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Characterization and provenance of Roman tiles from the archaeological sites of Cariati, Scala Coeli and Terravecchia (Calabria, Southern Italy)

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ABSTRACT
This paper concerns the archaeometric study carried out on a group of tiles and a brick belonging to the Roman period. In particular, the samples are dated back to the late 3rd-1st century BC and they come from the archaeological sites of Cariati, Scala Coeli and Terravecchia, in the province of Cosenza (Calabria, Southern Italy). Some of these samples are impressed with the stamps L./N. LUSIPETEL and M. MECONI, belonging to a production plant that operated in the north-central Ionian coast of the Calabria Region between the late Republican period and the Imperial age, owned to two important families of Petelia (today Strongoli). All samples were analyzed by Optical microscopy, X-ray Powder Diffraction and Energy Dispersion Microanalysis by Scanning Electron Microscope, in order to determine their minero-petrographic features and their geochemical composition, to identify the extraction area of the raw materials and the technological aspects related to the processing of the clay. In addition, the comparison between the chemical composition of the samples with the clay and the sand coming from some quarries of the Cariati area confirms that most of the samples were locally produced using raw materials from natural Pliocene outcrops.

Section: RESEARCH PAPER

Keywords: Archaeometry; stamped tiles and bricks; raw materials; clay; production technology; provenance

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1. INTRODUCTION

The samples analysed in this work were found 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 Cariati, Scala Coeli and Terravecchia (Figure 1), in the province of Cosenza (Calabria, Southern Italy). In particular, they correspond to fifteen Roman tiles and one brick, dated back to the late 3rd-1st century BC. Within them, some samples impressed with the stamps L./N. LUSIPETEL (Figure 2a and Figure 2b) and M. MECONI (Figure 2c) are present.

This type of stamped artefacts is very widespread along the Ionian coast of central-northern Calabria and, on the basis of archaeological and epigraphic evidences, it was hypothesized their belonging to *figlinae*, a production plant that worked 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, whose fortunes began after the end of the civil wars, were owners of large estates starting from the 1st century BC and still, in the Antonine age, they held vast landholdings, establishing themselves as one of the most important families in the area [2]. Indeed, north of the Nicà river, not far from the Ionian coast, in Cariati Zagaria, there was one of the *villae* of Manio Megonio; here, the electrical, magnetometric and georadar surveys,

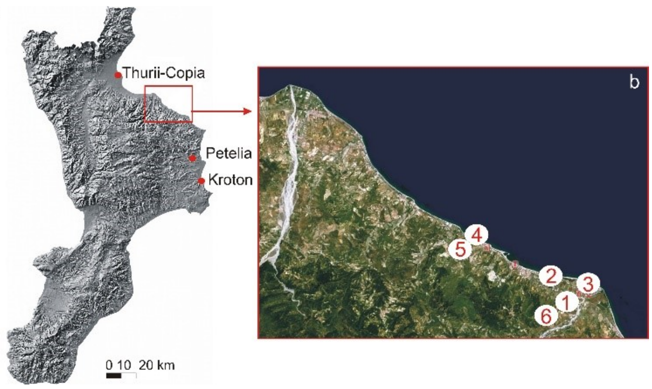

Figure 1. a) Calabria region with localization of the area under study. b) Satellite photo of the Ionian coast with details of the area [1: Cariati, Montagnola, 2: Cariati, Santa Maria, 3: Cariati, Serre Boscose, 4: Cariati, Zagaria, 5: Scala Coeli, Frassinetti, 6: Terravecchia, Merolla].

conducted in 1990 by the Department of Earth Sciences of the University of Calabria, located an important circular anomaly certainly attributable to the buried remains of a furnace, where - analysing the scraps on the surface - various forms of domestic pottery and, above all, the tiles with the stamp of the owner name were produced [3]. In the area of the Cariati railway station, instead, was recently brought to light a production plant, probably owned by the petelino Lucio Lusio, that was used to produce Dressel 2-4 amphorae and tiles. The archaeological investigations and the geophysical prospecting carried out in these two sites irrefutably attest the presence of furnaces for the production of these artefacts [4].

Territorial investigations have shown that in Roman times the first network of coastal elevations facing the Ionian Sea were affected by a dense network of *villae*, sometimes simply rustic, monumentalized at the end of the late Republican age. The topographical choice of these settlements seems aimed not only at a system of agricultural exploitation of the territory based on the specialization of crops (probably grain in the flat areas and oil or wine in the hilly areas), but also to other economic-commercial factors. In fact, the *villae* are distributed near the important coastal road that connected Reggio with Taranto, on which the Paternum *statio* gravitated, identified with the Roman settlement of Cariati, Santa Maria [4]; located *sub radice montis* (Serre Boscose and Zagaria, Gabbella of Mandatoriccio, Sorrenti and Santa Tecla of Crosia); near sea or river landings (Cariati Santa Maria, Gadice of Calopezzati, Decanato of Crosia, Strange of Cropalati, Fego and Solfara of Rossano) [5].

As regards the different landed properties, currently it is not possible to have any certainty, except for the *villa* in the locality of Zagaria, where the discovery of tiles stamped M. MECONI allows us to assign the land to the rich equestrian family of Petelia. Furthermore, the findings of Zagaria and the topographical distribution of the remaining epigraphic documentation (above all the artefacts characterized by the LUSIPETEL stamp) could represent a first clue to trace the pertinence limit between the *ager thurinus* and the *petelinus* one and to assign to the latter the territory located in the south of the Trionto river [6].

The sixteen samples collected from the archaeological sites of Cariati, Scala Coeli and Terravecchia were characterized from a mineralogical, petrographic, and chemical point of view, in order 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 [7].

As demonstrated by previous studies [8]-[11] these materials bear the potter's mark, and their study helps us to understand their production technology, the raw materials employed and their supply, but also the trade and the everyday life in the area in which the materials were found. In particular, the study of stamped artefacts allows us to reconstruct the aspects of the organization and the production processes of the local workshops [12] that, in most cases, in the investigated area, were located near the *villae*.

The identification and location of several new Roman production plants - used for the production of roof tiles, amphorae and domestic pottery - uniformly distributed in the area between the basins of the Trionto river to the north-west and the Nicà river to the south-east (Figure 3, Table 1), as well

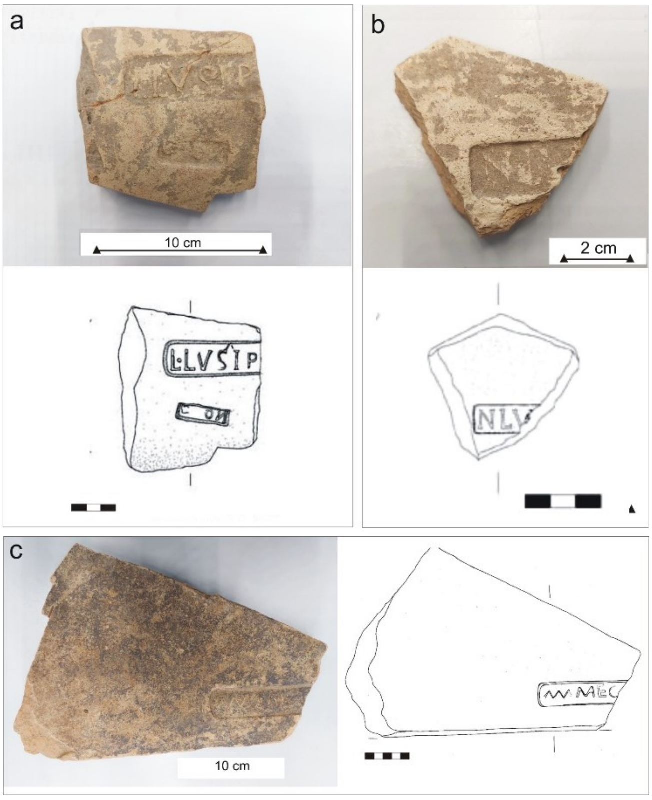

Figure 2. a) Sample CR058 with the L. LUSIPETEL stamp. b) Sample CR272 with the N. LUSIPETEL stamp. c) CR1051 with the M. MECONI stamp.

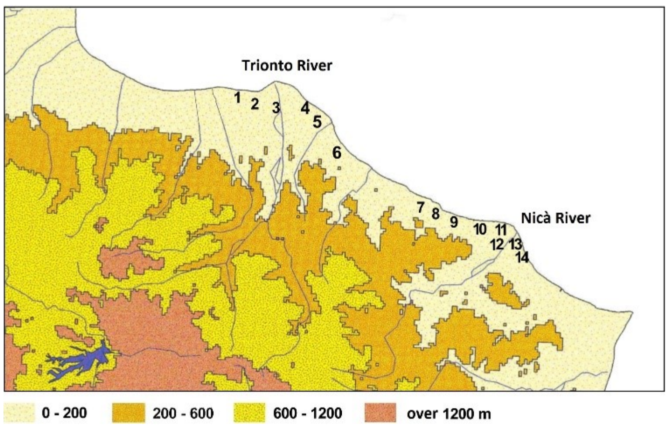

Figure 3. Distribution of Roman furnaces on the Ionian coast between the Trionto and Nicà rivers. The numbers correspond to the sites listed in Table 1, the legend of colors and meters indicates the height from the sea level.

Table 1. List of the sites with Roman furnaces with locality, date of survey and type of findings and production (the numbers in the first column are shown in Figure 3).

Site N.	Locality	Survey	Findings	Production
1	Rossano, Solfara	Excavation 1939	Circular furnace; furnace scraps	Bricks and domestic vases
2	Rossano, Fego	Reconnaissance 2011	Furnace remains; furnace scraps	Domestic vases
3	Cropalati, Strange	Reconnaissance 1989	Furnace remains; furnace scraps	Tiles
4	Crosia, Decanato	Reconnaissance 2016	Overfired bricks, furnace scraps and slag	Tiles, bricks, domestic vases
5	Crosia, Santa Tecla	Reconnaissance 2016	Furnace scraps	Tiles, domestic vases, loom weights
6	Calopezzati, Borea	Reconnaissance 1989	Furnace remains; furnace scraps	Household vases
7	Cariati, Zagaria	Geophysical prospecting, Reconnaissance 1990	Furnace remains; furnace scraps	Tiles, domestic vases
8	Cariati, Brello	Reconnaissance 1989	Furnace remains; overfired vases; furnace wedge	Domestic vases
9	Cariati, Station F.S.	Excavation 2008	Circular furnace; furnace scraps	Tiles, Dressel 2-4, domestic vases
10	Cariati, Santa Maria	Excavation 1983	Circular furnace; overfired vases	Domestic vases
11	Cariati, Sant'Angelo	Reconnaissance 2011	Furnace with a square plan; furnace scraps	Tiles
12	Cariati, Serre Boscose	Reconnaissance 2011	Furnace remains; furnace scraps	Tiles
13	Crucoli, Manele	Reconnaissance 1989	Furnace remains	-
14	Crucoli, Piano Mazza	Excavation 1981	Furnace with a square plan; furnace spacers	-

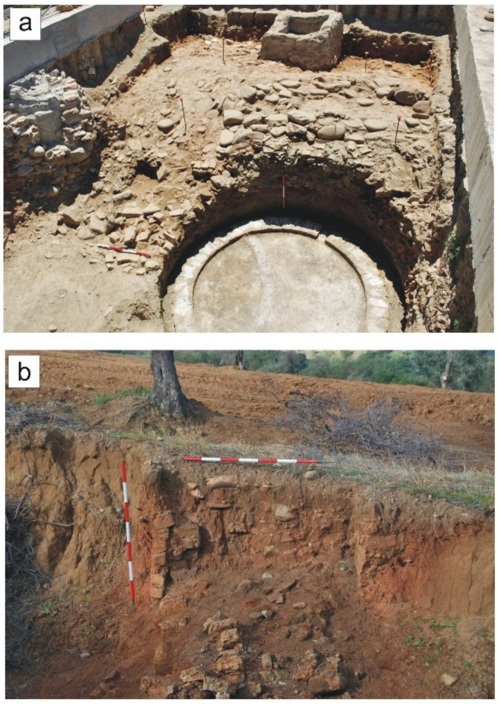

Figure 4. a) Production plant in Cariati railway station, under excavation (photo by E. Salerno). b) Furnace remains in Cariati S. Angelo.

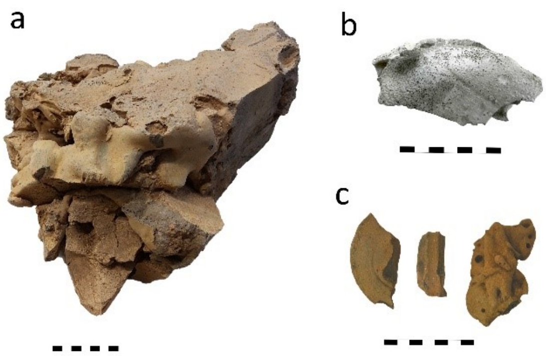

Figure 5. Furnace scraps. a) Cariati, railway station. b) Calopezzati, Borea. c) Cariati, Zagaria.

as the ease of finding raw materials due to the natural Pliocene outcrops present in the area, would seem to indicate this activity (next to those related to agriculture and pastoralism) as one of the main components of the economy of this area (Figure 4 and 5).

2. MATERIALS AND METHODS

The sixteen samples analysed in this work include twelve pieces of tile, three pieces of bent tiles and one brick (Table 2). These samples were found on the surface during topographic surveys carried out in the archaeological sites of Cariati, Scala Coeli and Terravecchia. Nine of them show a stamp, two are illegible but the others can be attributed to L./N. Petelinus (Figure 2a, Figure 2b) and Manius Meconius (Figure 2c).

The samples come from the municipality of Cariati, in the localities of Santa Maria, Montagnola, Serre Boscose and Zagaria; from the municipality of Scala Coeli, in the locality of Frassinetti and from the municipality of Terravecchia, in the locality of Merolla (Figure 1b – Table 2) and they date back to a period ranging from the late 3rd to the 1st century BC (Table 2). As regards 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 – their chronology (Table 2) has been hypothesized by the discovery contexts.

To study their petrographic features, all samples were analysed, in thin sections, by Polarized Light Microscopy (PLM), using a Zeiss Axioskop 40 petrographic microscope (Zeiss, Jena, Germany), equipped with a Canon PowerShot A640 photo camera (Canon, Tokyo, Japan) for the acquisition of the images. Roundness and sorting of the non-plastic inclusions were defined using qualitative visual estimation charts [13], [14], [15], while the semi-quantitative estimate of the percentages of non-plastic inclusions, temper and macroporosity ($d > 1/16$ mm) as volume fractions, was obtained by comparing the thin sections observed under optical microscopy with visual charts [16], [17].

The mineralogical composition was determined by X-ray powder diffraction (XRPD), performed through a Bruker D8 Advance X-ray powder diffractometer (Bruker, Karlsruhe, Germany), with Cu-Kα radiation, operating at 40 kV and 40 mA. Scans were collected with a step scan of 0.02° 2θ and 2 s/step, in the range 3-60° 2θ. To identify the mineralogical phases in each X-ray powder spectrum, DIFFRACplus EVA V. 11.3

Table 2. List of the samples with discovery area, typology, stamp and dating.

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

software program (Bruker, Karlsruhe, Germany) was used, by comparing the experimental peaks with PDF2 reference patterns.

To obtain a semi-quantitative estimate of the chemical composition of all samples, the bulk powders were analysed by Energy Dispersion Microanalysis through Scanning Electron Microscope (EDS-SEM), using a ZEISS CrossBeam 350 equipped with an EDS - EDAX OCTANE Elite Plus, Silicon drift type spectrometer. The acquisition instrumental conditions are: HV: 15 keV; probe current: 100pA, working distance: 11 mm and live time: 30 sec.

3. RESULTS AND DISCUSSION

3.1. Mineralogical and petrographic characterization

From a minero-petrographic point of view the tiles and the brick samples are very similar. They show a sub-rounded temper [10], [11] 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 - observed by optical microscopy and integrated by XRPD analysis (Table 3) – are: quartz, plagioclase, k-feldspars, pyroxene, and mica (both muscovite and biotite). 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% [13], [14]. The non-plastic elements, mainly composed of monocrystalline quartz and fragments of granite and quartzite (Figure 6a), show a moderately sorting [14], [15] and a size variable from “fine sand” to “coarse sand” [18]. Among them, sample CR276 is the only that shows an inhomogeneous distribution of the non-plastic inclusions (Figure 6b) 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% [16], [17]. The non-plastic inclusions are poorly sorted [14], [15], show a coarse sand size [18] and are mainly composed of reddish shale and metamorphic fragments with an elongated shape (Figure 6c).

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 (Figure 6d);
- CR812 sample contains several bioclasts and calcite, detected also by XRPD. In particular, it shows many pores with recrystallized calcite (Figure 6e).

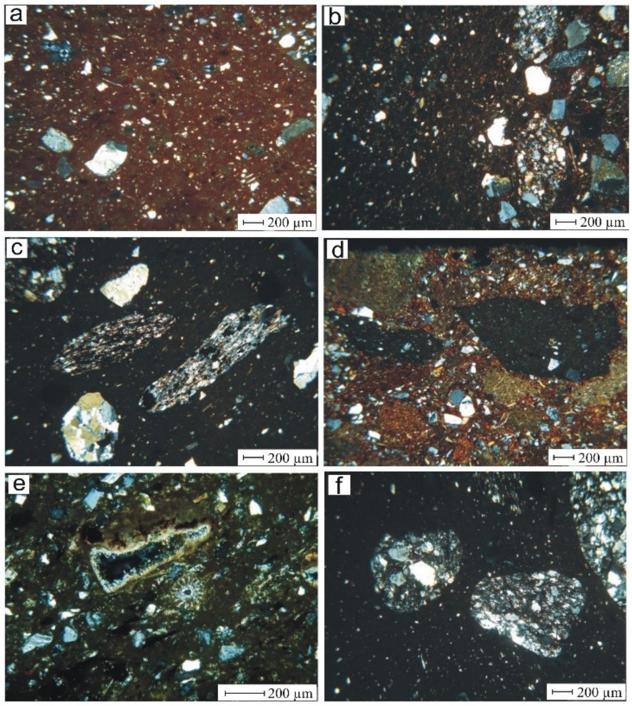

Figure 6. Microphotos in thin section under crossed nicols (from Taliano Grasso et al. [7]). a) Sample CR1056. b) Sample CR276. c) Sample CR272. d) Grog in CR382. e) Bioclasts and recrystallized calcite in CR812. f) Rounded rock fragments in CR1757.

- CR1757 sample is similar to the second group (G2), however it is characterized by rock fragments with a high sphericity (Figure 6f). This peculiarity is most likely due to the use of a different temper, probably deriving from a river.

By observing the mineralogical phases identified by XRPD analysis (Table 3), it is possible to note, in all samples, the presence of pyroxene, probably fassaite (i.e. ferrian aluminian diopside, according to the International Mineralogical Association's Commission on New Mineral Names), which forms at about 850 °C [19]. Its presence, together with mica (muscovite and biotite) that decompose around 950 °C, and the absence of chlorite, which is naturally contained in clays and disappears at temperatures above 650 °C, indicate that the samples were all fired at temperatures between 850 and 950 °C.

3.2. Geo-chemical characterization

The chemical composition of the samples allowed us to confirm the differences identified by optical microscopy. The diagram in Figure 7, obtained by processing the chemical data in agreement with Aitchison [20], 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 that show minero-petrographic differences, also in this case, deviate from the main groups as they contain a different calcium oxide (CaO) and silicon oxide (SiO_2) content.

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

3.3. 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, previously studied in Miriello et al. [21], to make hypotheses about the provenance of the raw materials employed in the production of the tiles and the brick. The sampled area is 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

Table 3. Mineralogical composition of the samples in order of abundance obtained by XRPD analysis [Cal: calcite, Hem: hematite, Ksf: k-feldspar, Pl: plagioclase, Px: pyroxene; Qtz: quartz].

Samples	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	

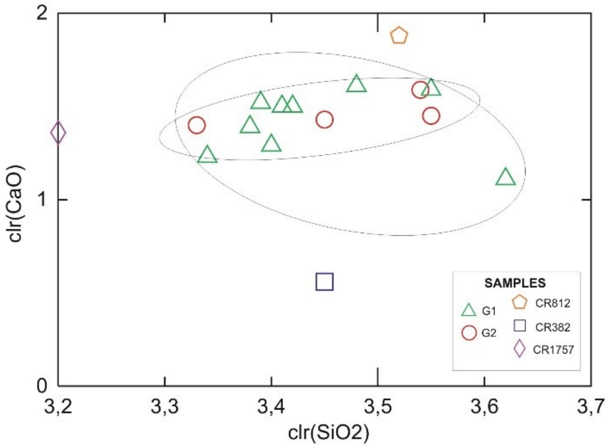

Figure 7. Bi-plot diagram CaO vs SiO_2 (from Taliano Grasso et al. [7]) with chemical data transformed into Centered Log Ratio (clr), in agreement with Aitchinson [17].

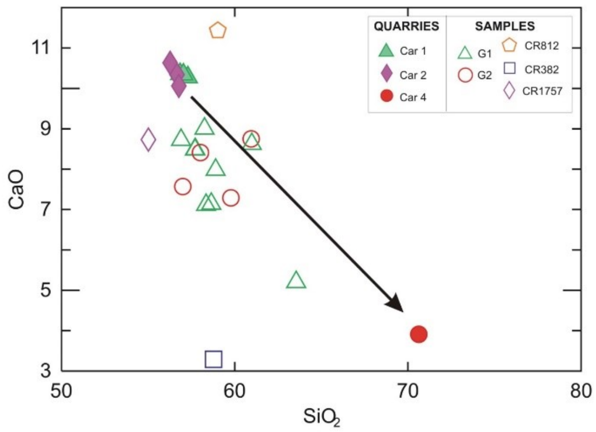

Figure 8. Bi-plot diagram CaO vs SiO_2 (from Taliano Grasso et al. [7]) where the comparison with the clay (Car1 and Car 2) and sand (Car 4) quarries studied by Miriello et al. [21] is shown.

Quaternary dominantly clastic basinal successions [22], [23]. In particular, for the comparison, the clays (Car1 and Car 2) collected from Upper Pliocene silty clay, and the sand (Car 4) sampled from sandy flood deposits were considered.

By observing the diagram in Figure 8 with the comparison of the chemical data, it is possible to note that the samples belonging to the two main 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 these quarries, due to the addition of sand compatible with the Car 4 outcrop, probably used as temper during the production of the artefacts.

In the diagram (Figure 8) it is possible to note that the tile sample CR1757 (empty rhombus) show a CaO and SiO_2 content very similar to the samples belonging to the two main groups (G1 and G2). Consequently, it is very probably that this tile was realized by using the same clay. However, being made up of very rounded clasts, it is possible to hypothesize that for its production a different temper was used.

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

While sample CR812 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.

4. CONCLUSIONS

The archaeological and topographical researches carried out in the sites of Cariati, Scala Coeli and Terravecchia, in the province of Cosenza (Calabria, Southern Italy) have brought to light very interesting materials and structures, especially stamped tiles and furnaces (Figure 4), whose products can be identified through the analysis of the recovered scraps (Figure 5, Table 1). They provide some useful elements for understanding types and methods of production, owners and clients in this part of the Bruttii territory [6].

The characterization of the sixteen samples of stamped tiles and brick coming from these sites, allowed us to determine their mineralogical, petrographical and chemical composition, obtaining information about the technological aspects related to their production and the provenance of the raw materials.

By considering the mineralogical phases present in the samples, it is possible to assume that all tiles and the brick were fired at temperatures between 850 and 950°C.

From a petrographic point of view, two main groups of samples (G1 and G2) were identified. They show some differences mainly liked to the nature of the non-plastic inclusions and to their sorting [14], [15]. However, the tiles belonging to these two groups have 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 these samples were locally produced and their petrographic differences are probably linked to different craftsmen.

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

From the two main groups, samples CR382, CR812 and CR1757 deviate. They show different petrographic features and a different chemical composition.

In particular, sample CR1757 (without stamp), most likely, was realized by using the same clay coming from the natural Pliocene outcrops present in the area of Cariati. However, being made up of very rounded clasts, it is possible to hypothesize for its production the use of a different temper, most likely coming from a river.

Instead, sample CR382 (without stamp) contains a different temper (composed of grog) that, most likely, is linked to its different function, as it is the only brick. Or it is also probably that it belongs to a different manufacturing, or it does not have a local origin.

As regards sample CR812 (that shows the stamp attributed to Lusius Petelinus) it is possible to hypothesize the use of a different clay or that the sample is not local.

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 [24].

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. In any case, the study should be expanded by contextualizing topographically and analysing, through archaeometric investigations, the tiles with the stamps of the Megonii and Lusii currently kept in the deposits of the archaeological museums of Sibari and Crotone [25]. This could provide further data useful for an overview of the economic history of the Ionian area between the ancient cities of Thurii-Copia and Petelia, that could complement what has been transmitted by the ancient historical sources.

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