

# Petrographic and chemical characterization of the archaeological finds from Muricelle site (Luzzi, CS - Italy)

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**Abstract** – Muricelle is an archaeological site located near Cosenza in Calabria (Italy), dated between the first century AD and the Late Antiquity. In Muricelle, numerous archaeological finds have been recovered including pottery, coins, metallic, glass and marble artefacts. In the present study we will illustrate the results obtained on seventeen glass finds, ten amphorae fragments and ten bricks. The petrographic and chemical characterization of the artefacts was undertaken using different analytical methodologies well known in the archaeometric field. Seven local clayey samples, collected from local outcrops were, also, analysed to define their characteristics as potential raw materials for the brick production. The archaeometric approach applied in the study provided important information contributing to reconstruct the archaeological context related to the Muricelle site.

## I. INTRODUCTION

The archaeological site of Muricelle is located in the territory of Luzzi, a village situated near Cosenza in Calabria (Italy) (Figure1) [1]. The site is characterised by the presence of wall structures built with mortar and *cocciopesto* and by the remains of a wall in *opus reticulatum* and a floor in *opus spicatum* all attributable to a Roman villa [1]. Different kinds of archaeological finds were recovered in the site: glass, pottery, marble and so on. The ceramic finds comprise common ware, amphorae, oil lamps and fine pottery testifying that the villa was inhabited from the first century up to the Late Antiquity (fourth-sixth century AD), when, probably, the site was abandoned [1, 2]. However, the typological analysis of ceramics and glasses highlights that the occupation of the villa occurred mainly in the Roman Imperial age (first - third century AD) [3].

In the present study thirty-seven samples collected from

the find assemblage were analysed with the aim of obtaining information on the composition and on the technological process for production of glass, pottery and brick.

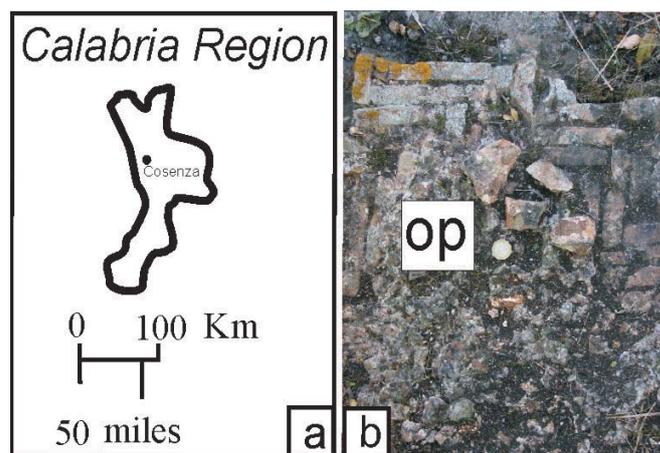


Fig. 1. a) Geographical location of archaeological site of Muricelle. b) *Opus spicatum* floor (op) of the Roman villa, and bricks samples.

The glasses fragments were analysed in order to determine their composition and to individuate similarities and/or differences among samples. In addition, the comparison between our results with the major Roman compositional groups provided the possible provenance of raw materials employed for glassmaking production.

The petrographic and chemical characterisation of the ten potteries, the ten bricks and the seven samples of clayey materials outcropping nearing the site, were carried out with the aim of identifying technological features, of gaining information on production technology and of defining the possible provenance of raw material.

## II. MATERIALS AND METHODS

In the present study a total of thirty-seven finds recovered in the archaeological site of Muricelle (Luzzi – CS) and seven clayey samples, collected from local outcrops, were analysed.

The archaeological samples include seventeen glass fragments, ten potteries and ten bricks.

Different and complementary techniques were used with the aim of executing the petrographic and chemical characterization of samples. The petrographic study of amphorae and bricks was conducted by polarizing optical microscopy (POM) on polished cross-thin sections, using a Zeiss Axiolab Optical microscope equipped with a camera Zeiss AxioCam MRc, useful for acquiring photomicrographs.

X-ray diffraction (XRD) was applied for mineralogical characterization of amphorae and bricks using a Philips PW 1730 diffractometer with vertical goniometer, Cu-K $\alpha$  radiation, operating at 40 kV and 20 mA. The investigated areas ranged between 5° and 60° of 2 $\theta$ .

X-ray fluorescence (XRF) was applied for chemical characterization of brick fragments and clayey samples, using a Philips PW 1480 spectrometer. The analyses were executed on pressed powder pellets and the correction of matrix effects was made through computer processing.

Electron Probe Micro Analyser with Energy-Dispersive X-ray spectrometry (EPMA/EDS) was employed for the chemical characterization of glasses. Analyses were carried out using a JEOL-JXA 8230 equipped with an EDS-JEOL EX-94310FaLIQ spectrometer.

Before the EPMA/EDS analyses, the polished surfaces were covered by a carbon sputter coating.

## III. RESULTS

### A. Glass finds

The morphological analyses executed on the seventeen glasses, despite their fragmentation, allows a shape attribution, therefore they were catalogued as follows: nine fragments of cup or plate, four bottles, one jug, one *bombilium*, one open shape, and one glass. As concerns the colour, the majority of the glasses shows a light blue-green shade, only five samples are colourless (Table 1).

As regards the major element concentrations, the samples show SiO<sub>2</sub> content varying from 68.72 to 71.35 wt%, and Na<sub>2</sub>O from 16.29 to 19.62 wt%, in addition values of both MnO and K<sub>2</sub>O are below 1.50 wt.%. These results indicate the natron (a sodium carbonate mineral compound abundant in some evaporitic basins) as the unique flux employed during the glassmaking production [4] confirming, as deduced from the archaeological investigations [3, 5], that the glass finds of Muricelle site fit perfectly into the Roman glass composition [6-17].

To understand the origin of raw materials and the technology of production employed in the Muricelle glass,

our results were compared with bibliographic data of the glass productions of the Roman Imperial period (first-third century AD). In detail the Muricelle glasses, can be divided into three groups: (1) HMn characterised by high MnO content, (three samples); (2) LMn with low MnO content and Sb below the detection limit (six samples); and (3) HSbHMn, (eight samples) characterized by colourless glass decoloured by both antimony and manganese.

Table 1. List of glass fragments collected in the Muricelle site (Luzzi - CS).

Group	Sample	Shape	Colour
HMn	Md	Bottle	Light green
	M15	Cup	Colourless
	M16	Cup	Colourless
LMn	Ma	Bottle	Light blue-green
	Mb	Bottle	Light blue-green
	Mg	Cup	Light blue
	Mh	Open shape	Light green
	Mi	Cup	Light blue-green
	Ml	Jug	Light blue-green
HSbHMn	Mc	<i>Bombilium</i>	Light blue
	Me	Bottle	Light blue-green
	Mf	Glass	Colourless
	Mm	Cup or plate	Colourless
	Mn	Plate	Light blue
	Mo	Cup	Light green
	M17	Cup	Colourless
	M18	Cup	light blue-green

As concerns the trace element concentrations, all samples of LMn and HSbHMn groups and one sample of HMn group, show quantities of CuO and/or PbO and/or SnO higher than 100 ppm. These results suggest that the majority of Muricelle glasses undergone a possible recycling of glass scraps during a re-melting process [6, 9, 10, 12].

Schibille et al. [7] utilised SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, and TiO<sub>2</sub> contents to discriminate the primary Roman glasses assigning to the antimony decoloured Roman glasses an Egyptian origin and to the Roman-Mn glasses a Levantine coast origin. In the diagram Al<sub>2</sub>O<sub>3</sub>/SiO<sub>2</sub> vs TiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> (Figure 2) the HMn and LMn Muricelle glasses plot in the area of Levantine sands, on the contrary, the glasses of the HSbHMn group show lower Al<sub>2</sub>O<sub>3</sub>/SiO<sub>2</sub> ratio and higher TiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> similar to the glasses of Egyptian origin. However, considering that the majority of Muricelle glasses are recycled, they represent a mixture of the two end members (i.e., Sb and Mn colourless glass), therefore it is impossible to define unambiguously the raw materials provenance [17].

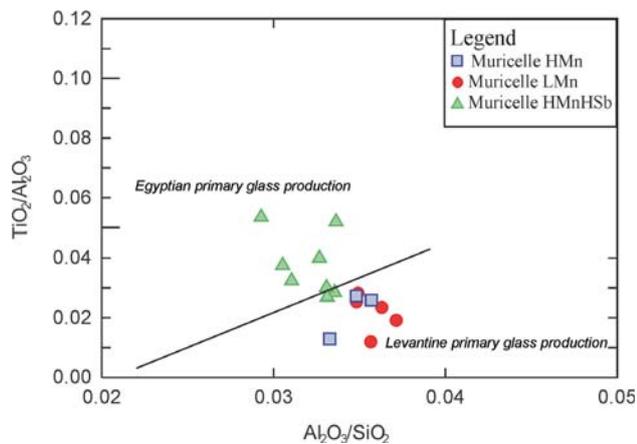


Fig. 2.  $Al_2O_3/SiO_2$  versus  $TiO_2/Al_2O_3$ . The Egyptian and Levantine origin areas of primary glass production have been separated as proposed by Schibille et al. [7].

### B. Petrographic study of amphorae and bricks

The amphora fragments have been separated into two groups, on the basis of the different quantity and grain size distribution of the clasts.

The first group includes wine amphorae Keay LII and unidentified amphorae (A1, A2, A5, A9, A10, AV2, AV3). It consists of ceramics that show a fine and homogeneous matrix with a reddish-brown colour. The clasts are composed by minerals and rocks of granitic and metamorphic origin: quartz, feldspars (plagioclase and K-feldspar), biotite and muscovite, represent the main mineralogical phases, together with gneissic and granitoid rock fragments (up to 2mm). The carbonatic component (from rare to frequent) appears as fragments of bioclcasts and Phoramminifera shells or as secondary microcrystalline calcite of pore filling (Figure 3). Small flakes of muscovite and biotite are abundant in most of the samples and show a slight orientation, justified by a probable use of wheel during the manufacturing.

The second group, constituted by two wine amphorae of oriental shape (A3, A51) and one (A8) unidentified amphora, shows a crystalline, slightly porous matrix of intense red colour. The medium grain size is prevailing, only few clasts show size up to 2 mm. Quartz is the most abundant mineral, with subordinate plagioclase and k-feldspar. The carbonates, are present only in A51 amphora whereas metamorphic and igneous rock fragments are frequent in A8 and A51 amphorae; those two last samples contain also few clasts of volcanic origin.

The bricks (samples L1-L10) contain homogeneous structural and textural characters. The matrix is well oxidized, brown-red in colour. The medium-sized percentage of clasts with respect to the matrix is about 20-30% and it is not regularly distributed. The clasts are

similar to those of the first group of amphorae, composed by minerals (quartz, plagioclase, K-feldspar) and rock of granitic and metamorphic origin (gneiss). The bricks contain abundant carbonate fraction, both as bioclcasts (mainly Phoramminifera shells) and as secondary calcite of pore filling.

The petrographic characteristics showed by the first group of amphorae (which includes some Keay LII Type) and by the bricks suggest a local origin. Granitic and metamorphic rocks are very common in the Sila Massif, on the eastern side of the river valley Crati, and are extremely similar to the lithic clasts contained in the studied ceramics. However, the greater relative quantities of clasts and carbonates (fossil shells and/or secondary calcite) present in the bricks suggest different production technologies between the bricks and the first group of amphorae.

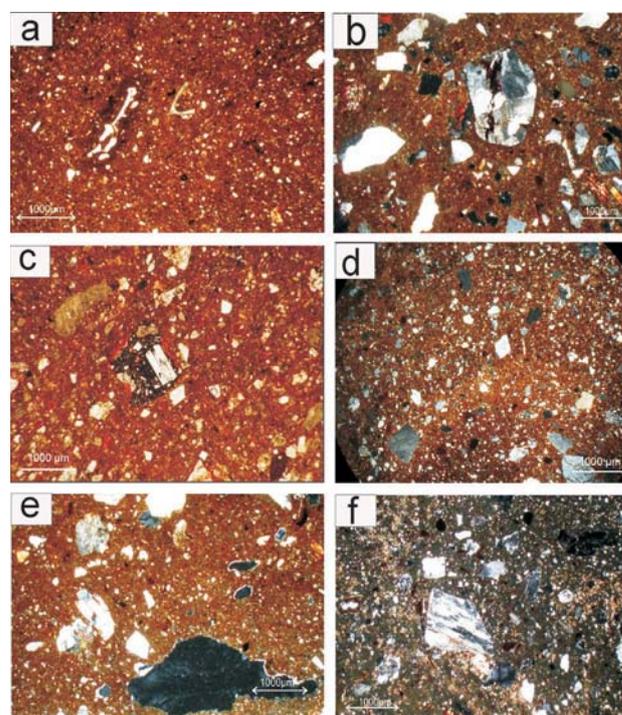


Fig. 3. Microphotographs in thin section of amphora and brick fragments, obtained by polarized optical microscopy (b, d, e, f crossed polars); (a) A10 sample (amphora of the first group) characterized by a homogeneous matrix with a reddish-brown colour; (b) AV2 sample (amphora of the first group) showing clasts constituted by minerals and rocks of granitic and metamorphic origin; (c) A51 sample (amphora of the second group) showing a fragment of volcanic rock; (d) A8 sample (amphora of the second group) showing numerous clasts of quartz and rock fragments of granitic and metamorphic origin; (e) L1 brick sample characterized by a brown-red matrix; (f) L2 brick sample showing clasts constituted by minerals and rocks of granitic and

metamorphic origin.

### C. Chemical characterization of bricks and clay materials

The chemical composition of all amphorae and bricks fragments, was determined by X-ray fluorescence spectroscopy (XRF), in terms of major, minor and some trace elements.

Five Pliocene clay sediments and two silty clay samples from the area, were sampled and analysed for comparisons with the selected pottery and bricks, with the hypothesis that they could be representative of the potential raw materials used for a local production.

Chemical analysis of bricks and clays shows a similar variation range of CaO+MgO content (varying from 14.49 wt% to 22.20 wt%), while the amphorae evidence higher values of SiO<sub>2</sub>, varying from 55.07 wt% to 69.45 wt%. Only the two samples A3 and A8, coherently with the petrographic observations, show higher SiO<sub>2</sub> content and a lower CaO+MgO. In the Ni vs Cr binary diagram (Figure 4), we observe that all the bricks and the amphorae of the first group overlap with the sampled local clays (around 100 ppm of Cr and 50 ppm of Ni) with the exception of the amphorae of the second group showing higher values (around 180 ppm of Cr and 120 ppm of Ni).

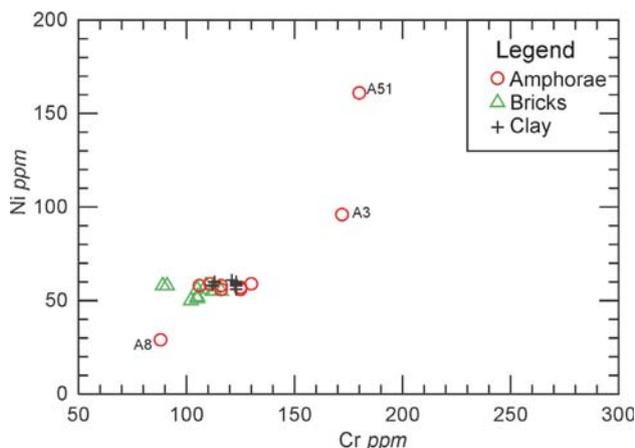


Fig. 4. Cr versus Ni diagram. A3, A8 and A51 are the amphorae of the second group.

According to the literature [18-20] when Ni and Cr contents are lower than, respectively, 150 and 250 ppm, the provenance of the clays can be referred to South Italy. For the samples of the second group it is arduous to indicate the provenance. However, the presence of volcanic inclusions in two of three samples allows us to hypothesize a possible origin from the southern Mediterranean area.

### IV. CONCLUSION

The archaeometric study conducted on the archaeological finds collected in the Muricelle site

suggests that the villa and the surrounding area were active in the Imperial period [3, 5]. Indeed, the analysed glasses, despite the recycling, can be considered as being produced in both Levantine and Egyptian primary workshops, in agreement with the results obtained by various authors [6-15] on the coeval finds from different Roman archaeological sites dated to the first–third century AD.

The petrographic and chemical characteristics, showed by the first group of amphorae (some of which Keay LII Type) and the bricks, suggest a local origin.

Because kiln for the amphorae production, around the Muricelle site, are not known, despite the high compositional affinity with local raw materials, for the first group of amphorae, cannot be excluded a provenance from other Calabrian areas, where similar rocks outcrop.

The second group is characterised by different petrographic features, supporting the hypothesis that the amphorae of this group are imported. In addition, the chemical composition differs from the local clays, confirming the petrographic observations.

The results obtained in this study testify the richness and the variety of the archaeological assemblage indicating that the site was commercially active and played a leading role within the middle valley of Crati River during the Imperial age.

### REFERENCES

- [1] A. La Marca, “Nuovi materiali per una carta archeologica del territorio di Luzzi”, in La Marca A. (a cura di), *Archeologia nel territorio di Luzzi: stato della ricerca e prospettive*, Ed. Rubbettino, Soveria Mannelli 2002, pp. 33-57.
- [2] A.M. De Francesco, T. Graziano, E. Andaloro, A. La Marca, C. Colelli, G.M. Crisci, E. Barrese, M. Bocci, “Archaeometric characterization of amphorae and bricks of Imperial Age found in a roman villa near the Luzzi town (Cosenza, Calabria, Italy)”. *Period. di Mineral.* 2011, 80, 217–230. <https://doi.org/10.2451/2011PM0017>.
- [3] C. Colelli, “Rinvenimenti ceramici di età imperiale romana da Muricelle di Luzzi”. In *Archeologia e Ceramica. Ceramica e Attività Produttive a Bisignano e in Calabria Dalla Protostoria ai Giorni Nostri*; La Marca, A., Ed.; Atti del Convegno; Grafosud Rossano-Italia: Bisignano, Italy, 25–26 June 2005; pp. 93–120.
- [4] A.J. Shortland, “Evaporites of the Wadi Natrun: Seasonal and annual variation and its implication for ancient exploitation”. *Archaeometry* 2004, 46, 497–516.
- [5] A. La Marca, “Una villa rustica di età imperiale romana nel territorio di Luzzi”. *Riv. Stor. Calabr.* 1997, 18, 241–270.
- [6] F. Gallo, A. Silvestri, G. Molin, “Glass from the Archaeological Museum of Adria (North-East Italy): New insights into Early Roman production

- technologies". *J. Archaeol. Sci.* 2013, 40, 2589–2605.
- [7] N. Schibille, A. Sterrett-Krause, I.C. Freestone, "Glass groups, glass supply and recycling in late Roman Carthage". *Archaeol. Anthropol.Sci.* 2017, 9, 1223–1241.
- [8] C.M. Jackson, "Making colourless glass in the Roman period". *Archaeometry* 2005, 47, 763–780.
- [9] C.M. Jackson, S.A. Paynter, "Great big melting pot: Exploring patterns of glass supply, consumption and recycling in Roman Coppergate, York". *Archaeometry* 2016, 58, 68–95. <https://doi.org/10.1111/arcm.12158>.
- [10] A. Silvestri, G. Molin, G. Salviulo, "The colourless glass of Iulia Felix". *J. Archaeol. Sci.* 2008, 35, 331–341.
- [11] E. Gliozzo, "The composition of colourless glass: A review". *Archaeol. Anthropol. Sci.* 2017, 9, 455–483.
- [12] S. Paynter, "Analyses of colourless Roman glass from Binchester, County Durham". *J. Archaeol. Sci.* 2006, 33, 1037–1057.
- [13] P. Mirti, A. Casoli, L. Appolonia, "Scientific analysis of Roman glass from Augusta Praetoria". *Archaeometry* 1993, 35, 225–240.
- [14] I.C. Freestone, "The recycling and reuse of Roman glass: Analytical approaches". *J. Glass Stud.* 2015, 57, 29–40.
- [15] I. Coutinho, T. Medici, L.C. Alves, Š. Perović, "Colourless Roman glass from the Zadar necropolis: An exploratory approach". *J. Archaeol. Sci. Rep.* 2017, 15, 194–202.
- [16] A.M. De Francesco, R. Scarpelli, M. Conte, L. Toniolo, "Characterization of Roman glass from Casa Bacco deposit at Pompeii by Wavelength-Dispersive Electron Probe Microanalysis (EPMA)". *Mediterran. Archaeol. Archaeom.* 2019, 19, 79–91.
- [17] A.M. De Francesco, A. La Marca, C. Colelli, D. Barca, "Chemical Characterization of the Roman Glass Finds from Muricelle Archaeological Site (Luzzi, Cosenza)". *Minerals*, 2022, 12, 475. <https://doi.org/10.3390/min12040475>.
- [18] G. Barone, S. Ioppolo, D. Majolino, C. Branca, L. Sannino, G. Spagnolo, G., Tigano, "Archaeometric analyses on pottery from archaeological excavations in Messina (Sicily, Italy) from the Greek archaic to the Medieval age". *Per. Min.*, 2005, 74, 1, 11-41.
- [19] G. Barone, V. Crupi, S. Galli, S. Ioppolo, F. Longo, D. Majolino, P. Mazzoleni, G. Spagnolo, "Archaeometric analyses on Corinthian B transp ort amphorae found at Gela (Sicily, Italy)". *Archaeometry*, 2004, 46, 553-568.
- [20] S.T. Levi, "Produzione e circolazione della ceramica nella Sibaritide protostorica". Ed. All'insegna del Giglio, Firenze, 1999.