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Archaeometric investigations on Roman stamped tiles and bricks from the Cariati territory (Calabria, Southern Italy)

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***Abstract* – The present work shows the preliminary results of an archaeometric study involving a group of tiles and bricks dated back to the late 3^{rd}-1^{st} century BC, found in the archaeological site of Scala Coeli, Terravecchia and Cariati, in the province of Cosenza (Calabria, Southern Italy). The materials were analyzed by Optical microscopy, X-ray Powder Diffraction and Energy Dispersion Microanalysis by Scanning Electron Microscope, to identify the composition of the samples, the area of extraction of the raw materials and the technological aspects related to the processing of the clay.**

The comparison between the chemical composition of the samples with the clay and the sand coming from quarries of the Cariati area confirms that most of the tiles were locally produced using raw materials from natural Pliocene outcrops.

I. INTRODUCTION

During surface surveys carried out between 2010 and 2011 by the Laboratory of Ancient Topography and Calabrian Antiquities of the University of Calabria, in the municipalities of Scala Coeli, Terravecchia and Cariati (Figs. 1a, 1b), in the province of Cosenza (Calabria, Southern Italy) a group of tile and brick, dated back to the late 3^{rd}-1^{st} century BC, was found. Very significant within them are some samples impressed with the stamps L. LUSIPETEL (Fig. 2a) and M. MECONI (Fig. 2b).

This type of stamped tiles and bricks is very widespread along the Ionian coast of central-northern Calabria. On the basis of prosopographical and archaeological evidences, it was hypothesized their belonging to *figlinae*, a production plant that operated in the north-central Ionian coast of the Region between the late Republican period and the Roman imperial age, owned, respectively, by the family of the Lusii and the *gens* Megonia of Petelia (today Strongoli) [1].

From the epigraphic sources it is known that the *Megonii* of Petelia were owners of large estates starting from the 1^{st} century BC and, in the Antonine age, they held vast landholdings, establishing themselves as one of the most important families in the area [2].

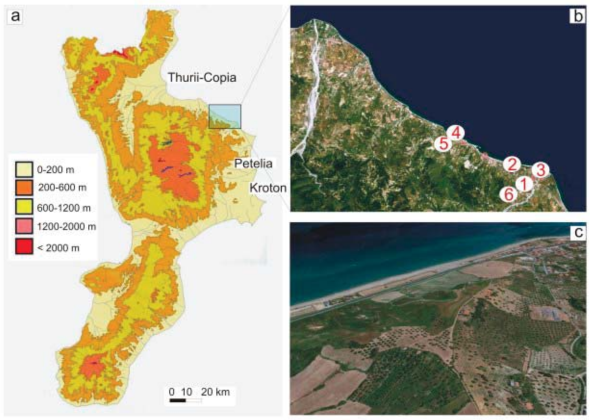

Fig. 1. a) Calabria region with localization of the area under study. b) Satellite photo of the Ionian coast with details of the area [1: Cariati, Montagnola, 2: Cariati, Santa Maria, 3: Cariati, Serre Boscose, 4: Cariati, Zagaria, 5: Scala Coeli, Frassinetti, 6: Terravecchia, Merolla]. c) Aerial photo of the Zagaria area (Cariati).

Territorial investigations have shown that in Roman times the first network of coastal reliefs belonging to the territories of Cariati, Terravecchia and Scala Coeli were affected by a dense network of *villae* - sometimes simply rustic, monumentalized at the end of the late Republican age - served by the route of the nearby coastal road that connected Reggio with Taranto, on which the *statio* of Paternum, identified with the Roman settlement of Cariati Santa Maria, gravitated. Indeed, not far from the Ionian coast, were located: the villa of Manio Megonio, in Cariati Zagaria, where tiles with the stamp of the owner name were produced, and the production plant owned by the petelino Lucio Lusio, recently brought to light in the area of the Cariati railway station, used for the production of Dressel 2-4 amphorae and tiles. The archaeological investigations and the geophysical prospecting carried out in the two sites irrefutably attest the presence of furnaces for the production of these artifacts [3].

The discovery of stamped artefacts in the archaeological sites of Cariati, Scala Coeli and Terravecchia, allowed us to assume that, in Roman times, these territories economically gravitated around the city of Petelia or, even, were administratively part of the ager petelinus.

In this work sixteen tile and brick samples coming from the archaeological sites mentioned above, were studied with the aim to determine their composition, to identify the area of extraction of the raw materials and to obtain information about the technological aspects related to the processing of the clay.

II. MATERIALS AND METHODS

The examined samples include sixteen pieces of tiles, bent tiles and a brick (Table 1) found on the surface during topographic surveys carried out in the different archaeological sites. Nine of them show a stamp, two are illegible but the others can be attributed to *Lusius Petelinus* (Fig. 2a) and *Manius Meconius* (Fig. 2b).

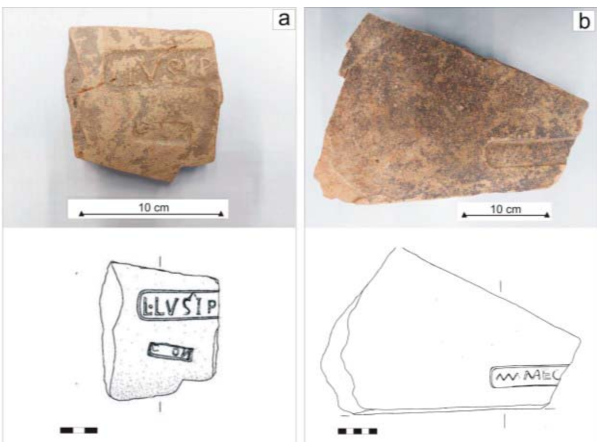

Fig. 2. a) Sample CR058 with the L. LUSIPETEL stamp. b) Sample CR1051 with the M. MECONI stamp.

The samples come from the municipality of Cariati, in the localities of Santa Maria, Montagnola, Serre Boscose and Zagaria (Figs. 1b and 1c); from the municipality of Scala Coeli, in the locality of Frassinetti (Fig. 1b) and from the municipality of Terravecchia, in the locality of Merolla (Fig. 1b, Table 1).

Table 1. List of the samples with discovery area, typology, stamps and dating.

Sample	*Area of provenance*	*Typology*	*Stamp*	*Dating*
CRO58	Cariati Santa, Maria	Bent tile	L. LUSIP[...]	Late 2^{nd}- 1^{st} cent BC
CR271	Cariati, Montagnola	Tile	NA[...]	Late 3^{rd}- 2^{nd} cent BC
CR272	Cariati, Montagnola	Bent tile	N. LU[...]	Late 2^{nd}- 1^{st} cent BC
CR276	Scala Coeli, Frassinetti	Tile	Illegible	Late 1^{st} cent BC
CR277	Scala Coeli, Frassinetti	Tile	[…]CON[.]	Late 1^{st} cent BC
CR375	Cariati, Serre Boscose	Tile	Absent	Late 3^{rd}- 1^{st} cent BC
CR382	Cariati, Serre Boscose	Brick	EP[...]	Late 3^{rd}- 1^{st} cent BC
CR420	Cariati, Serre Boscose	Tile	Absent	Late 3^{rd}- 1^{st} cent BC
CR812	Cariati, Serre Boscose	Tile	L. LUSIPETEL	Late 2^{nd}- 1^{st} cent BC
CR944	Cariati, Zagaria	Tile	Absent	Late 2^{nd}- 1^{st} cent BC
CR945	Cariati, Zagaria	Tile	Absent	Late 2^{nd}- 1^{st} cent BC
CR963	Cariati, Zagaria	Bent tile	Absent	Late 2^{nd}- 1^{st} cent BC
CR1051	Cariati, Zagaria	Tile	M. MEC[...]	Late 1^{st} cent BC
CR1056	Cariati, Zagaria	Tile	Illegible	Late 1^{st} cent BC
CR1757	Scala Coeli, Frassinetti	Tile	Absent	Late 2^{nd}- 1^{st} cent BC
CR1758	Terravecchia, Merolla	Tile	Absent	Roman Imperial Age

The chronology of samples CR375, CR420, CR944, CR945, CR963, CR1757 and CR1758 - which do not show stamps and do not have diagnostic elements useful for a correct dating - has been hypothesized by the discovery contexts.

Samples were analyzed through Polarized Light Microscopy (PLM), on thin sections, using a Zeiss petrographic microscope equipped with a Canon PowerShot A640 photo camera to study the petrographic features of the samples; by X-ray Powder Diffraction (XRPD), carried out through a Bruker D8 Advance, to determine their mineralogical composition, and by Energy Dispersion Microanalysis by Scanning Electron Microscope (EDS-SEM), through a ZEISS CrossBeam 350 equipped with an EDS - EDAX OCTANE Elite Plus, Silicon drift type spectrometer, performed on the bulk powder, to obtain a quantitative estimate of the chemical composition of all samples.

III. RESULTS AND DISCUSSION

The minero-petrographic composition of the tile and brick samples is very similar. They show a sub-rounded temper [5] principally composed of granitic and metamorphic rock fragments, such as quartzites and phyllites. In samples CR058, CR271 and CR812 traces of bioclasts are also present. The mineralogical phases mainly visible are quartz, plagioclase, k-feldspars, pyroxene and mica (Table 2). In addition, the presence of hematite was detected in samples CR1757, CR382 and CRO58 and the presence of calcite in sample CR812.

Despite these analogies, it was possible to divide the samples into two main groups:

- the first group (named G1) includes samples CR058, CR276, CR277, CR420, CR945, CR963, CR1051, CR1056 and CR1758;
- the second group (named G2) includes samples CR271, CR272, CR375 and CR944.

The samples belonging to the first group (G1) show a matrix percentage between 75 and 90% and a percentage of inclusions between 7 and 20%. The non-plastic elements, mainly composed of monocrystalline quartz and fragments of granite and quartzite rocks (Fig. 3a), show a moderately sorting [4, 5] and a size variable from "fine sand" to "coarse sand" [6]. Among them, sample CR276 is the only that shows an inhomogeneous distribution of the non-plastic inclusions (Fig. 3b) to indicate an inaccurate dough process.

In the samples belonging to the second group (G2), the matrix percentage ranges from 70 to 89%, while the percentage of inclusions varies between 7 and 25%. The non-plastic inclusions are poorly sorted [4, 5], show a coarse sand size [6] and are mainly composed of reddish shale and metamorphic fragments with an elongated shape (Fig. 3c).

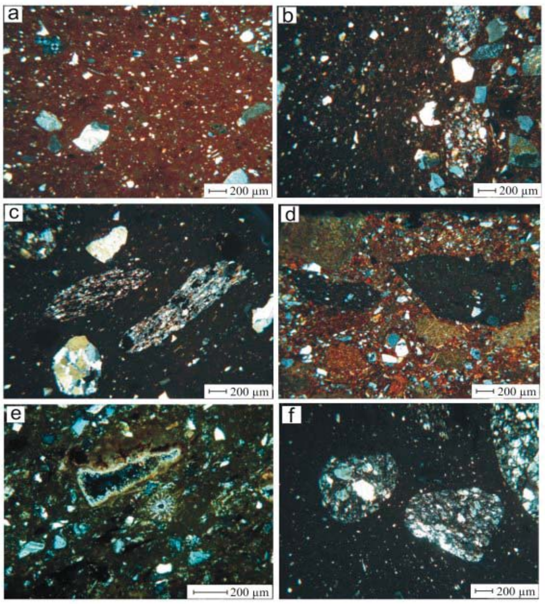

Fig. 3. Microphotos in thin section under crossed nicols. a) Sample CR1056. b) Sample CR276. c)Sample CR272. d) Grog in CR382. e) Bioclasts and recrystallized calcite in CR812. f) Rounded rock fragments in CR1757.

From these two groups three samples (CR382, CR812 and CR1757) deviate, due to the following features:

- CR382 is the only brick sample and it is the only one that contains grog (Fig. 3d).
- CR812 sample is almost composed exclusively from pure clay and, as confirmed by the chemical microanalysis, shows a calcium content higher that other samples, most likely linked to the presence of bioclasts and recrystallized calcite (Fig. 3e).
- CR1757 sample is similar to the second group (G2), however it is characterized by inclusions with a high sphericity (Fig. 3f). This peculiarity is most likely due to the use of a different temper, probably deriving from a river.

Table 2. Mineralogical composition of the samples in order of abundance [Cal: calcite, Hem: hematite, Ksf: k-feldspar, Pl: plagioclase, Px: pyroxene; Qtz: quartz].

Sample	***Max*** ***Min***
CRO58	Qtz, Pl, Px, Ksf, Hem, Mica
CR271	Qtz, Pl, Ksf, Px, Mica
CR272	Qtz, Pl, Px, Ksf, Mica
CR276	Qtz, Pl, Ksf, Px, Mica
CR277	Qtz, Pl, Px, Ksf, Mica
CR375	Qtz, Pl, Px, Ksf, Mica
CR382	Qtz, Pl, Ms, Ksf, Px, Hem
CR420	Qtz, Pl, Px, Ksf, Ms, Mica
CR812	Qtz, Pl, Px, Ksf, Cal, Mica
CR944	Qtz, Pl, Ksf, Px, Mica
CR945	Qtz, Pl, Ksf, Px, Mica
CR963	Qtz, Pl, Px, Ksf, Mica
CR1051	Qtz, Ksf, Pl, Px, Mica
CR1056	Qtz, Pl, Ksf, Px, Mica
CR1757	Qtz, Pl, Px, Ksf, Hem, Mica
CR1758	Qtz, Pl, Mica, Ksf, Px

By observing the mineralogical phases identified by XRPD analysis (Table 2), it is possible to note, in all samples, the presence of pyroxene (probably fassaite) which forms at about 850 °C [7]. Its presence with the presence of mica (illite/muscovite and biotite) that decompose around 950 °C, and the absence of chlorite, which is naturally present in clays and disappears at temperatures above 650 °C, indicate that the samples were all fired at temperatures between 850 and 950 °C.

The chemical composition of the samples allowed us to confirm the differences identified by optical microscopy. The diagram in Figure 4, obtained by processing the chemical data in agreement with Aitchison [8], shows that the samples belonging to the first (G1) and the second (G2) group have a very similar chemical composition, while the other three samples CR382, CR812 and CR1757 show some differences.

In particular, the content of calcium oxide (CaO) is the highest in sample CR812 (which shows the presence of bioclasts and recrystallized calcite) and the lowest in sample CR382 (that contains grog), while sample CR1757 shows the lowest amount of silicon oxide (SiO_2).

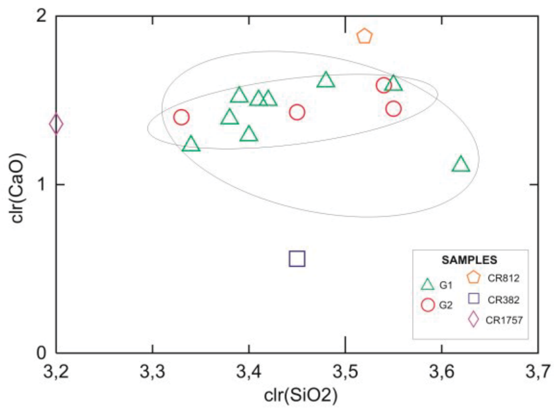

Fig. 4. Bi-plot diagram CaO vs SiO_2, with chemical data transformed into Centered Log Ratio (clr), in agreement with Aitchinson [8].

To make hypotheses about the provenance of the raw materials, the chemical composition of the samples was compared with the chemical data relating to the clay and sand samples taken from different quarries in the Cariati area, studied in Miriello et al. [9]. The considered area is located in the Ionian margin of the Sila Massif, and consists of alpine structural units having a Paleozoic basement with a Mesozoic sedimentary cover, and Neogene to Quaternary dominantly clastic basinal successions [10, 11]. In particular, for the comparison were considered the clays (Car1 and Car 2) collected from Upper Pliocene silty clay, and the sand (Car 4) sampled from sandy flood deposits.

By observing the comparison of the chemical data, in Figure 5, it is possible to note that the samples belonging to groups G1 and G2 show a chemical composition compatible with the clay quarries (Car 1 and Car 2). However, the samples show a lower calcium content than the clay taken from the quarries, due to the addition of sand compatible with the Car 4 quarry, probably used as temper during the production of the artefacts.

Also in this case, samples CR382, CR812 and CR1757 show different features. In particular:

- CR382 sample shows a lower calcium content than that present in the clays. This may be linked to several factors: the use of grog; the use of extremely purified clay, low in calcium; or a non-local origin of the sample.
- CR812 sample has a higher calcium content than that found in clays, so it is possible to hypothesize that in the clayey mixture of this sample a different clay, very rich in calcium, was employed, or that the sample does not have a local origin.
- CR1757 sample shows a SiO_2 content lower than that present in the clays. Being made up of very rounded clasts, it is possible to hypothesize that for the production of this tile a different temper was used, most likely coming from the river.

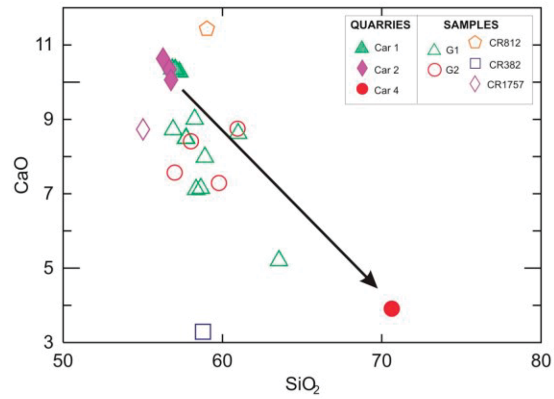

Fig. 5. Bi-plot diagram CaO vs SiO_2 where the comparison with the clay (Car1 and Car 2) and sand (Car 4) quarries [8] is shown.

IV. CONCLUSION

The archaeometric study performed on the sixteen samples of tiles and bricks stamped coming from the archaeological site of Scala Coeli, Terravecchia and Cariati, in the province of Cosenza, allowed us to determine their composition, the provenance of the raw materials and the technological aspects related to their production.

All samples were fired at temperatures between 850 and 950°C. From a petrographic point of view, it was possible to identify two main groups of samples (G1 and G2). However, the tiles belonging to these two groups show the same chemical composition that is compatible with the raw materials coming from the natural Pliocene outcrops present in the area of Cariati. Consequently, it is possible to assume that the samples belonging to these two groups were locally produced and their petrographic differences are probably linked to different craftsmen.

In G1 and G2 groups, tiles with both stamps (L. LUSIPETEL and M. MECONI) are included, therefore the production technology of these two types of artifact is the same.

From the two main groups, samples CR382, CR812 and CR1757 deviate. They show different petrographic features and their chemical composition is not compatible with the clays taken from the studied quarries.

In particular, sample CR382 (without stamp) contains a different temper (composed of grog) that, most likely, is linked to its different function (it is the only brick), or to its belonging to a different manufacturing.

As regards samples CR812 (that shows the stamp attributed to Lusius Petelinus) and sample CR1757 (without stamp) is possible to hypothesize respectively the use of a different clay and a different temper, that could be of non-local origin or could indicate that the tiles were produced in a different area.

However, the different composition of the samples does not necessarily indicate a different provenance, but it could also simply indicate a different processing of the dough [12]. It is also likely that the raw materials are of local origin, but that they were taken from an outcrop of which, unfortunately, no samples were collected to verify their provenance.

REFERENCES

[1] A.Taliano Grasso, "La Sila Greca. Atlante dei siti archeologici". Edizioni Corab, Gioiosa Ionica, 2008.

[2] A.Taliano Grasso, "Bolli laterizi inediti di Manio Megonio da località Zagaria di Cariati (Cosenza)", in "Minima epigraphica et papyrologica", L'Erma di Bretschneider, III, 2000.

[3] A.Taliano Grasso, "Il parco archeologico di Cariati e Terravecchia. Storia e archeologia di un territorio", Edizioni TS, Settingiano, 2005.

[4] D.A.Jerram, "Visual comparators for degree of grain-size sorting in two and three-dimensions", Computers & Geoscience, 27, 2001, 485-492.

[5] S.Jr.Boggs, "Petrology of sedimentary rocks", Cambridge University Press. Cambridge UK. 2010.

[6] C.K.Wentworth, "A scale of grade and class terms for clastic sediments", Journal of Geology, 30, 1922.

[7] C.Rathossi, Y. Pontikes, "Effect of firing temperature and atmosphere on ceramics made of NW Peloponnese clay sediments: Part II. Chemistry of pyrometamorphic minerals and comparison with ancient ceramics", Journal of the European Ceramic Society 30 (9), 2010, 1853-1866.

[8] J.Aitchison, "The statistical analysis of compositional data (with discussion)", Journal of the Royal Statistical Society, Series B (Statistical Methodology) 1982, 139-177.

[9] D.Miriello, A.Bloise, R.De Luca, C.Apollaro, G.M.Crisci, S.Medaglia, A.Taliano Grasso, "First compositional evidences on the local production of Dressel 2–4 amphorae in Calabria (Southern Italy): characterization and mixing simulations", Applied Physics A, 119(4), 2015, 1595-1608.

[10] M.Barone, R.Dominici, F.Muto, S.Critelli, "Detrital modes in a late Miocene wedge-top basin, northeastern Calabria, Italy: compositional record of wedge-top partitioning", Journal of Sedimentary Research, 78(10), 2008, 693-711.

[11] C.Apollaro, L.Marini, T.Critelli, R.De Rosa, A. Bloise, D.Miriello, M.Catalano, V.Armano, "Modeling of the impact of dolomite and biotite dissolution on vermiculite composition in a gneissic shallow aquifer of the Sila Massif (Calabria, Italy)", Applied Geochemistry 35, 2013, 297–311.

[12] G.Eramo,"Ceramic technology: how to recognize clay processing", Archaeological and Anthropological Sciences 12(8), 2020, 1-24.