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ARTISANS, MOULDS AND ARCHITECTURAL TERRACOTTAS FROM POPULONIA (TUSCANY): NEW INSIGHTS FROM ARCHAEOMETRIC INVESTIGATIONS

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Abstract: This contribute aims to provide new insight on the production and circulation of full-figure architectural terracotta images adorning temples, namely *fictiles*, in northern Etruria. The investigation focuses on the recent discovering of a relevant corpus of architectural terracottas in Populonia, emerged during the excavation in La Casaccia locality, on the eastern slopes of Poggio del Castello (Baratti, Livorno, Tuscany). The review of the typological study and the archaeometric analysis on a selection of representative antefixes and relief plaques disclosed a complex scenario revealing the presence of both local and imported *fictiles*. Future and already planned investigations of architectural terracottas from Volterra promise to enlarge the frame on the circulation of imported *fictiles* from the nearby Campanian areas, redrawing the dual interpretation of mobility of goods vs mobility of men for decorating public buildings in northern Etruria.

Keywords: Archaeometry, architectural terrecottas, Populonia, travelling artisans, Etruscan art

1. Introduction

A disastrous flood occurred in 2015 and involving the site of Populonia promoted two different archaeological investigation campaigns (Baratti & Megale, 2016, 2017) interesting areas sited along the municipal road joining the Gulf of Baratti to Populonia Alta. The 2016 excavation enabled identifying a private house (fig. 1) consisting of numerous rooms having a view on a small, paved road. To date, the stratigraphic excavation of the solely courtyard revealed the presence of three *dolia* (Bacci & Sciortino, 2017) and massive accumulations of seeds[1], suggesting its use as a warehouse.

The life of the house seems to start in the early 4th century BC, ending at the beginning of the 3rd century BC, when a serious fire involved the entire area determining its abandonment. In 2017, further research carried out in an area located about 100 meters northwest of the so-called "*House of Seeds*", revealed a road made of iron slag, a complex sewerage system and different and complex structures still to be investigated. This scenario would suggest that the urban context including the House of Seeds belongs to the lower nucleus of the ancient city

[1] Preliminary studied by Osti (2017).

fig. 1. The so called “House of Seeds” during the excavation works.

fig. 2. The urban context behind the “House of Seeds”.

of Populonia (fig. 2), already mentioned as «*poplion polis*» by Claudius Ptolemy (I,1,324) and as «*epineion*» by Strabo (V.333).

The preliminary phase of the excavation[2] unexpectedly disclosed one of the largest excavated groups of architectural terracotta coming from the site of Populonia (Bacci 2019a, 2019b). Even though they were all found in the 'House of the Seeds' area, the fragments cannot be related to a stratigraphic sequence, probably coming from a collapse involving the nearby site of *La Casaccia*. Dating such a heterogeneous group seems difficult; based on typological comparisons, the terracottas nucleus can be dated between the 6th and 3rd centuries BC. These circumstances offered the occasion for an in-depth investigation of the terracottas' materiality and appearance, including typological, minero-petrographic and geochemical analysis, and the characterization of pictorial traces.

2. Materials

Fictiles

The group of *fictiles* (*i.e.* terracotta decorations adorning ancient religious and public buildings) is rather heterogeneous and consists of thirty-one fragments of antefixes and relief plaques (tab. 1), some of which in excellent condition, while others in poor preservation state with clear signs of damages and ruptures probably due to the involvement in the cited collapse.

Sample ID	Typology and decorative motif	Notes
T01	Palmettes plaque	
T02	Composite nimbus with concentric bands.	Twin specimen of T09. Traces of white engobe.
T03	Plaque with deep strigils	Trace of colours (red) at the center of the strigils.
T04	Antefix with female hairstyle	Weak traces of red.
T05	Plaque with strigils	Trace of colours (red) at the center of the strigils.
T06	Plaque with lotus	Brilliant traces of dark. Volcanic inclusions
T07	Left lateral of a bearded figure. Antefix.	Traces of red at the base of the antefix.
T08	Plaque with palmettes between arches.	Volcanic inclusions
T09	Composite nimbus with concentric bands	Twin specimen of T02. Lack of white engobe.
T10	Central shell of a nimbus	
T11	Plaque with *anthemion*	
T12	Antefix with beard	
T13	Plaque with strigils	Volcanic inclusions
T14	Left of a nimbus	
T15	Palmettes antefix	
T16	Plaque with *anthemion*	
T17	Plaque with palmettes	
T18	Plaque with palmettes	

tab. 1. List of analysed samples

In the corpus, nimbus antefixes decorated with Silenus are recognizable (fig. 3); the series is attested by numerous conspicuous fragments (among them T12 11,5×16 cm, T07 6×12 cm)

[2] The archaeological excavations were led by dott. Andrea Camilli (Soprintendenza Archeologia della Toscana), with the joint supervision of Prof. Giorgio Baratti and Dr. Carolina Megale

fig. 3. Fragments of the antefixes shells (left: T10, T14 and T15) and the silenic beards (right: T07 and T12).

fig. 4. Maenad's hairstyle fragment (T04).

of curled beards belonging at least to two different specimens and by the discovery of three nimbus shells with seven-leaf palmette decoration (T10, T14, T15).

A single fragment (T04: 11×9 cm, fig. 4) representing a wavy hairstyle[3] confirms the presence – next to the Silenus – of at least one specimen of a Maenad, ascribable to the same series of nimbus antefixes.

According to the style and the typology of the terracottas, this first group of nimbus antefixes decorated with Silenus and Maenads can be dated to the first half of the 4th century BC.

Two other fragments (T02 and T09, fig. 5) attest the series of antefixes with a composite nimbus, with two concentric bands: the upper one characterized by convex strigils and the innermost one by *anthemion*, for which only the lower portion of vegetal spirals and the first leaves of the palmettes are preserved. Unfortunately – to date – it has not been possible to refer any central decoration to this type of nimbus[4].

The relief plaques represent the largest group of architectural terracottas. Twenty-one fragments – some of which contiguous making possible putting them together – and in excellent preservation state, enabled recognizing at least two types of decorative motifs. The first one, including samples T03, T05, T11 and T17 (fig. 6), is characterised by two distinct bands defined by a semi-circular torus: the upper frame has a continuous succession of concave strigils which end with a strong protrusion, while the lower one is decorated with a rich *anthemion* with plant motifs (palmettes and four-petal rosettes). This type of plaques decoration can

[3] A very close comparison with the maenad hairstyle from Cannicella, Orvieto (Andrèn, 1940, pp. 68-221 and Andrèn 1967, XXV).

[4] Even though close comparisons from Volterra, it may suggest a central decoration with amazons (Galluccio, 1999, fig. 13). Samples T02 and T09 can cautiously be also dated to the end of 4th century BC as suggested for the Volterra specimens.

fig. 5. Shell framing element (left: T02 and right: T09).

fig. 6. Terracotta Plaques with Anthemion (top: T03, T05, T11, bottom: T17).

be dated – as well as the antefixes with Silenus and Maenads – between the 4th and the 3rd century BC; credibly, both groups decorated the same building[5].

The second group includes only two large fragments of relief plaques (fig. 7, samples T06, T08) exhibiting also peculiar and unique features among the whole relief plaques series (Bacci, 2019a, p. 524) for their different clay paste colour and occurrence of mineral inclusions. They consist of an *anthemion* decorated with palmettes and lotus flowers linked by pendulous arches which can be dated, based on the style, to the 6th century BC. Unfortunately, for these two fragments, the upper frames of the slab are absent, which – most likely – were concave strigils.

Traces of lively red colour persisting on the surface of the lower portion of the antefixes were evident from macroscopic investigation (fig. 8). In the studied samples, consistent red pictorial traces were preserved on antefixes with Silenus, on the surviving beards of the Silenus and on the fragment of the Maenad's hair (sample T04); red traces are also clearly visible in the centre of the strigils of the plaques with *anthemion* (sample T03, T05,). Black is attested, in the group, only as a large background in the lotus stem of the 6th century BC plaque, and, despite superficial degradation processes, in traces on a strigil of the same fragment (sample T06). Both in the case of red and black pigments, the colours seem to be applied without any kind of engobe, but simply spread over a polished surface. The same cannot be said for the nimbus in sample T02, which clearly shows traces of white engobe, used for the retention of colours and as a basis for the more superficial polychromies, which has completely disappeared.

[5] In many sites, maenads and silens nimbus antefixes are found in association with this type of plaques. For further details see discussion section.

fig. 7. Plaques with palmettes and lotus flowers (left: T08, right: T06).

fig. 8. Red pictorial traces in samples (a) T05 and (b) T07; (c) black traces on T06 plaque (details), as examples.

3. Methods[6]

The selected architectural terracottas (No 18 samples, labelled as T*, Table 1) have been preliminary characterized through microscopy observations on polished thick sections. On a selection of samples based on matrix and tempers features, thin section analysis has been carried out by a Zeiss Axioplan microscope following Whitbread classification (Whitbread, 2017). Samples bearing volcanic inclusions have been analysed by SEM-EDS to provide provenance indicators; in fact, multivariate statistical analysis on clinopyroxenes has been applied to determine raw materials' geological location, according to the well establish method proposed by Barone et al. (2010).

Carbon-coated thin sections have been analysed by a field emission scanning electron microscopy FEI Quanta 450 ESEM FEG equipped with a Bruker EDS QUANTAX XFlash detector at the Centre for Instrument Sharing of the University of Pisa (CISUP). Finally, on pictorial traces micro-Raman investigation has been carried out by using Raman Jasco NRS-3100 apparatus, equipped with a laser excitation source at 785 nm. The system was calibrated using a 520.6 cm^{-1} Raman band of a silicon wafer before each experimental session. Spectra were collected through multiple acquisitions by using 785 nm laser; typical measurement condition were 20 s integration time and 10 accumulations; laser power was set at ~10 mV by using 100x objective.

[6] Analytical investigations and data processing have been carried out by S.R.

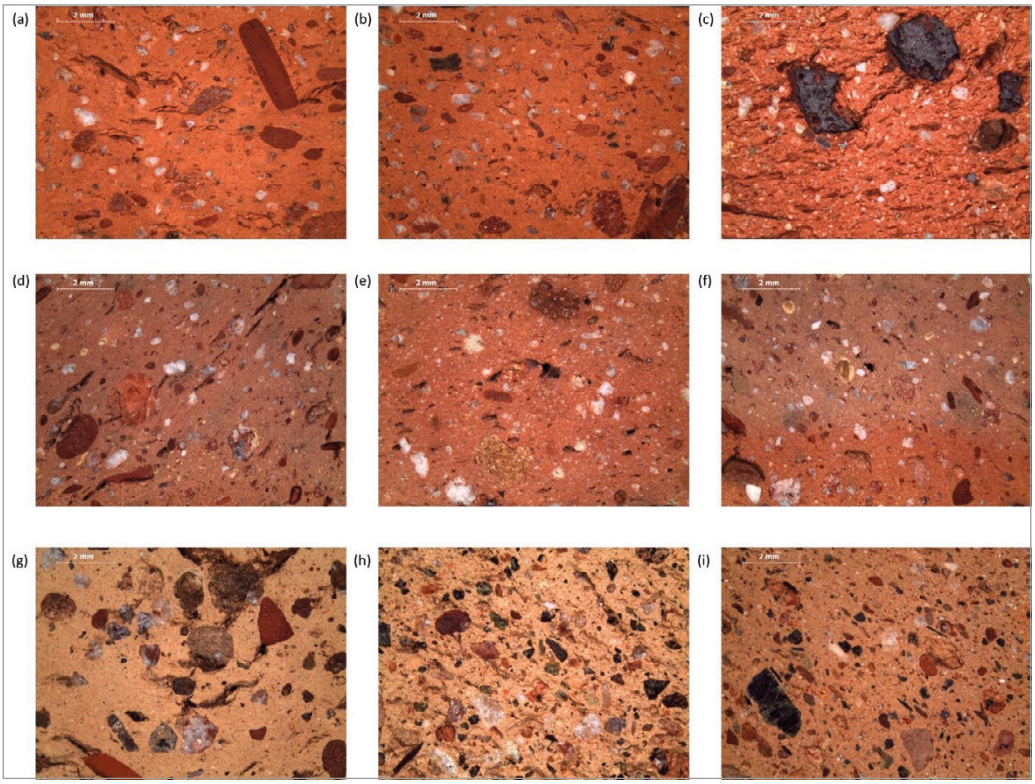


fig. 9. Macro-pictures of studied architectural slabs. Reddish paste: fictiles (a) T10 (b) T12 (c) T15, and architectural slabs (d) T3 (e) T9 (f) T11. Yellow-brownish paste: (g) T06 (h) T08, and (i) T13.

4. Results

4.1 Preliminary observations and minero-petrographic analysis

The majority of antefixes (T01, T04, T07, T10, T12, T14, T15) and relief plaques (T02, T03, T05, T09, T11, T16, T17, T18) are characterized by quite common textural and compositional features, even considering a slight variability in sorting and thickening of inclusions (fig. 9.a-c). In particular, all the antefixes are characterized by a quite homogenous and compact clay paste, red-orange in colour; abundant inclusions with polymodal grain distribution and medium grain size of 1-3 mm are dispersed in the matrix. The coarse-grained distribution of inclusions enabled the identification of quartz, polycrystalline rock fragments, siltstones, sandstones and in some cases black metallurgic slags. Elongated and preferentially oriented voids are quite evident and abundant, as well. Relief plaques exhibit quite similar textural features respect to antefixes, despite a colour grading from the core to the border of the samples and the higher temper thickness (fig. 9.d-f).

Among overall relief plaques, samples T06, T08 and T13 are discriminated for their peculiar textural and composition features; in particular, the clay paste is quite porous, with elongated and oriented voids, yellow-brownish in colour and characterized by abundant inclusions (from sub-rounded to sub-angular) ranging from 1 to 3 mm in the coarser fraction due to crystals and rock fragments black, red and green in colour (fig. 9.g-i).

A selection of architectural terracottas from the two identified compositional groups have been investigated in thin section to improve compositional and textural characterization provided by the preliminary analysis of fragments.

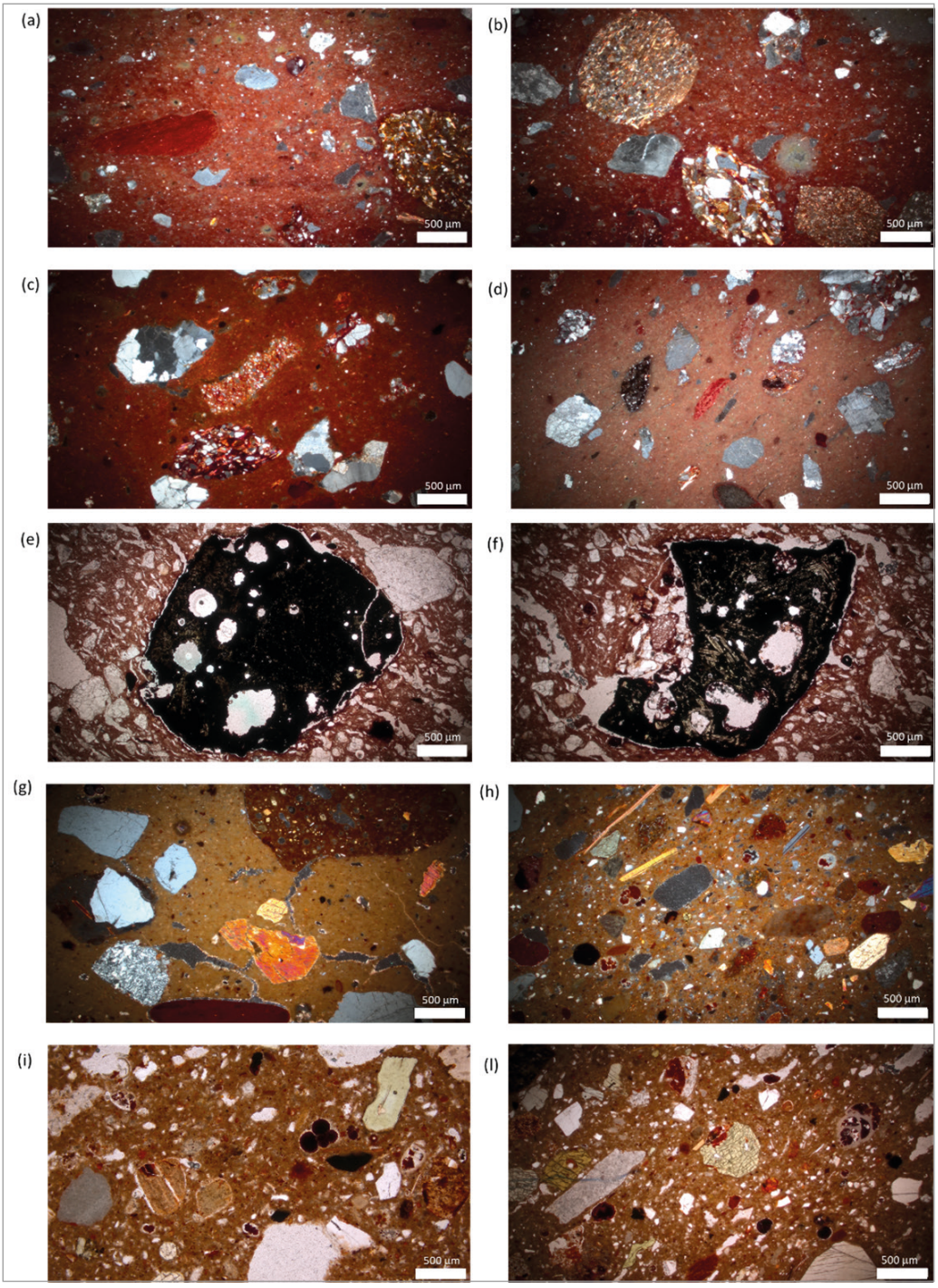


fig. 10. Pictures in thin section of samples representative of the two identified petrographic fabrics. (a) T02 (b) T09 (c) T10 (d) T15. Details of scoria in samples T15 (e-f). Samples bearing volcanic inclusions (g) T06 and (h) T13, and details on fossil-rich matrix (i-l).

Petrography is quite in accordance with discrimination based on microscopy observations. In fact, in samples T02, T07, T09, T10, T11, T12, T15, including both antefixes and relief plaques, the microstructure is due to irregular voids (50-200 μ) ranging from subrounded to elongated. The matrix is clayey, homogenous, iron-rich, low carbonatic[7] and scarcely micaceous, with finely dispersed quartz grains (<50 μm) and low to absent optical activity. Inclusions (40%) are polymodal in grain side distribution (300 μm-2.5 mm) with subangular shape and rare sub-rounded fragments. They are mainly due to polycrystalline quartz, feldspars, chert and fragments of sandstones, siltstones, argillite, and metamorphic rocks (low-medium grade) (fig. 10.a-d). In samples T09 and T15 black scoria can be recognized, even millimetric in dimension, which nature could be related to metallurgic activity. Slightly textural differences can be observed between antefixes and relief plaques, attributable to the different use of the fragments (fig. 10. e-f).

The relief plaques labelled as T06, T08 and T13 exhibited very peculiar features since macroscopic observation, evidencing the occurrence of volcanic inclusions not detected in the whole corpus; in these samples, microstructure is due to elongated and irregular voids (about 100 μm). The matrix is quite heterogenous, fossil-rich and calcareous, yellow-brownish in colour with low-absent birefringence. Inclusions are due to volcanic rock fragments with texture from vitrofiric to porphyric, olivine and pyroxenes, plagioclase, opaque minerals, chert. Abundant ACF (textural concentration elements) deep red in colour are present (fig. 10.g-l).

4.2 Volcanic inclusions and pyroxenes

Keeping unaltered their chemical composition during the eruption process, clinopyroxenes have been demonstrated to be powerful tool for investigating provenance of volcanic inclusions in archaeological ceramics (See Barone et al., 2010; Barone et al., 2018). About 20 pyroxenes crystals for each sample bearing volcanic inclusions, namely samples T06, T08 and T13, have been selected and investigated by SEM-EDS analysis (Table 2). Geochemical data have been processed according to the multivariate statistical methods proposed by Barone et al. (2010); discriminant functions explaining the variables better discriminating among groups (DF1 dependent on FeO, SiO_2, TiO_2; DF2 dependent on FeO, MgO and Al_2O_3) have been calculated and plotted along with reference data (fig. 11). Discriminant functions evidenced a good accordance with clinopyroxenes from Campanian magmatic provinces.

Oxide%						
	T06 No of crystals = 20		**T08 No of crystals = 6**		**T13 No of crystals = 21**	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
SiO_2	48.22	2.96	51.50	3.48	50.07	3.59
TiO_2	0.94	0.38	0.58	0.47	0.85	0.62
Al_2O_3	5.83	1.68	3.33	1.75	4.74	1.99
FeO	8.01	2.06	5.73	2.54	7.15	2.76
MnO	0.16	0.17	0.26	0.19	0.19	0.18
MgO	10.85	2.11	13.33	1.80	11.34	2.56
CaO	25.35	2.70	24.75	1.20	25.14	2.06
Na_2O	0.38	0.84	0.33	0.20	0.30	0.24
K_2O	0.12	0.16	0.08	0.20	0.09	0.10
Cr_2O_3	0.13	0.15	0.11	0.13	0.13	0.25

tab. 2. Average composition and standard deviation of clinopyroxenes for each analysed architectural terracotta. For each crystal almost 3-point analysis have been collected.

[7] SEM-EDS analysis have been carried out also on matrix to determine the overall chemical composition. Data are not herewith reported.

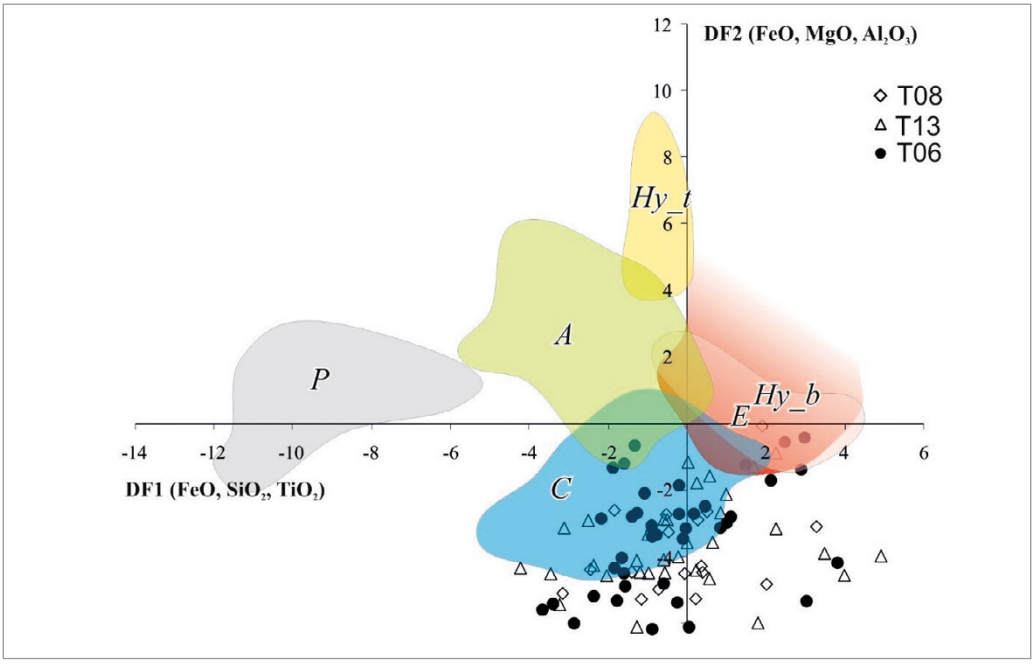


fig. 11. DF1 vs. DF2 diagram for the clinopyroxenes discrimination according modified from Barone et al., 2010. A = Aeolian Arc, C = Campanian province and P = Pantelleria Island from Barone et al., 2010 and data collected on T06, T08 and T13 architectural terracottas.

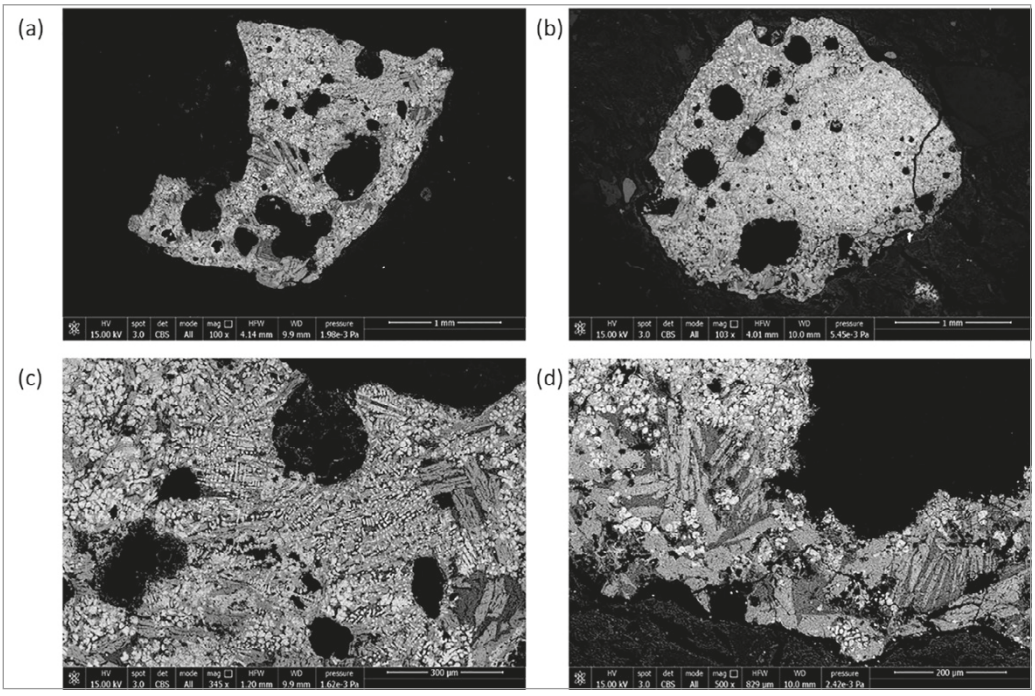


fig. 12. Skeletal fayalite (light grey) crystalized after the Fe-oxides dendritic structures (white), in a glassy groundmass. (a-b) General view of the scoria and (c-d) details showing crystals in the groundmass in T09, as examples.

4.3 Scoria

In samples T09 and T15 few and big fragments of scoria interpretable as metallurgic slag have been observed since macroscopic and thin section observations. SEM-EDS investigation enables characterizing their microstructure, evidencing the presence of subrounded iron-oxides, skeletal fayalite crystals in a glassy matrix (fig. 12). Composition and microstructure enabled classifying them as slags from iron smelting (Roland et al., 2014; Theeraporn et al., 2014).

4.5 Pictorial traces

Micro-Raman investigation on red and black pictorial traces observed on some of the analysed architectural terracottas revealed the composition of pigments used for the coloured decoration (fig. 13), almost lost due to degrade; in particular, in the red areas hematite has been identified, with the typical Raman modes at 230, 293, 410, 495, 611, and 1334 cm^{-1} (De Faria et al., 1997), while on the black traces the typical broad bands at about 640 cm^{-1} suggested the presence of Mn-based pigments (Sepulveda et al., 2015); moreover, bands at 1222 and 1337 cm^{-1} attributable to metakaolin (Sepulveda et al., 2015) would suggest the use of a white engobe to host the colours and create white surfaces on the typical coeval trichrome decorative motives (Barone et al., 2017; Barone et al., 2018).

Discussion and conclusions

The analytical investigation on the studied architectural terracottas certainly provided very interesting and new data on a long-lasting debate (Among others: Riis, 1981, p. 44; Cristofani, 1981, pp. 195-197; Bonghi Jovino, 1990, pp. 21-26) related to the organization of coroplast workshops, the mobility of the artisans and the relationship between clients and production centres in northern Etruria (tab. 3).

Sample ID	Typology	Chronology	Petrofabrics (optical microscopy)	Pictorial layers and pigments identified (micro-Raman spectroscopy)	Provenance
T01, T04, T07, T10, T12, T14, T15	antefixes	4th century BC	Group 1: from homogenous to heterogenous red-orange clay paste; polycrystalline rock fragments, siltstones, sandstones and black slag as tempers	Hematite, pyrolusite and metakaolin	Local provenance (nearby of Populonia) as suggested by the presence of typical iron smelting slags
T02, T 03, T05, T09, T11, T16, T17, T18	relief plaques	4th/3th century BC			
T06, T08, T13	relief plaques	6th century BC	Group 2: yellow-brownish clay paste and abundant volcanic rocks fragments and related minerals (plagioclase, pyroxene, opaque minerals)		Campanian mangmatic provenances (based on chemical composition of pyroxenes, SEM-EDS analysis)

tab. 3. Summary of the results obtained from thin section and geochemical analysis.

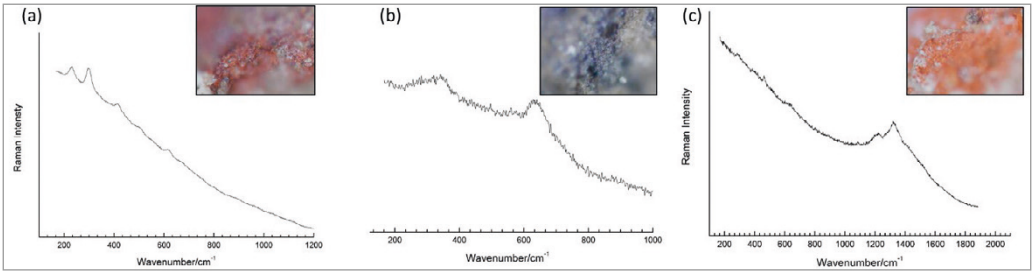
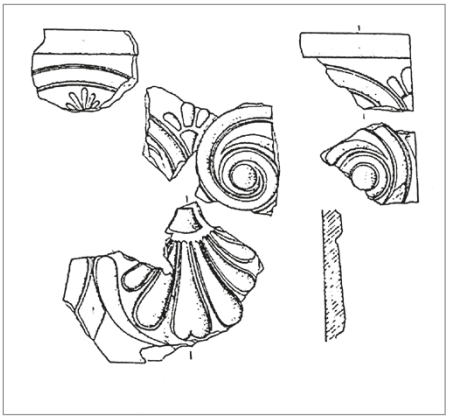


fig. 13. Examples of micro-Raman spectra collected on (a) red pigment from T02 sample, (b) black pigment from T06 sample, and (c) creamy pigment from T03 sample.

fig. 14. Plaques from Populonia (a) and drawing of plaques from Orvieto (b) - Via San Leonardo (from Antonielli and Periali 1928, III.11)



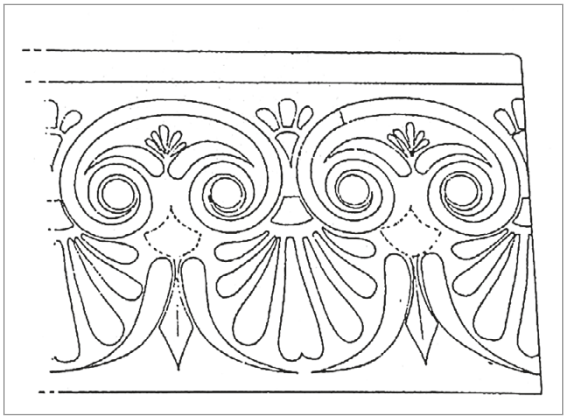


fig. 15. Plaques from Volterra (from Bonamici 2005, fig. 5, p.218)

Modeling with moulds (Cuomo di Caprio, 2007, 223-225) certainly enables rather rapid assembly batch of production, not renouncing to high-quality creations. The craftsman (the *fictor*), specialized in the manufacture of architectural decorations, had at his disposal numerous terracotta moulds, or the negative cast of the prototypes. The positive cast was obviously obtained by pouring previously purified clay into the mould, which had to adhere

well to its walls. Although highly standardized and repetitive, the process never resulted in products identical each other, considering the normal variability on the processes of drying, firing and decorating.

The great specialization required to produce architectural terracotta led these craftsmen to be in great demand, especially in ancient expanding urban centres, which public buildings had to be adorned with exquisite antefixes and plaques. This would explain why, for several decades, terracottas derived from the same casting prototype are attested in different buildings of the same urban centre, as well as in locations hundreds of kilometers away from each other[8]. This phenomenon would be interpreted as related to a mobility of men: artisans would have travelled through different geographic areas requested by different clients bringing with them their own moulds and their expertise, while exploiting local raw materials for the casting of architectural terracottas in different centres.

This interpretation seems to be the case for the majority of architectural terracottas herewith analyzed, which constitute a rather homogeneous group of fabric, even considering textural variabilities probably due to different manufacture details and firing environment. Minero-petrographic analysis would confirm, in fact, a local origin for all the antefixes and most of the relief plaques, enforced by the occurrence of iron slags in the body of two fragments (T09 and T15). The attestation of metallurgic slags in the terracottas clay mixtures is certainly unusual, except for Populonia whose territory was – and still is – literally strewn with ferrous residues derived from the smelting process of Elban hematite (Camilli, 2016).

The nimbus antefixes (samples T04, T07, T10, T12, T14) find very precise comparisons in the terracotta decorations of the sanctuaries of Orvieto (fig. 14, Andrén, 1940, 68:220 for Belvedere and Riis 1981, III, 11J for Cannicella) and of some other centres of central Italy, strongly suggesting a common archetype and the use of derivation moulds. Similarly, the plaques with *anthemion* find stringent analogies with the decorations of Orvieto, Talamone, Roselle, Tarquinia, Volterra (Andrén, 1940, II:47, 82:25, 85:299. Galluccio, 1999, fig. 15), often found in association with similar antefixes.

Comparably, composite nimbus with strigils and *anthemion*; although the fragments are not sufficient to reconstruct the entire antefix and to recognise the complete decorative motif, the typology recalls some antefixes found in Volterra (Galluccio, 1999, p. 94).

In conclusion, a first group of compositionally homogenous materials with clear traces of local supplies (T01-T05, T07, T09-T12, T14-T18), seems to confirm the existence of itinerant artisans, using local clays and raw materials, bringing with them moulds to be used at the occurrence in different cities. Between the 4th and 3rd centuries BC[9], Populonia credibly enjoyed from the experience of these coroplasts for the entire decorative cycles of some sacred building of considerable size, whose location remains still unknown[10].

The analyses on pictorial trace on these fragments denote the classic use of red ochre (along with manganese black and white kaolin-based engobe) obtained from the inorganic pigment of hematite (Cuomo di Caprio, 2007, pp. 285-286) which, among other things, must have been abundant locally on the coasts of Populonia where iron ore was smelted.

On the contrary, data emerged from the archaeometric analyses on relief plaques T06, T08 and T13 would suggest a different manufacturing and circulation pattern. Specifically, two notable fragments of relief plaques (T06 and T08) differ from the entire group in terms of typology and texture. In fact, the peculiarity of the relief decoration, consisting of palmettes alternating with lotuses between arches founds no comparison within the area of Etruria, except for some specimens found in Volterra's Acropolis (fig. 15 a-b, see Bonamici, 2005, p.218). In 2003 Marisa Bonamici proposed a clear Campanian influence in this type of decoration, finding specific comparisons in Cuma, Fratte and Poseidonia, above all in Sicily (Naxos and

[8] Interesting point of view in Wikander & Wikander, 2006, pp. 42-43.
[9] For the 4th and 3rd century Populonia see Fedeli et al., 1993 and Romualdi, & Settesoldi, 2009.
[10] A plausibile location could be the close neighbourhood as suggested in Bacci, 2019a, p. 525.

Syracuse: see notes 18 and 19 from Bonamici 2005), where workshops were clearly inspired to Campanian models.

The archaeometric analysis clearly indicate that these relief plaques were manufactured in Campanian area, thus suggesting that Populonia (together with Volterra, where clear comparison were found), were the two northernmost cities (to date) enjoying in their public buildings the fashionable Campania style, likewise many temples in Tyrrhenian Italy during the 6th century BC.

These new data reopen the quite debated topic[11] related to the idea of massive "exportation" of entire Campanian roofs or, in any case, parts of them. Unfortunately, the attestation of only three fragments – albeit conspicuous – of a possible Campanian decorative cycle in Populonia, does not allow us to propose the occurrence of an entire roof bought by the city for such specific decorative cycle. However, the southern provenance of the clays of the two Populonia specimens demonstrates that *"not only the idea, the design, the techniques, and the moulds came from Campania, but also the primary materials, such as the temper, and paints, and probably also the clays"* (from Lulof 2006, p. 237).

Sea transport remains the most plausible possibility[12], facilitated by Populonia's maritime position at the centre of the Tyrrhenian routes.

Pending further already planned investigations on the Volterran Campanian fragments, it is reasonable that Populonia served as the main port for the arrival in northern Etruria of Campania terracotta products.

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Authors' statement

Conceptualization and methodology: F. Bacci; Data collection and curation: F. Bacci, S. Raneri; Data analysis: S. Raneri; Writing and review of the Original Draft: F. Bacci, S. Raneri; Visualization: F. Bacci, S. Raneri.

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[11] Good digest in Lulof, 2006.

[12] As proposed by Bonamici, 2005

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