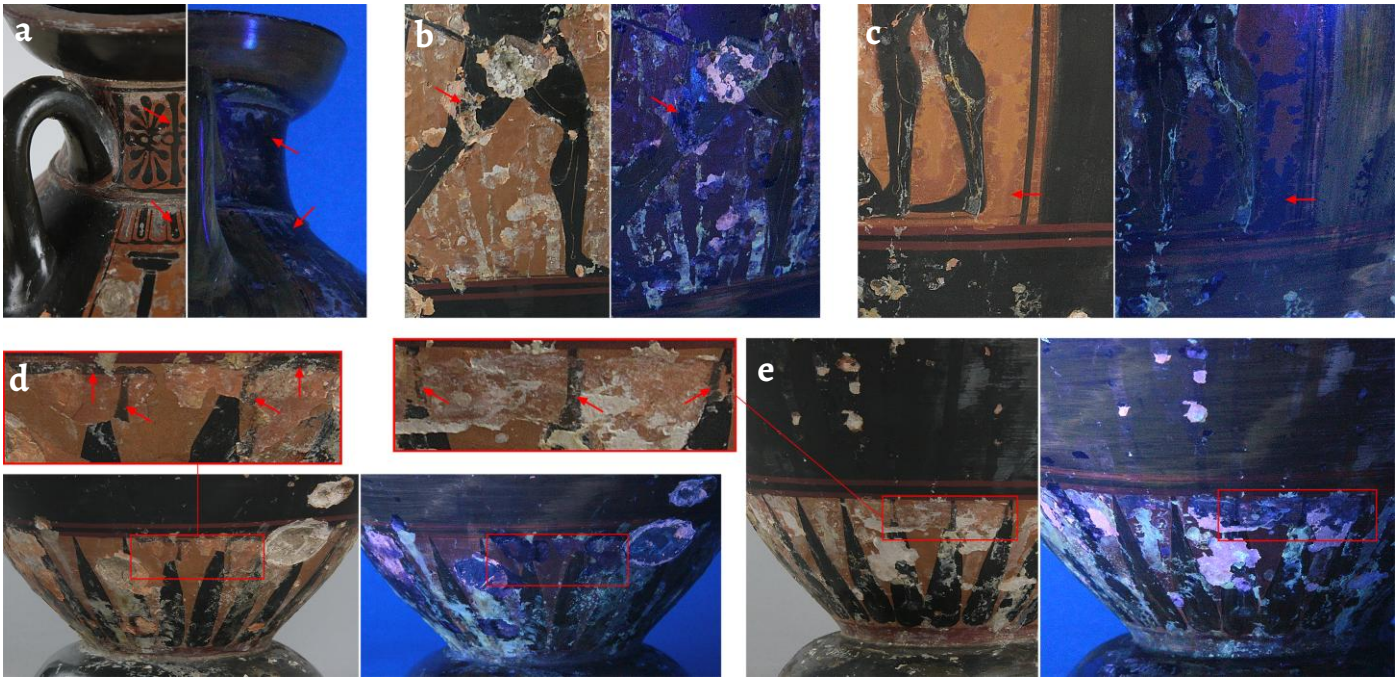

Figure 8. Vis and UV imagery details revealing at least two distinct painting interventions: *a)* the honeysuckle pattern and clay on the neck and the black elongated tongue pattern below appear dark under the UV light, without any fluorescence (red arrows), while other black areas (e.g., rim, handles, sides) fluoresce in a milky brownish-yellow tone with visible brushstrokes. Side B panel: *b)* black colour beneath the wrestler's leg; *c)* overpainted background around the *Paidotribes* (or *ephedros*). Lower part of the body: *d-e)* details showing modern painted layers with a similar pattern underneath. The exposure, gamma correction, and sharpness of the UV images have been adjusted for higher readability of some features.

Surprisingly, some details on the lower part of the body reveal a modern painted layer atop another painted layer – which could be original, ancient or modern – with similar painted motifs (Figure 6 and Figure 8). A few details on the side B panel and elsewhere also indicate similar colours beneath. These unexpected findings are also supported by UV imagery analysis, and to some extent by CT radiodensity data. This means that the coloured layer beneath did not fluoresce under UV light and went undetected by CT scan.

Lid

The outer surface of the lid is entirely decorated with concentric patterns and coloured bands (Figure 4). It has a black knob with a red band below, followed by a pattern of radiating elongated black shapes (possibly rays or leaves), and two thin red bands on each edge of a broad black band. On the border, there is black ivy with a stem but without petioles. It has a red edge.

The lid is overpainted and varnished, as confirmed by UV and CT imagery. It also has thick crusts over the black sections and the fragmented surfaces of the knob while thinner crusts (which may have been partially removed during restoration work) have spread over the top of the lid. The inner surface of the lid is neither decorated nor exhibits crusts.

Discussion and conclusions

So, returning to the initial question: "Is MNA 999.1.1 an ancient vessel with extensive overlayers of modern interventions" or "is it a completely modern product?"

In short, it is possible to confirm with confidence that this vessel has extensive overlayers of modern interventions – these results are in line with Prates et al. [11]. However, in light of the latest evidence, which leads to a reassessment, I cannot confirm with confidence that it is a completely modern vessel, as I discuss next.

Dimensions and integrity

The size of this vessel is interesting, 361.9 mm high (Table 1): it is smaller than the usual prize-amphorae from the Panathenaic Games, but smaller versions of prize-amphorae do exist [18, 37] – and this vessel could fall into the lower range of the group of pseudo-Panathenaic amphorae (36-46 cm) [9, p. 113]. So it could be an ancient pseudo-Panathenaic amphora [1, 9-10] or a completely modern product dated to a maximum of 1000 years ago [11]. In view of this, I propose that MNA 999.1.1 should instead be referred to as a terracotta "amphora of Panathenaic shape".

Concerning the integrity of MNA 999.1.1, the CT imagery shows two very distinct conditions: overall, the vessel is in a non-fragmented state of conservation, but there is extensive fragmentation of the lid. Complete ancient Greek vessels do exist and the state of this vessel could be explained by having been kept in a well-preserved context (e.g., a sanctuary or funerary). Lids are prone to breakage or loss, and the black band lining the inner surface of the vessel's mouth may suggest that it originally had no lid [17]. The UV fluorescence of this black band may not be enough *per se* to cast doubt on the antiquity of the vessel, as it may merely indicate a simple overpaint or a decorative innovation. Nonetheless, the significant geometrical differences between the amphora mouth and the lid suggest that they may not belong to each other [11, 18] – it is also conceivable that, in antiquity, a lid that did not fit exactly could be intentionally placed on the vase, so long as it fulfilled its function. Although mineralogical-petrographic analysis would help to determine if the vessel and the lid are made from the same or distinct clays, I doubt this merits further study.

Surface layers

It is hardly surprising that the authenticity of the extensive overpainted pictorial layer went unnoticed by scholars for so long. Delamination is a clear sign of modern intervention, as originally the colours were not exactly painted but obtained through the black-figure technique (see section "Black-figure technique"). The extensive surface delamination, supported by UV-induced visible fluorescence and CT radiodensity data, immediately confirmed the presence of modern heavily painted overlayers rather than small occasional retouches. Filling surface losses with plaster and extensive repainting on a plaster ground (to smooth the surface) were common in the 19th century [38–39]. Likewise, the modernity of the visible black paint on the handles, body sides and upper/lower bands, and mouth was substantiated by: CT images showing fissures on the ceramic clay repaired with a material with high radiodensity, but beneath the visible black paint [11]; and UV light showing the material fluorescing in a milky brownish-yellow colour, characteristic of shellac, which was commonly used in the nineteenth century but not in ancient times. This shows that these areas are modern and have been painted in black after the clay was fired.

It is also well-known from the scientific literature (and from personal experience) that the ancient coloured surfaces acquired through the red- and black-figure techniques should appear dark under UV light, without any fluorescence, as with the honeysuckle pattern on the neck and the black elongated tongue-pattern below, and the black coloured underlayer areas of the vessel (Figure 6 and Figure 8). The fact that the ancient BGc technique was only successfully rediscovered in 1942 [40-42] is of particular relevance here (Figure 9). Hence, if the black colour on the neck and/or underneath the modern paint overlayers is BGc, it would have to be either ancient or produced after 1942. This makes it difficult to date this vessel as it entered Portugal much earlier than 1942 (~1834) but the ceramic paste has been dated to a maximum of 1000 years ago. To this end, further testing would be required to determine if the black colour is either BGc (i.e., ancient) or some black pigment (i.e., modern). And this would eventually help us solve the last piece of the authenticity puzzle.

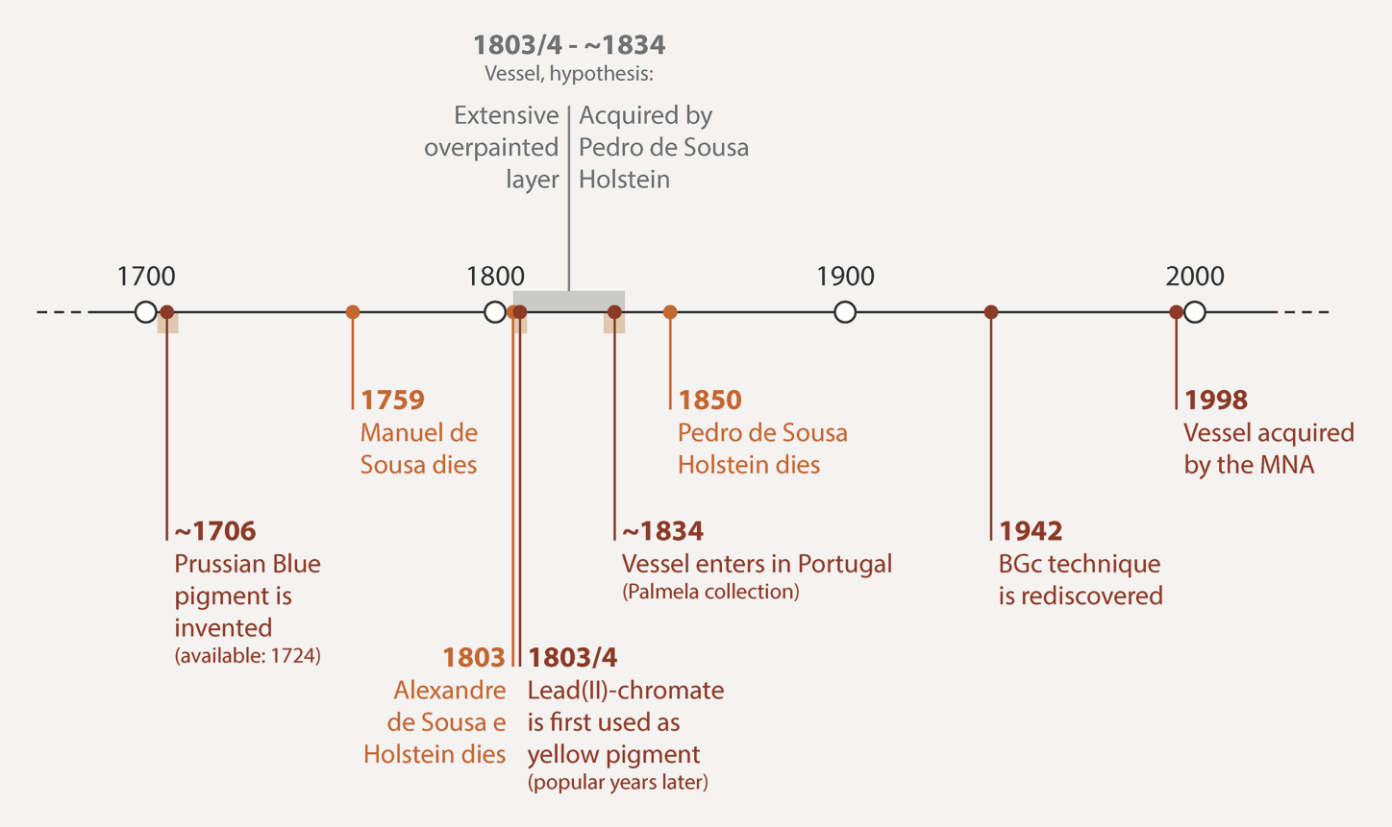

Figure 9. Timeline of some relevant events related to the MNA 999.1.1 vessel.

Interestingly, the detection of modern pigments by UV light and μ-FTIR helped to establish a temporal frame for the extensively overpainted surface layer and patina. The invention of the Prussian blue pigment can be dated back to the beginning of the 18th century [40-42], while lead(II)-chromate was first used as a pigment for yellow in 1803 or 1804 [45-47]. For this vessel, both have been used to produce the greyish-green patina, while the latter was used for the clay colour. Although the year of acquisition of the vessel is unknown, we should recall that the vessel entered Portugal around 1834, as part of the Duke of Palmela collection of antique Greek vases. Accordingly, it is possible to assume that this extensive overpainted layer or "restoration" intervention may have taken place sometime between 1803/4 and ~1834 (Figure 9).

As to why this vase was heavily overpainted, I can only speculate. Perhaps the decoration underneath – which could be original, ancient or modern – was in a poor condition, or it just did not meet early nineteenth-century taste or expectations. Likewise, it could be that its bad condition was somehow recreated to give more 'realism' and hence increase its commercial value.

Considering the analytical data hitherto available and that nineteenth-century restorers, such as the Neapolitan Raffaele Gargiulo or the French Jean-Jacques Lagrenée, often altered the painted decoration, it was not possible for me to confirm whether the overpainted motifs fully and faithfully reproduce the ones underneath.

Despite not being able to trace back the location of the "restoration" (or forgery?) at this stage, I am lured into believing that it took place in Italy, possibly in or around Rome or Naples. It is known that Manuel de Sousa, Alexandre de Sousa e Holstein, and Pedro de Sousa e Holstein had all been diplomats in Rome. The former even obtained permission to excavate around Ariccia, near Rome. As to the artist's name, well, to discover this would be an undertaking in its own right.

Provenance and acquisition

Although said to have been brought from the Herculaneum and(or?) Pompeii excavations [1], the original provenance of the vessel has never been confirmed. At the same time, the growth

in antiquities collecting among the European aristocracy and bourgeoisie during this period must be taken into account. This in turn created a demand for imitations and replicas as gifts and souvenirs, while also attracting the attention of antiquity dealers and thus of forgers [48].

The following points are significant in assessing the vessel's provenance: (1) it is assumed that this vessel was acquired as it is (i.e., with extensive modern overpainting); (2) Manuel de Sousa and Alexandre de Sousa e Holstein died in 1759 and in 1803, respectively; and (3) lead(II)-chromate was not used as a yellow pigment until 1803 or 1804 (and only becoming popular but expensive some years later) (Figure 9). Based on these considerations, it is reasonable to suggest that this vessel could have been acquired by Pedro de Sousa Holstein (who later became the First Duke of Palmela) and not by his ancestors, as previously thought.

Millingen's [35] concept of *perfection dangereuse* in relation to the science of certain "restorations" has become less pervasive as analytical methods and techniques have eventually helped to distinguish ancient from modern interventions. Furthermore, the archaeological and historical interest of this vessel renders it of particular value for critically reflecting on distinct analytical techniques, restoration practices, antiques collecting and the art market, the fashion for the Grand Tour, and their impact on socio-cultural transformations.

Within a conceivable scenario of fakes and copies, what should happen with this vessel? Is it old enough to be protected in its own right, namely, as an object that tells us about antiques collecting? Likewise, one may wonder whether this vessel was originally added to the Palmela collection as a real antique (pseudo-)Panathenaic amphora, as a contemporary restoration, or simply as an imitation or souvenir. Deceived or aware? Whatever its true story, it seems to have been lost in time. Meanwhile, many other archaeological materials from unknown provenance, lacking context or any other valuable data whatsoever, rest quietly in public and private collections all over the world. The work presented here is an attempt to 're-excavate' some of the many stories of MNA 999.1.1.

Acknowledgements

I am grateful to the Portuguese National Museum of Archaeology (Museu Nacional de Arqueologia, MNA), in particular António Carvalho and Patrícia Batista, for granting access to MNA 999.1.1 for Vis and UV imaging. I also much appreciate IMI-art/Affidea for permission to use the CT imagery of the vessel and the lid. Special thanks extended to Carlos Prates and Rui Morais for the many enthusiastic discussions on this vessel. Lastly, I thank the anonymous reviewers for their valuable comments and suggestions, which have helped improve the quality of the manuscript. This research was partially supported by the Portuguese Foundation for Science and Technology under the project grants CEECINST/00050/2021/CP2787/CT0002 (https://doi.org/10.54499/CEECINST/00050/2021/CP2787/CT0002), UID/04059/2025 (https://doi.org/10.54499/UID/04059/2025), and UID/00308/2025 (https://doi.org/10.54499/UID/00308/2025).

Data availability statement

The CT DICOM dataset used for this study is available from IMI-art/Affidea on reasonable request. Larger images and further characterisation of the MNA 999.1.1 vessel are available online as supplementary material [36] to this article at the Zenodo repository, under a CC BY-SA 4.0 license, https://doi.org/10.5281/zenodo.16880854.

REFERENCES

1. Rocha Pereira, M. H., 'Notícia acerca de vasos gregos existentes em Portugal. II[a] parte', *Humanitas* **11-12** (1959) 11-58.
2. Lucidi, E., *Memorie storiche dell'antichissimo municipio ora terra dell'Ariccia, e delle sue colonie Genzano, e nemi dedicate a Sua Eccellenza Il Signor D. Agostino Chigi … Dal Canonico Emmanuele Lucidi*, Lazzarini, Rome (1796), https://arachne.dainst.org/entity/15883 (accessed 2025-08-20).
3. Degortes, M., 'Aquisição de móveis e ornamentação para a residência de um diplomata: o gosto de Alexandre Sousa Holstein', in *Actas do III colóquio internacional A casa Senhorial. Anatomia de interiores*, eds. G. Vasconcelos Sousa & A. Pessoa, Universidade Católica Editor, Porto (2018) 311–328, https://repositorio.ul.pt/handle/10451/37510 (accessed 2025-08-20).
4. Guerra, A., 'Alexandre de Sousa e Holstein (1751-1803): o gosto pelas antiguidades e as escavações de Arícia', in *Ex Baetica Romam: Homenaje a José Remesal Rodríguez*, eds. V. Revilla Calvo, A. Aguilera Martín, L. Pons Pujol & M. García Sánchez, Universitat de Barcelona, Barcelona (2020) 1439-1469.
5. BAPD, 'BAPD-9023288', in *Beazley archive pottery database*, Classical Art Research Centre, University of Oxford (1997-), http://www.beazley.ox.ac.uk/record/0AAC51D6-07BF-4190-A0A5-3E2B45D62909 (accessed 2025-08-20).
6. Rocha Pereira, M. H., *Greek vases in Portugal*, Instituto de Estudos Clássicos da Universidade de Coimbra, Coimbra (1962).

7. Rocha Pereira, M. H., *Greek vases in Portugal*, 1st ed., Imprensa da Universidade de Coimbra, Coimbra (2010), https://doi.org/10.14195/978-989-8281-25-8.
8. Rocha Pereira, M. H., *Vasos gregos em Portugal. Aquém das colunas de Hércules*, Museu Nacional de Arqueologia, Lisboa (2007).
9. Bentz, M., 'Appendix 1: Schwarzfigurige pseudo-Preisamphoren (ca. 550-475 v. Chr.)', in *Panathenaïka, symposion zu den Panathenäischen Preisamphoren*, Rauischholzhausen, eds. M. Bentz & N. Eschbach, Zabern, Mainz (2001) 177-195.
10. Morais, R., *Iberia Graeca. Arte griego en los museos y colecciones de la Península Ibérica*, Centro Iberia Graeca, Barcelona (2019).
11. Prates, C.; Moitinho de Almeida, V.; Sousa, S.; Rodrigues, A. L.; Dias, M. I., 'Palmela's "pseudo-Panathenaic" amphora: unveiling the truth, more than 200 years later', in *Myths, gods, and heroes. Greek vase collections in Portugal / Mitos, deuses e heróis. As coleções de vasos gregos em Portugal*, vol. 2, eds. R. Morais, R. Centeno & D. Ferreira, Câmara Municipal de Santa Maria da Feira – Museu Convento dos Lóios; Reitoria da Universidade do Porto; Faculdade de Letras da Universidade do Porto; Imprensa da Universidade de Coimbra, Porto, Coimbra (2023) 249-268.
12. Dooijes, R., 'Keeping alive the history of restoration: nineteenth century repairs on Greek ceramics from the National Museum of Antiquities in Leiden', in *ICOM glass and ceramics conservation, interim meeting of the ICOM-CC working group*, ed. L. Pilosi, Nova Gorica (2007) 103-112.
13. Bourgeois, B.; Matz, F. (eds.), *Une perfection dangereuse, la restauration des vases Grecs, de Naples à Paris, XVIIIe – XIXe siècles*, Centre de Recherche et de Restauration des Musées de France (C2RMF), Paris (2010).
14. Tjon Sie Fat, E., *Reading restorations. 19th century restorations on red-figure south Italian vases from the National Museum of Antiquities*, Leiden University, Leiden (2012), https://hdl.handle.net/1887/19489 (accessed 2025-08-20).
15. Dooijes, R.; Düring. M., 'The Canino collection: historical restorations on Greek vases in the National Museum of Antiquities in Leiden', in *The Canini connections. The history and restoration of ancient Greek vases from the excavations of Lucien Bonaparte, Prince of Canino (1775-1840)*, ed. R.B. Halbertsma, Sidestone Press, Leiden (2017) 103-116.
16. Bentz, M., 'Schwarzfigurige amphoren panathenäischer form. Typologie, funktion und verbreitung', in *Panathenaïka, symposion zu den Panathenäischen Preisamphoren*, Rauischholzhausen, eds. M. Bentz & N. Eschbach, Zabern, Mainz (2001) 111-127.
17. Schreiber, T., *Athenian vase construction. A Potter's analysis*, The J. Paul Getty Museum, Malibu (1999).
18. Noble, J. V., *The techniques of painted Attic pottery*, Faber & Faber in cooperation with the Metropolitan Museum of Art (New York), London (1966).
19. Aloupi-Siotis, E., 'Ceramic technology: how to characterise black Fe-based glass-ceramic coatings', *Archaeological and Anthropological Sciences* **12**(8) (2020) 191, https://doi.org/10.1007/s12520-020-01134-x.
20. Sparkes, B. A., *The red and the black. studies in Greek pottery*, Routledge, London, New York (1996).
21. Ingo, G. M.; Bultrini, G.; de Caro, T.; Del Vais, C., 'Microchemical study of the black gloss on red- and black-figured Attic vases', *Surface and Interface Analysis* **30** (2000) 101-105, https://doi.org/10.1002/1096-9918(200008)30:1<101::AID-SIA830>3.0.CO;2-5.
22. Jansen, R.; Koens, H.; Neeft, C.; Stoker, J., 'Scenes from the past: CT in the archaeology of ancient Greek ceramics', *RadioGraphics* **21** (2001) 315-321, https://doi.org/10.1148/radiographics.21.2.g01mr12315.
23. Berg, I., 'Looking through pots: recent advances in ceramics X-radiography', *Journal of Archaeological Science* **35**(5) (2008) 1177-1188, https://doi.org/10.1016/j.jas.2007.08.006.
24. Karl, S.; Jungblut, D.; Mara, H.; Wittum, G.; Krömker, S., 'Insights into manufacturing techniques of archaeological pottery: industrial X-Ray computed tomography as a tool in the examination of cultural material', in *Craft and science: international perspectives on archaeological ceramics*, ed. M. Martinón-Torres, Bloomsbury Qatar Foundation, Doha, Qatar (2014) 253-261, https://doi.org/10.5339/uclq.2014.cas.ch27.
25. Ricci, G., *Archaeometric studies of historical ceramic materials*, Università Ca' Foscari Venezia, Venice (2016), http://hdl.handle.net/10579/10321 (accessed 2025-08-20).
26. Moitinho de Almeida, V., 'Contributions of 3D digital methods and techniques to the study of ancient pottery', in *Myths, gods, and heroes. Greek vase collections in Portugal / Mitos, deuses e heróis. As coleções de vasos gregos em Portugal*, vol. 2, eds. R. Morais, R. Centeno & D. Ferreira, Câmara Municipal de Santa Maria da Feira – Museu Convento dos Lóios; Reitoria da Universidade do Porto; Faculdade de Letras da Universidade do Porto; Imprensa da Universidade de Coimbra, Porto, Coimbra (2022) 269-291.
27. 3D Slicer, *3D slicer image computing platform* (1998-), http://www.slicer.org (accessed 2025-08-20).
28. Fedorov, A.; Beichel, R.; Kalpathy-Cramer, J.; Finet, J.; Fillion-Robin, J.-C.; Pujol, S.; Bauer, C.; Jennings, D.; Fennessy, F.; Sonka, M.; Buatti, J.; Aylward, S. R.; Miller, J. V.; Pieper, S.; Kikinis, R., '3D slicer as an image computing platform for the quantitative imaging network', *Magnetic Resonance Imaging* **30**(9) (2012) 1323-1341, https://doi.org/10.1016/j.mri.2012.05.001.
29. Moitinho de Almeida, V., *Towards functional analysis of archaeological objects through reverse engineering processes*, Universitat Autònoma de Barcelona, Cerdanyola del Vallès (2013), http://hdl.handle.net/10803/129161 (accessed 2025-08-20).
30. Spelitz, S.; Moitinho de Almeida, V.; Lang-Auinger, C., 'Automatic geometry, metrology, and visualisation techniques for 3D scanned vessels', *Digital Applications in Archaeology and Cultural Heritage* **17** (2020) e00105, https://doi.org/10.1016/j.daach.2019.e00105.
31. Maritan, L., 'Ceramic abandonment. How to recognise post-depositional transformations', *Archaeological and Anthropological Sciences* **12**(8) (2020) 199, https://doi.org/10.1007/s12520-020-01141-y.
32. IPPAR, *Ficha de laboratório Nº83*, Instituto Português do Património Arquitectónico (IPPAR), Departamento de Arqueologia, Lisbon (1998) 1-6.
33. Petrakova, A., 'Restoration and conservation of the vases in the 18th-19th centuries', in *Myths, gods, and heroes. Greek vase collections in Portugal / Mitos, deuses e heróis. As coleções de vasos gregos em Portugal*, vol. 2, eds. R. Morais, R. Centeno & D. Ferreira, Câmara Municipal de Santa Maria da Feira – Museu Convento dos Lóios; Reitoria da Universidade do Porto; Faculdade de Letras da Universidade do Porto; Imprensa da Universidade de Coimbra, Porto, Coimbra (2022) 236-248.

34. Koob, S., 'Obsolete fill materials found on ceramics', *Journal of the American Institute for Conservation* **37**(1) (1998) 49-67, https://doi.org/10.1179/019713698806082958.
35. Millingen, J. V., *Peintures antiques et inédites de vases grecs: tirées de diverses collections, avec des explications*, Imprimé par de Romanis, Rome (1813), https://doi.org/10.11588/DIGLIT.4842.
36. Moitinho de Almeida, V., *3D archaeological Greek pottery: MNA 999.1.1 (BAPD 9023288), Palmela amphora of Panathenaic shape* [Dataset], Zenodo (2025) 1-20, https://doi.org/10.5281/zenodo.16880854.
37. Bentz, M., 'Les amphores Panathénaïques: une étonnante longévité', in *Le vase grec et ses destins*, eds. P. Rouillard & A. Verbanck-Piérard, Biering et Brinkmann, Munich (2003) 111-117.
38. Snow, C. E., 'The Affecter amphora: a case study in the history of Greek vase restoration', *The Journal of the Walters Art Gallery* **44** (1986) 2-7.
39. Bukina, A., 'Restorations on the Canino vases of the State Hermitage Museum', in *The Canini connections. The history and restoration of ancient Greek vases from the excavations of Lucien Bonaparte, Prince of Canino (1775-1840)*, ed. R.B. Halbertsma, Sidestone Press, Leiden (2017) 117-124.
40. Schumann, T., 'Oberflächenverzierung in der antiken Töpferkunst, terra sigillata und griechische Schwarzrotmalerei', *Berichte der Deutschen Keramischen Gesellschaft* **23** (1942) 408-426.
41. Schumann, T., 'Terra sigillata und die Schwarz-Rot-Malerei der Griechen', *Forschungen und Fortschritte* **19** (1943) 356-358.
42. Weickert, C., 'Zur technik der griechischen Vasenmalerei', *Archäologischer Anzeiger* (1942) 512-528.
43. Gettens, R. J.; Fitzhugh, E. W., 'Azurite and blue verditer', in *Artists' pigments. A handbook of their history and characteristics*, vol. 2, ed. A. Roy, National Gallery of Art, Washington (1993) 23-35.
44. Kraft, A., 'On the discovery and history of prussian blue', *Bulletin for the History of Chemistry of the American Chemical Society* **33**(2) (2008) 61-67, https://doi.org/10.70359/bhc2008v033p061.
45. Berthollet, C. L.; Vauquelin, L. N., 'Rapport fait à la classe des sciences physiques et mathématiques de l'Institut, sur un mémoire de M. Godon', *Annales de Chimie* **53** (1805) 222-229, http://hdl.handle.net/1908/1038 (accessed 2025-08-20).
46. Kühn, H.; Curran M., 'Chrome yellow and other chromate pigments', in *Artists' pigments. A handbook of their history and characteristics*, vol. 1, ed. R.L. Feller, National Gallery of Art, Washington (1986) 187-217.
47. Saunders, D.; Trentelman, K.; Maish, J., 'Collaborative investigations into the production of Athenian pottery', in *New approaches to ancient material culture in the Greek & Roman world*, ed. C. Maish, Brill, Leiden, Boston (2020) 124-135, https://doi.org/10.1163/9789004440753_007.
48. Szilágyi, J. G., 'Wisest is time: ancient vase forgeries', in *Manufacturing a past for the present: forgery and authenticity in medievalist texts and objects in nineteenth-century Europe*, eds. J.M. Bak, P.J. Geary & G. Klaniczay, Brill, Leiden, Boston (2014) 171-223, https://doi.org/10.1163/9789004276819.

RECEIVED: 2023.8.30
REVISED: 2025.8.20
ACCEPTED: 2025.10.14
ONLINE: 2026.1.31