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Petrographic analysis to understand Etruscan architectural terracotta's technology and provenance: a study in progress.

Fugazzotto M[1,2], Stroscio A[2], Bertino A[2], Barone G[2], Russo A[3], Mazzoleni P[2],

[1] *Department of Humanities – University of Catania, Piazza Dante, 32 – Catania,* maura.fugazzotto@phd.unict.it

[2] *Department of Biological, Geological and Environmental Sciences – University of Catania, Corso Italia, 57 - Catania,* gbarone@unict.it, antonella.bertino98@gmail.com, pmazzol@unict.it, antonio.stroscio@phd.unict.it

[3] *Parco Archeologico del Colosseo, Piazza Santa Maria Nova, 53 - Roma,* alfonsina.russo@beniculturali.it

***Abstract* – Painted architectural terracotta fragments, presumably belonging to the ancient archaeological site of Caere (Cerveteri), dated back to 530-480 B.C., have been analysed by petrographic observation in order to scientifically assess the provenance hypothesis and, contemporarily, improve our knowledge regarding the manufacture technology on this kind of remains. The samples under study have been retrieved in 2016 during an investigation of the Comando Carabinieri Tutela Patrimonio Culturale on the international illegal trade of archaeological artefacts. A huge amount of fragmentary ceramic materials came back in Italy and started to be investigated by non-invasive analysis that gave interesting clues, mainly regarding painting techniques and colour palette, individuating the compatibility with the Etruscan sites. The good chemical homogeneity of the slabs made essential the petrographic investigation, of which we show here the preliminary results, obtained also by the comparison with reference materials of certain Etruscan origin and by the pyroxene's chemical composition investigation.**

I. INTRODUCTION

In the first half of 2016, the Comando Carabinieri Tutela Patrimonio Culturale, recovered numerous cases containing fragments of artefacts from an illegal antiquities trade involving the Ny Carlsberg Glyptotek in Copenhagen and the private collection of the antiquarian Robin Symes, in Geneva. Part of the fragmentary remains got back are supposed to originally belong to the important UNESCO archaeological Etruscan site of Caere (today Cerveteri). Essential to underline is how the archaeological and scientific study of the remains is affected by their history, included that of their recovery. When archaeological material is moved from the original context or from the discovery site without an appropriate documentation allowing to trace it and to attribute it to its stratigraphic context, key information is lost [1], both concerning provenance and authenticity. In addition, it is necessary to take in mind that in many cases, decontextualized materials undergone eventual treatments to be more attractive on the clandestine market. Today, the availability of a so huge amount of novel materials represented a very high potential for studying the technology of the polychrome architectural terracotta together with their relative production sites, in a contest in which few are the scientific information and not complete database is present. A preliminary chemical investigation has been carried out in a previous work by means of not invasive and not destructive techniques, focusing particularly on the compatibility provenance assessment with the Etruscan sites and on the painting techniques and colour palette identification, giving interesting results and notable clues to deepen investigations [2]. However, the similarities enhanced among all the slabs investigated determined the requirement of complementary analysis on ceramic pastes. Here the petrographic study performed in order to pursue this objective are shown. Furthermore, being needful a comparative study with reference materials in order to identify any forgery and to attest the authenticity of the finds, as well as to investigate eventual connections and technological knowledge exchanges or the ancient commerce, in this specific case, samples coming from the Banditaccia Necropolis in Caere, from the Temple of Veii, from the Ricci Portoghesi excavation in the locality of Quartaccio of Caere and from the

Temple B of Uni-Astarte in Pyrgi, have been used as reference materials.

II. STATE OF THE ART

The materials under study (Fig. 1) date back to a period ranging from the sixth to the fifth century B.C., time during which the ancient Etruscan centre of Caere was in full economic and cultural development. Well-known is, in southern Etruria, the tradition of using *Pinakes*, polychrome architectural terracotta for decorating religious and public buildings with figurative scenes. It is furthermore the period in which some innovations are recorder, probably introduced in Italy by the Ionic artists and presumably determining both stylistic and technological changes [3, 4]. Despite the great historical, archaeological and scientific interest of the finds, a complete review on this type of terracotta, specifically including the identification of raw materials was never published [2]. In addition, the architectural terracotta works analysed until now have been studied as single entities [5] and not in an overall perspective. Moreover, the same materials derive from different archaeological contexts, as well as from illegal trade of antiquities, so that a homogeneous reference group was not yet available [2]. The studies carried out through non-invasive and non-destructive investigations in a previous work, provided interesting indications on the manufacturing techniques of the pictorial layer and on the composition and stratigraphy [2, 6, 7]. In particular, the presence of metakaolin, suggested the use of kaolin slips as preparatory layer fired at temperatures between 750 and 900 °C [8, 9]. Furthermore, the detection of anatase, possibly related to the Kaolin sources [10], allowed to hypothesize a connection with Mt Sughereto, where anatase is attested among trace elements/mineral phase of kaolin [7]. In addition, hematite, gypsum [11], ochre based pigments [12], yellow and brown earths, iron and manganese-based pigments [13] were identified. Interesting are the results regarding the violet tint, obtained with a mixing of black and red particles, which require, together with the green tint, a deeper chemical investigation due to the not straightforward Raman data obtained [2]. Nevertheless, the definition of a routine in Etruscan architectural slab painting techniques still represent the centre of a debate [2]. Preliminary studies have also been carried out on the ceramic body suggesting good homogeneity of the clay mixture and dividing materials into macro-groups with similar characteristics of the ceramic body observed with reflected light microscope on cross-sections [2]. In order to support the discrimination based on the investigated cross-section, and with the aim to complement the chemical characterization of the ceramic paste and obtain possible clues in supporting hypothesis on manufacture technology [2], X-ray diffraction patterns were collected on selected slabs for which the superintendence authorized the sampling. Summarizing, the obtained results suggested the evidence of two main productions, supported by differences in terms of chemical composition, assessed in the same regional context: Caere and Banditaccia Necropolis, and Veii and Pyrgi. Actually, the majority of the studied slabs retrieved in 2016 exhibits wider similarities with Caere production. Still open questions regard the firing temperature for the ceramic manufacture, hypothesising a double firing, the first at higher temperature in order to create the object and the engobe, the second one at temperature minor of 250°C in order to fix less stable pigments [2]. However, only advanced and destructive analysis would solve these issue and give more information related to the production sites and raw materials supply.

Fig. 1. Example of the fragments of painted architectural terracotta under study.

III. RESULTS

Starting from an already bearing data substrate, the following study focused on the petrographic characterization of a corpus of 38 samples which, as previously mentioned, include architectural terracotta slabs of presumably Etruscan origin, came back in Italy in 2016, and reference samples of certain provenance, particularly from Caere, from the Banditaccia Necropolis belonging to Caere and from the near centres of Pyrgi and Veii. For the samples description the authors refer to the Barone et al., 2019. Beside to a relative microstructure homogeneity, the thin-sections observation by the polarized light optical microscope allowed to distinguish, according to Withbread, 1995 [14], different groups considering the groundmass characteristics and optical activity, together with the type of the inclusions. The samples could be grouped in two main groups (Fig. 2a and 2b):

1) L7, L10, L11, L12, L13, L14A, L14B, L14C and L15 show a light-brown groundmass, with a moderately active optical state. Inclusions grain size distribution is bimodal. Coarse inclusions are predominantly green pleochroic pyroxenes and the volcanic fragments, coming up beside to quartz, plagioclases, sanidine and biotites. Few differences regard the presence of volcanic scoriaceous rock fragments in samples L13, L14A, L14B, L14C and L15;

2) fragments (L1, L2, L3, L4, L5, L6, L8, L9, HIN794, SYM158) show a dark-brown-reddish groundmass with a not

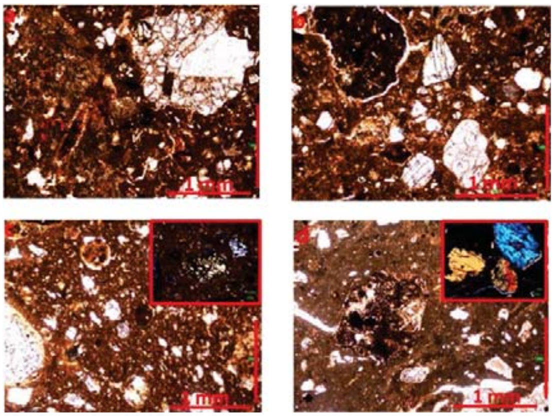

Fig. 2. Microfoto of ceramic bulk of samples under study, 5x observation, parallel nicols, a) example of the group 1; b) example of the group 2; c) sample L16 and d) 19913 sample. In the red square of the Fig.2c and 2d details pyroxenes are shown at 10x observation and crossed nicols.

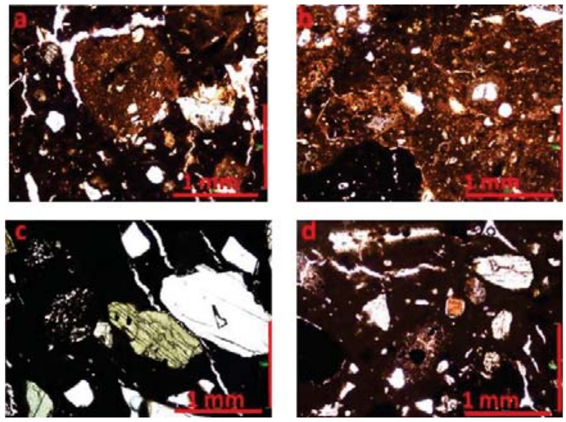

Fig. 3. Microfoto of ceramic bulk of the reference materials, 5x observation, parallel nicols: a) example of group a; b) example of the group b; c) example of the group c and d) example of the group d.

active optical state. The inclusions are mainly characterized by quartz, plagioclases, sanidine, biotite, green pleochroic pyroxenes and volcanic rock fragments inclusions. Fragments of volcanic scoria are visible in L1, L2, L3, and HIN794.

The samples L16 and 19913 differ from these two main groups (Fig. 2b and 2c): L16 shows a homogeneous matrix with abundant fine inclusions and rare altered volcanic inclusions; the sample 19913 presents brown-beige colour of the groundmass and very coarse inclusions prevalently formed by pyroxenes.

Regarding the reference materials, four groups are distinguished (Fig. 3):

a) the first group (CBAND82, CBAND65 and CERI21-27-15, 11-52-77) shows a dark-brown-reddish groundmass sometimes rich in microfossils and scoriae, and a not active optical state. The inclusions are only coarse in grain size and involve the presence of quartz, plagioclases, sanidine, green and not coloured pyroxenes and volcanic inclusions. To this group, could be related also one sample coming from Pyrgi (B59B);

b) the second group (CBAND66, CBAND9, CBAND4, CBAND232 and CERI10) differs substantially for the presence of fine inclusions and more active groundmass;

c) a distinct group is formed by Veii samples, in which pyroxenes are more abundant and coarser in grain size than the first group. Furthermore, volcanic scoriaceous fragments are common;

d) a fourth group involves the samples 32567 and B57 from Pyrgi together with two samples from the Banditaccia Necropolis (CBAND71 and CBAND81). These are characterized by intermediate characteristics in respect to the previous groups: a quite homogeneous fine matrix, with quartz, plagioclases, sanidine, green pleochroic pyroxenes and biotite, together with volcanic inclusions in the CBAND samples.

The petrographic characteristics of the samples under study grouped in the group 1 allow to unambiguously link them with the group b of the reference materials. Samples L10 and L16, macroscopically attributed to Pyrgi production show different petrographic features, where L10 is now attributed to the previous group and the L16 goes a part. The sample 19913 shows good analogies with the samples from Veii. Finally, the group 2 of the samples under study find similar characteristics with the reference materials in the group a, even though exhibiting variabilities between the samples concerning mainly the inclusions abundance and typology. Overall the samples could be thought as materials obtained with similar manufacturing conditions, with temperature higher than 800°C, confirming what previously hypothesized, as suggested by the not active or quite active optical state of the groundmass.

Petrographic analysis confirms the distinction between the Caeri and Banditaccia samples from Veii and Pyrgi pottery. Worth of note is that the samples CBAND71 and CBAND81, belonging to the Banditaccia reference group have similar petrographic features of Veii and Pyrgi samples suggesting close exchange relationship between the two Etruscan towns. For what concern the material supply the presence of the green clinopyroxenes and the scoriaceous volcanic rocks fragments suggest the use of local materials. In particular, it is conceivable that the volcanic inclusions may be related to the volcanic complexes of the Roman magmatic province [15, 16]. SEM-EDS analysis of volcanic rock inclusions exhibit SiO_2 abundances ranging from 53.81% to 64.07% and plot in the TAS diagram (Fig. 4) in the fields of Vulsinian lavas and Tolfa, Cerveteri and Manziana volcanic products

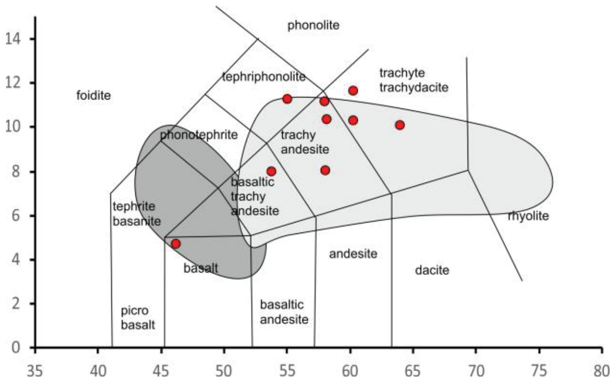

Fig. 4. TAS diagram showing the composition of the analyzed samples in the area of Vulsinian lavas and Tolfa (dark grey), Cerveteri and Manziana volcanic products (light grey area).

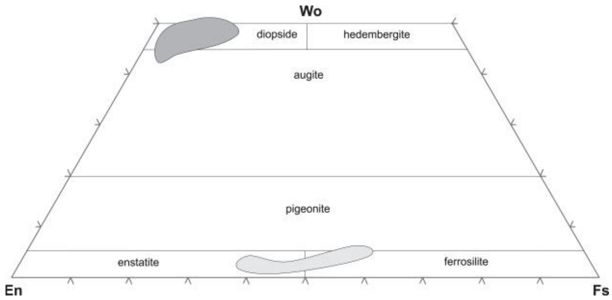

Fig. 5. Classification diagram [20] of ceramic pyroxenes analysed on a selection of samples retrieved from the Comando Carabinieri Tutela Patrimonio Culturale operation (L10, L14A, L5, L8, 19913 and L16) and on some representative samples of the different reference archaeological site (CBAND81, CBAND9. CERI10; VEXM01).

[17, 18]. Regardless to the petrographic individuated groups, about 6 pyroxenes for each terracotta samples selected, with a total of 63 pyroxenes, have been studied. Among the selected samples have been chosen also three reference materials. The data obtained has been, thereafter, elaborated with the Win Pyrox Software [19], and plotted on the Morimoto diagram (Fig. 5). Hence, the obtained data have been compared with the typical pyroxene's distribution of the Tuscan, Roman and Campanian areas according to literature [20, 21]. Besides to a main diopsidic and augitic composition of the pyroxenes, some ortopyroxenes have been individuated (Fig. 5). The presence of orthopyroxene together clinopyroxene addresses the provenance identification of the raw materials since in the Cerveteri area is well know the presence of high silica volcanic rocks characterised by the coexistence of these two pyroxene types [16, 17, 18, 22, 23].

IV. CONCLUSIONS

The petrographic characterization by the polarized light optical microscope of the samples retrieved from the illegal trade and attributable to Caere, compared with Etruscan reference materials, provided interesting answers to the questions left opened by the non-invasive investigations. The acquired data support the hypothesis of diverse production sites in the Southern Etruria. It is maintained the idea of a Caeretan site of production, including the area of the Banditaccia Necropolis, individuating two subgroups; while two distinctive sites are attributed to the areas of Veii and Pyrgi, although they show similar petrographic appearance if compared with the samples from Caere. Looking deeper to the identified groups, differences are enhanced suggesting the idea of possible exchanges among the centres or the presence of many craftsman schools, thus explaining, for instance, the presence in the Caere area of samples with more similar characteristics to the ceramics from Pyrgi and Veii. However, the overall similarities of the ceramic corpus under study allow to confirm the authenticity of the remains. The only sample, that already by literature and by the naked eye observation arouses suspicious, is the L16, the only one presenting litharge for the yellow tint and without any ceramic correlation. Furthermore, this study highlighted some technical characteristics which contribute to improve our knowledge about the technological level of the ceramists in southern Etruria. Interesting is, for this reason, the discovering of pumice fragments, that on one site could be related with a conscious choice in order to lighten the slab weight; on the other side it could be, together with the pyroxenes, a precious clue for provenance identification of the raw materials. To this regard, it is plausible a correlation with the volcanism of central Italy, particularly with the Tuscan and Roman provinces, while it is equally possible that the pumice inclusions were imported from other magmatic provinces such as Campanian, Aeolian or Etnea ones. Promising are indeed the obtained data, that will be integrated with a deepened complementary geochemical analysis and statistical treatment with a suitable literature comparison of pyroxenes and pumice from various magmatic provinces. Interesting further studies would involve, moreover, the chemical investigation of sediments retrieved in the neighbouring to the archaeological excavations.

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