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POTTERY PRODUCTION DURING "ROMANIZATION" OF SICILY: AN ARCHAEOMETRIC STUDY OF PLAIN TABLE-WARE CLASSES FROM ANCIENT AKRAI (SICILY)

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ABSTRACT

In this paper, petrographic, mineralogical and chemical analyses have been performed on plain table-ware fragments discovered in the ancient town of Akrai (modern Palazzolo Acreide, Syracuse, Sicily) and dated between the Hellenistic and the Late Roman periods (4^{th}-5^{th}/6^{th}century A.D.). The project is developed in the context of the archeological debate on the cultural and political process occurred in Sicily since the 3^{rd}century B.C. and known in archaeological literature as *Romanization*. In this framework, a gradually substitution of Greek-Hellenistic materials with the Roman ones has occurred in Sicilian colonies and the city of Akrai was deepened involved in this process. As the sensitiveness of material culture to cultural and social changes, the archaeometric investigation has been focused on provenance and technological manufacture aspects of table-ware production, in order to delineate the eventually changes took place in the area during the investigated period. The comparison of obtained data with numerous references local groups of ceramics allows to identify different highly specialized local productions, drawing-back the commercial movements of potteries in Sicily during Roman Age.

KEYWORDS: Akrai (Palazzolo Acreide), archaeometry, pottery, plain table-ware

1. INTRODUCTION

1.1 Archeological framework

Ancient Akrai (in Latin Acrae, Agris, Acrenses), located near the modern town Palazzolo Acreide (Syracuse, Sicily, Fig. 1(a,b)), occupied one of the plateaus of the Hyblaean Mountains, called Acremonte. The city was founded in 664 B.C. as a subcolony of Syracuse and was remaining under the influence of metropolis, equally in politics, economy and culture up to the fall of Syracuse in 212 B.C. Afterward, Akrai was listed among *stipendiariae civitates* as a self–supporting and tax–paying town, yet obviously dependent on Rome (civitas decumana).

Since the Roman conquest of Syracuse in 214–212 B.C., the political, administration and culture state and the conditions of the Greek colonies in Sicily have to be changed. A gradual vanishing of the Hellenistic elements and its substitution with the Roman ones took place in a long-lasting cultural process, known in the archaeological literature as Romanization. Gradually, Rome introduced its own life model, but the organization of the first provinces delivered many difficulties. The Romans were faced with something that went beyond their experience and their approaches to solving problems (Wilson, 1988); the old Greek urban centres had, in fact, their own infrastructure and model of civic administration, and the inhabitants of Sicily, who were different culturally and ethnically from the Romans, were not very loyal to them. This situation forced the Romans to adopt a moderate assimilation instead of power solutions, thanks to which the culture of the conquered people made a lasting impression on the culture of the victors; therefore, it wasn't lost, becoming a permanent element of the new order. Thanks to these long-term multidimensional relations and arrangements, in the course of which the Romans demonstrated a growing interest in shaping life on the island, a specific mix of languages, legal systems, culture, architecture and religion was created (Alcock, 1989; Buscemi, 2007; Dearden, 2004; Hollegaard et al., 1995;Wilson, 1990).

The archeological excavations within the ancient Greek colony of Akrai conducted on behalf of the Archeological Mission of University of Warsaw, in deep cooperation with Superintendence for Cultural Heritage of Syracuse, began in 2011. The research is still continued and is focused on exploring the history of the Greek-Roman urban centre after the fall of Syracuse in 212 B.C. as well as the material culture of its inhabitants.

The archaeological excavations of the town of Akrai brought many interesting observations about the Romanization process, allowing to better understand the changes that involved Sicilian colonies during this period. Doubtlessly, Akrai took new political realities, even if its character and role after the conquest of Syracuse by Romans is still widely debated (Chowaniec, 2013; Więcek*et al.*, 2014).

The first stage of archaeological works was focused on exploring and documenting the Late Roman and Byzantine strata, in which architectural remains, built with re–used blocks and architectural elements from earlier foundations, have been found. These discovered levels were only remains of a secondary use of a Late Hellenistic and Early Roman residential complex and were filled with strongly intermingled, heterogeneous archaeological material, represented mainly by artifacts dated from the 4thto the 6thcenturies A.D. (Chowaniec, 2014; Chowaniec, 2015b). On the basis of archaeological evidences, it possible to suppose that the town functioned continuously as far as the Late Antiquity, when the structural changes have been done; in fact, no urban long-term abandonment can be observed. A change in the arrangement of the Hellenistic-Roman town has been registered in the last decades of 4thcentury A.D. and has been testified by a modification of the arteries from the original town grid, by a less intense inflow of the coins and by a quite heedless Late Roman architectural remains, which more or less duplicated the earlier Hellenistic-Roman foundations (Fig. 1(c)).

1.2 Fine and plain table-wares from Akrai

The archaeological excavations of Akrai delivered a vast amount of potteries, mainly represented by splendid examples of thin-walled ceramic (*i.e.*, Hellenistic thin-walled bowls, terra sigillata), amphorae and storage vessels (*i.e.*, dolia, pithoi, etc.) (Chowaniec *et al.*, 2014; Chowaniec, 2015a).

Among them, several fragments of table-wares have been found; this category of pottery can be divided into two groups: fine table-ware and plain table-ware. Fine table-ware is mainly represented by terra sigillata italica, usually considered the symbol of the Romanization process. It is a ceramic class characterized by glossy red slipped surface, with thin walls, stamps and relief decorations, whose production begun around the half of 1stcentury B.C. at Arretium (modern Arezzo), in northern Tuscany, and spread out in the Mediterranean area during the next centuries, also beyond the Italy geographic limits (e.g.in Gallic provinces; see Picon et al., 1975; Maggetti and Kupfer, 1978). In Sicily the finds of terra sigillata italica are mainly focused in coastal areas, in the principal economic centers-ports (i.e. Messina, Catania, Syracuse, Tyndaris, Thermae Himeraeae, Palermo, Marsala, Agrigento), even if examples of shards have been found also in the interior centers (i.e. Morgantina, Centuripe, Troina, Monte Iato, Megara Hyblaea, Camarina (Malfitana, 2004)). About 130 fragments of this class of pottery were discovered also in Akrai.

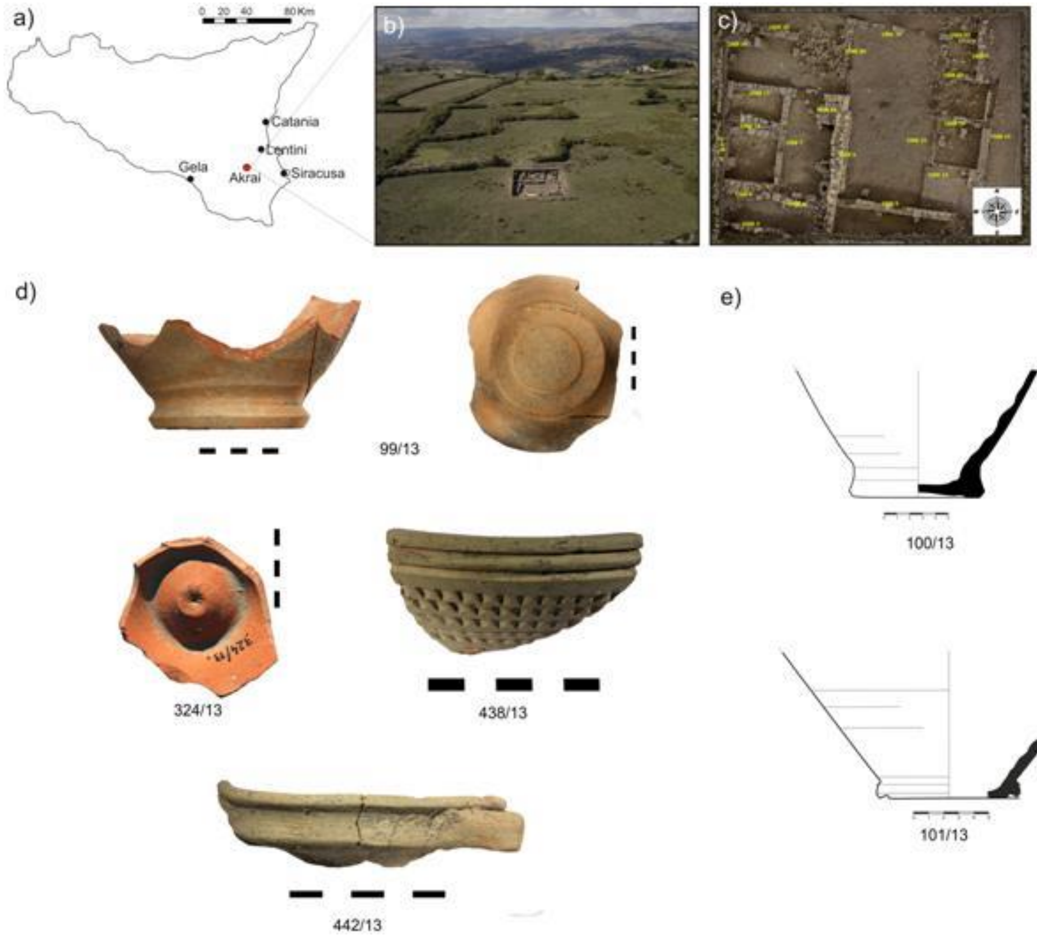

Figure 1. (a) Geographical localization of the site of Akrai (Palazzolo Acreide, prov. Syracuse), (b) aerial view with excavated area, (c) picture of Trench I with architectural structures found (USM#) and (d) pictures and (e) drawing of representative examples of plain table-ware from Akrai (photo and drawing by Wicenciak U., Krakowian J. and Wójcik K)

The fine table-ware found in Sicily is partially diagnosed and widely discussed in scientific and archeological literature (Polito, 2000; Malfitana, 2004; Olcese, 2011-2012), while the study of plain table-ware is neglected and not commonly published. This is a critical and vast gap in our knowledge about Antiquity, because such pottery class was the most widespread and commonly used in ancient time, being also a substantial part of the Ancient Mediterranean frame (Hayes, 1997). Therefore, the better knowledge of this class of material could support us in the interpretation about the presence/absence of specific pottery types in particular regions of Sicily. Moreover, in the case of Akrai, an in-depth investigation of plain table-wares could allow us in recognizing workshops, commercial interests, possible trade routes, habits of the households and finally drawing-back relevant changes in complex culture contexts, characterized by different cultural phases.

In general, the identification of provenance and technological features of plain table-ware class is difficult in view of the fine grain of the clay paste, often high depurated and without inclusions. For this reason, the knowledge of aspects as manufacture process, aesthetics and role of the pottery in the society can be achieved only by archaeometric analyses, including comparison with a great number of ceramics and reference raw materials with certain provenance. In this sense, the presence in scientific literature of reference ceramics and clay sediments supplies a fundamental issue in the fine pottery researches.

For aforementioned, this work is focused on the archaeometric characterization of a selection of representative samples of plain table-ware obtained during the 2013 excavation season at Akrai (totally, 1161 fragments of fine table-ware and 1413 fragments plain table-ware have been excavated, representing about 58% of all the pottery fragments found in this year), with the aim to characterize samples in term of both technology and manufacture, and identify the provenance of the studied artifacts, trying to delineate the commercial movements that have involved the site during Roman Age.

2. MATERIALS AND METHODS

2.1 Materials

Generally, the plain table-ware class includes vessels intended for serving and consuming food and for meal preparation. The plain table-wares founded in Akrai present a huge diversity in shape and chronology, even if the large typologically variety is represented by undecorated fragments. Among the pottery shards, the following shapes have been distinguished: table amphorae, jugs, basins, bowls, lekanai, craters, unguentaria and lids (Młynarczyk, 2015).

For the present study, a totally of 47 specimens supposed to be related to a local production and mainly dated between the Hellenistic and the Late Roman periods (4th–5th/6th century A.D.) have been selected for archaeometric analyses.

The selection of the fragments was performed while the macroscopic analysis, that allow the identification of several macro-fabriques, including fine and plain table-ware fragments recovered in the framework of the 2013 archaeological excavation season (Młynarczyk 2015); the plain table-wares represent mainly three macro-fabriques, namely fabrique F1 (red to orange clay, cream to greenish wash: Munsell Index 5 YR 6/6, 2.5 YR 6/6; very dense clay paste, clean or exhibiting some small to medium–size white grits and some small black grits, often with white wash), fabrique F3 (brownish to reddish break/surface: M.I. 2.5 YR 6/6 - 5 YR 6/6; rather dense clay paste with some small black and white grits) and fabrique F10 (red to orange clay: M. I. 10R 5/8; coarse grain clay paste with medium–size black grits and some small white ones). In consideration of the large amount of pottery fragments excavated in the site and the identification of the aforementioned archeological typologies and macro-fabriques, the selection criteria has been based on the representatively of the samples in term of shape, chronology and archaeological fabriques (Table 1; Figure 1(d, e)); moreover, all samples represent diagnostic fragment parts of potteries (rim/base/handle).

2.2 Methods

All studied samples have been analyzed by petrographic, mineralogical and chemical analyses (see Table1).

In detail, petrographic characterization of samples has been obtained by Whitbread classification (Whitbread, 1995). Moreover, X-ray diffraction analysis (XRD) have been performed on all samples in order to obtain mineralogical composition; analysis have been carried out through a SIEMENS D5000 with Cu–Kα radiation and an Ni filter. Randomly oriented powders were scanned from 2° to 45° 2θ, with a 0.02° 2θ step size and a counting time of 2s per step. The tube current and the voltage were 30 mA and 40 kV, respectively. Finally chemical composition of studied samples have been obtained by X-ray fluorescence analysis (XRF) performed by using a Philips PW 2404/00 on powder-pressed pellets of ceramic. Further details are reported on previous papers (Barone *et al.*, 2014; Barone *et al.*,2012).

Chemical data have been treated with statistical methods according to Aitchison (1986) by using CoDaPack (Thio-Henestrosa and Martin Fernandez, 2005), a compositional software that implements the basic methods of analysis of compositional data based on log-ratios. In addition, chemical results and chemical data of reference materials have been treated with a statistical and computational method proposed by Tukey (1977) by using software STATISTICA (Hill and Lewicki, 2007).

Table 1. Synthetic chart of studied materials with indications on samples IDs, shape, archeological fabrique, provenance, dating of stratigraphic units (US), surface and bulk color determined by Munsell color chart (Munsell Color Chart, 2000; M.I. = Munsell Index) and analyses performed are reported.

Sample ID	Class	Shape and fragment	Archeological fabrique	Provenance	US dating	M.I. (Munsell Index)
324/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**2,5 YR 5/8
						Bulk:2,5 YR 5/8
326/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5YR 5/8
						Bulk:2,5 YR 5/8
327/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/4
						Bulk:GLEY1 6/5G
328/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**2,5 YR 6/8
						Bulk:2,5 YR 5/6
329/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/6
						Bulk:2,5 YR 4/8
331/13	Plain-table ware	Lekane; rim	Fabrique 3	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/8
						Bulk:10 YR 6/6
332/13	Plain-table ware	Jug; bottom part	Fabrique 3	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/6
						Bulk:5 YR 6/8

333/13	Plain-table ware	Jug; bottom part	Fabrique 3	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/8 **Bulk:**5 YR 5/8
336/13	Plain-table ware	Big basin; rim	Fabrique 3	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**7,5 YR 7/6 **Bulk:**10 YR 7/4
529/13	Plain-table ware	Big basin; bottom part	Fabrique 1	Trench I; US 3	III-II B.C. - VII A.D.	**Surface:**5 YR 6/6 **Bulk:**7,5 YR 6/6
99/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 6/6 **Bulk:**2,5 YR 5/8
100/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 5/6 **Bulk:**5 YR 5/6
101/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 6/4 **Bulk:**5 YR 5/6
102/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 YR 6/6 **Bulk:**2,5 YR 5/8
113/13	Plain-table ware	Big basin; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 YR 6/6 **Bulk:**10 YR 6/3
114/13	Plain-table ware	Big basin; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 5/6 **Bulk:** 7,5 YR 6/6
339/13	Plain-table ware	Pithos; bottom part	Fabrique 10	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 7,5 YR 6/6 **Bulk:** 7,5 YR 6/6
342/13	Plain-table ware	Basin; rim	Fabrique 10	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 6/8 **Bulk:**10 YR 6/2
349/13	Plain-table ware	Krater; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 6/6 **Bulk:** 5 YR 6/6
351/13	Plain-table ware	Lekane; rim	Fabrique 3	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 YR 6/6 **Bulk:**5 YR 5/8
353/13	Plain-table ware	Lekane; rim	Fabrique 3	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 6/6 **Bulk:**7,5 YR 6/6
355/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 7/4 **Bulk:** 5 YR 5/6
374/13	Plain-table ware	Lid	Fabrique 3	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 6/6 **Bulk:** 5 YR 5/6
375/13	Plain-table ware	Lid	Fabrique 3	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 7/4 **Bulk:** 7,5 YR 5/6
377/13	Plain-table ware	Lid; handle	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 7/3 **Bulk:**2,5 YR 5/8 - GLEY1 5N
378/13	Plain-table ware	Jug; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 7/4 -2,5 Y 7/3 **Bulk:**2,5 YR 5/8
383/13	Plain-table ware	Jug; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 8/2 **Bulk:**2,5 YR 5/8
386/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**10 YR 5/2 **Bulk:**5 YR 5/8
387/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 6/6 **Bulk:**5 YR 5/6
388/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**10 YR 4/2 **Bulk:**5 YR 4/6
392/13	Plain-table ware	Jug; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 7/3 **Bulk:**2,5 YR 5/8
393/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 7/2 **Bulk:**2,5 YR 5/6
394/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**10 YR 6/4 **Bulk:**2,5 YR 5/6
400/13	Plain-table ware	Jug; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**5 YR 7/6 **Bulk:**5 YR 5/6
424/13	Plain-table ware	Bottle; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 8/2 **Bulk:**2,5 YR 5/8
435/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:**2,5 Y 8/2 **Bulk:**2,5 YR 6/6 -10 YR 5/1
436/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 2,5 Y 7/2 **Bulk:** 2,5 YR 5/8
437/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 2,5 Y 7/2 **Bulk:** 2,5 YR 5/8
438/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 2,5 Y 7/4

						Bulk: 5 YR 5/8
444/13	Plain-table ware	Bowl; rim	Fabrique 1	Trench I; US 4	III-II B.C. - V A.D.	**Surface:** 5 YR 7/4 **Bulk:** 5 YR 5/6
301/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 7	III-II B.C. – half V A.D.	**Surface:** 2,5 Y 7/3 **Bulk:** 2,5 Y 7/4
305/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 7	III-II B.C. – half V A.D.	**Surface:**10 YR 8/4 **Bulk:** 5 YR 7/6
306/13	Plain-table ware	Jug; bottom part	Fabrique 1	Trench I; US 7	III-II B.C. – half V A.D.	**Surface:** 2,5 YR 5/6 **Bulk:** 7,5 YR 5/4
293/13	Plain-table ware	Dish; rim	Fabrique 10	Trench I; US 8	III-II B.C. – half V A.D.	**Surface:** 7,5 YR 5/4 **Bulk:** 2,5 YR 5/6
284/13	Plain-table ware	Basin; rim	Fabrique 1	Trench I; US 10a	I B.C. – half V A.D.	**Surface:** 10 YR 6/3 **Bulk:**5 YR 5/6
285/13	Plain-table ware	Krater; rim	Fabrique 1	Trench I; US 10a	I B.C. – half V A.D.	**Surface:**2,5 Y 8/3 **Bulk:**2,5 YR 5/8
550/13	Plain-table ware	Pithos; rim	Fabrique 10	Trench I; US 10a	I B.C. – half V A.D.	**Surface:** 2,5 Y 7/3 **Bulk:** 2,5 YR5/8

3. RESULTS

Thin section analysis allows to identify four petrographic fabrics on the basis of groundmass features (Fig.2); noteworthy is that for each petrographic group slight variations in term of inclusions have been recognized.

The first petrographic group, namely Fabric 1 (specimens 113/13 (Figure 2(a)), 327/13, 332/13, 339/13, 387/13, 388/13 (Fig. 2(b)), comprises basin and jug fragments with a medium grain size. The groundmass, quite homogeneous, is micaceous and exhibits also fine grained quartz (< 0.1 mm). Additionally, it is characterized by a medium-high birefringence and reddish-brown colour. The vughy microstructure consists in sub-rounded vughs and rare vesicles, exhibiting a spatial distribution from double spaced to open, without a preferential orientation. Finally, inclusions (inclusion: groundmass ratio 30:70) are mainly represented by dominant volcanic rocks fragments, common plagioclase and pyroxene, with unimodal grain size distribution. Noteworthy is the presence of magmatic biotite in sample 339/13.

The most numerous class is represented by fine-grained specimens with homogeneous, micaceous and fossil-rich groundmass, fine quartz and carbonatic fragments sub-angular in shape and sub-millimetric in dimension (< 0.1 mm) (Fabric 2). Groundmass exhibits an high birefringence and a reddish colour. The vughy microstructure consists in sub-rounded vughs, channels and vesicles with spatial distribution from open to double spaced and a slightly preferential orientation of channels. The majority of samples are characterized by absence of inclusions (99/13, 100/13, 101/13, 102/13 (Figure 2(c)), 331/13, 355/13, 375/13, 377/13, 383/13, 393/13, 438/13, 349/13, 394/13, 400/13, 424/13, 435/13, 436/13, 437/13, 444/13). However, in some cases, scarce volcanic inclusions (114/13, 284/13, 285/13, 324/13, 351/13, 374/13, 392/13), zeolites (293/13 (Figure 2(d)), 550/13), volcanic glass (306/13, 326/13, 329/13) and chamotte (378/13) have been observed. Finally, secondary calcite has been observed, especially in samples 331/13, 438/13, 349/13, 394/13, 400/13, 435/13.

Fabric 3 comprises fine-grained samples characterized by carbonate, fossiliferous and poorly micaceous groundmass, and absence of inclusions (specimens 328/13; 333/13 (Figure 2(e)); 336/13; 353/13; 386/13; 529/13). Groundmass is quite homogeneous, with abundant fine quartz (<0.1 mm), medium-high birefringence and yellowish-brown colour. The vughy (sub-spherical voids) microstructure is characterized by sub-rounded vughs and rare vescicles, with a spatial distribution from open to double spaced and a slight preferential orientation of vescicles (in samples 328/13 and 529/13).

Finally, a fine-grained fabric characterized by carbonate groundmass has been distinguished (Fabric 4: specimens 301/13, 305/13, 342/13). It is characterized by a vughy microstructure with dominant rounded vughs and rare vescicles, exhibiting a spatial distribution from single to double spaced. The homogeneous and fossil-rich groundmass is characterized by a light brown color and low birefringence in samples 301/13 (Figure 2(f)) and 305/13. Only in sample 342/12, a medium-high birefringence and the presence of inclusions (inclusion:groundmass ratio 40:60) consisting in fine grain quartz and dominant volcanoclastic fragments have been recognized.

Information on groundmass optical activity can be useful to obtain preliminary information on firing temperature in archaeological ceramics (Barbera *et al.*, 2013). In this sense, the thin section analysis of studied potteries highlights for all petrographic fabrics a medium-high groundmass birefringence, attesting firing temperature in a medium range (850-900 °C). Moreover, the fine grain texture observed in all samples, both in term of matrix and inclusions (when present) suggests the use of high depurated clay sediments for the manufacture of this ceramic class.

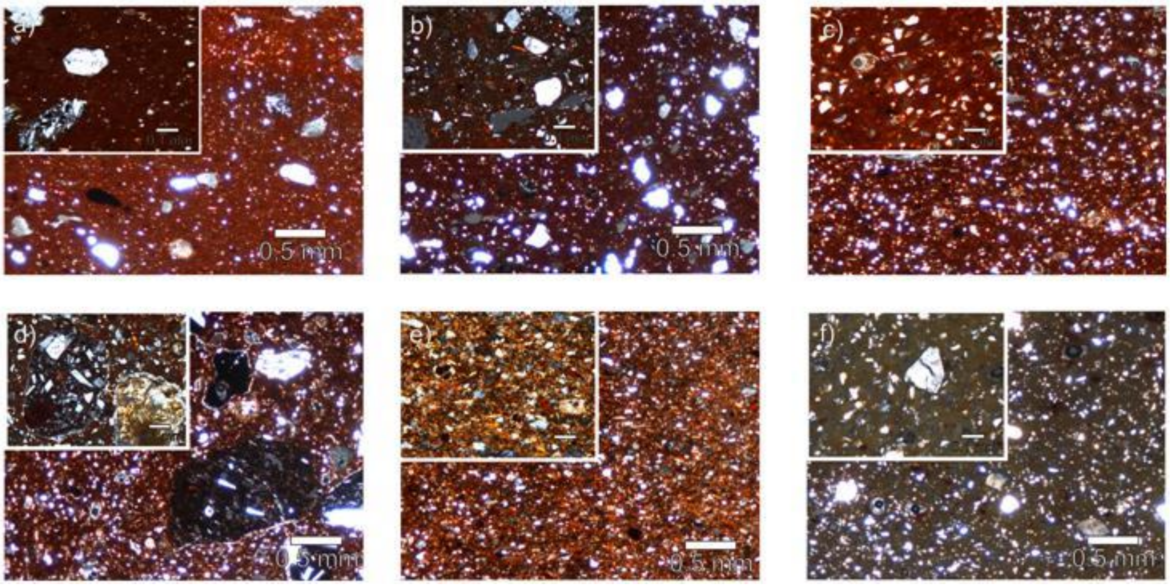

Figure 2. Microscopic pictures of studied samples representative of each petrographic fabric identified. (a, b) Fabric 1 (samples 113/13 and 388/13); (c, d) Fabric 2 (samples 102/13 and 293/13); (e) Fabric 3 (sample 333/13); (f) Fabric 4 (sample 301/13).

In order to confirm the hypotheses suggested by petrographic features and determine the firing temperature on the basis of mineralogical composition, XRD analyses have been performed. In fact, reactions in the matrix during firing bring to modifications of the original mineralogical association of the groundmass (mainly clay minerals and calcite) and to the formation of cryptocrystalline new phases (*i.e.*, anorthite, diopside, wollastonite and gehlenite) (Maggetti, 1982; Riccardi *et al.*, 1999; Cultrone *et al.*, 2001), indicative in many cases of the temperature achieved. The mineralogical associations of all the studied potteries are reported in Table 2 together with information on birefringence of the groundmass. The use of Ca-rich sediments (CaO> 6%; see chemical composition in Table 3) allows the presence of gehlenite, anorthite and/or diopside in almost all samples; therefore, on the whole, medium-high temperature (in a range of T_{max}~ 850 -900°C) can be hypothesized for all studied specimens. Exceptions are represented only by two samples belonging to Fabric 4 (301/13 and 305/13), in which the absence of birefringence and the absence of newly formed minerals has to be correlated whit lower temperatures. Finally, noteworthy is the coexistence, in some cases, of newly formed minerals and calcite, especially in samples characterized by fossil-rich groundmass (see Fabric 3), explainable only considering the presence of secondary calcite due to circulation of Ca-rich solutions in burial conditions (Cultrone *et al.*, 2014).

Table 2. Petrographic and mineralogical data of the studied samples. Bir. = Birefringence: +++ = high; ++ = medium; + = low or absent birefringence; Qtz = Quartz; Cal = Calcite; Gh = gehlenite; An = Anorthite; Di = diopside; Hem = Hematite; CM = Clay Minerals. The number of (+) is related to the mineralogical phase abundance: +++= abundant; ++= present; += scarce/rare; - = absent; tr= trace

			Sample ID	*Bir.*	*Qtz*	*Cal*	*Gh*	*An*	*Di*	*Hem*	*CM*
FABRIC 1	**micaceous groundmass, medium grain size and quartz**	**with volcanic inclusions**	**113/13**	+++	+++	tr	+	++	tr	+	+
			327/13	++	+++	-	-	+++	+	-	+
			332/13	+++	+++	-	+	++	-	+	+
			387/13	++	+++	tr	tr	++	-	tr	+
			388/13	++	+++	tr	tr	++	-	tr	+
		with magmatic biotite	**339/13**	+++	+++	+	tr	++	++	tr	++
FABRIC 2	**micaceous and fossil-rich groundmass and fine quartz**	**Without inclusions**	**99/13**	+++	+++	+	-	+	-	tr	+

			100/13	+++	+++	++	tr	+	-	-	+
			101/13	+++	+++	tr	+	++	tr	+	+
			102/13	+++	+++	tr	tr	+	-	tr	+
			331/13	++	+++	++	tr	tr	-	tr	+
			349/13	++	+++	tr	+	++	++	tr	+
			355/13	+++	+++	+	tr	+	-	tr	+
			375/13	+++	+++	+	tr	+	-	-	+
			377/13	+++	+++	tr	+	++	+	+	+
			378/13	++	+++	+	+	+	+	+	+
			383/13	++	+++	+	+	+	tr	tr	+
			393/13	++	+++	+	+	++	tr	tr	+
			394/13	++	+++	tr	tr	++	tr	tr	+
			400/13	++	+++	+	tr	+	tr	-	+
			424/13	++	+++	+	+	+	-	tr	+
			435/13	++	+++	tr	+	++	++	+	+
			437/13	++	+++	tr	+	+	+	tr	+
			436/13	++	+++	tr	-	+	tr	tr	+
			438/13	+++	+++	++	-	+	-	-	+
			444/13	++	+++	+	tr	++	tr	tr	+
		with scarce volcanic inclusions	114/13	++	+++	++	tr	++	-	tr	+
			284/13	+++	+++	+	tr	++	+	tr	+
			285/13	+++	+++	tr	tr	tr	-	tr	+
			324/13	++	+++	+	+	++	+	+	+
			351/13	+++	+++	++	tr	+	tr	tr	+
			374/13	++	+++	++	-	+	-	tr	++
			392/13	++	+++	tr	+	++	-	+	+
			293/13	+	+++	+	-	++	+	tr	+
			550/13	+	+++	+	-	+	tr	tr	+
		with volcanicglass	306/13	++	+++	tr	+	+	+	tr	+
			326/13	++	+++	+	+	+	-	tr	+
			329/13	++	+++	+	tr	tr	-	tr	+
FABRIC 3	**fossiliferous and poorly micaceous groundmass and absence of inclusions**		328/13	+++	+++	+	+	++	-	+	+
			333/13	+++	+++	+	-	+	-	-	+
			336/13	+++	+++	+++	-	tr	-	tr	++
			353/13	+	+++	++	-	tr	-	-	+
			386/13	++	+++	tr	+	++	tr	-	+
			529/13	+++	+++	+++	-	tr	-	tr	+
FABRIC 5	**carbonate groundmass**	**without inclusion and rich in foraminifera**	305/13	-	++	+++	-	-	-	-	++
		with absent micromass optical activity	301/13	-	+++	tr	tr	+	+	-	+
		with volcanic inclusions	342/13	+++	+++	++	-	++	+	tr	++

Even if petrographic and mineralogical data help to supply useful information on manufacture technology (*i.e.*, firing temperature and features of clay sediments), information on provenance can be obtained only by chemical analysis, due to the fine grain size of studied materials, often exhibiting absence of inclusions. For aforementioned, XRF data (Table 3) have been used to investigate eventually significant variation in chemical composition. Most of samples show a quite compositional homogeneity, as inferred by the inspection of triangular and binary diagrams shown in Figure 3. In detail, the CaO-SiO_2-Al_2O_3 diagram (Figure 3(a)) indicates the use of Ca-rich clays for the manufacture of almost all analysed samples, mainly plotted in the stability fields of anorthite and wollastonite as potential newly formed minerals in high firing temperature conditions. The similarity in chemical composition has been also highlighted by trends shown in binary diagrams (Figure 3(b)); in fact, referring to major elements, comparable abundances can be observed for all analysed samples. Small variations are detectable in SiO_2, CaO, MgO, Fe_2O_3 levels; in detail, samples belonging to Fabric 1 exhibit the lower abundance of CaO, respect to the all analysed set, overall characterized by average CaO contents of about 15 wt%; the higher contents have been detected in samples 336/13, 529/13 (Fabric 3) and 305/13 (Fabric 4), as evidenced also by mineralogical data. Additionally, really low levels in Fe_2O_3 can be observed for sample 306/13 (Fabric 2). Regarding minor elements, also in this case an homogeneity in chemical composition can be assessed; noteworthy is the high contents of Rb in sample 339/13 (Fabric 1), and the really high level of Co in sample 306/13 (Fabric 2).

3. DISCUSSION

As suggested by the petrographic analysis, among the plain table-ware class artifacts, three main groups can be identified on the basis of groundmass features, namely (i) micaceous, (ii) fossiliferous and (iii) a combination of them, with slightly variation due to the presence/absence of inclusions.

In this sense, the variation in term of inclusions can be attributed to technical expedient finalised to realize different ceramic shape and/or typology.

In facts, shapes as basins, bowls, lids, dishes, kraters and pithoi are mainly made with highly purified clay pastes and without inclusions, while for the manufacture of the larger dimension vessels, as big basins and jugs, the use of volcanic inclusions has be observed. Therefore, an high technical specialized manufacture can be hypothesized.

Referring to provenance issues, the manufacture features determined throughout thin section and mineralogical analyses (*e.g.* groundmass composition, use of highly depurated clays, medium-high firing temperature and presence, in some petrographic fabrics, of volcanic inclusions) suggest several similarities with some local fine well-known ceramic workshops active in Sicily during Hellenistic and Roman Age, namely Syracuse, Gela, Lentini and Catania ones.

In fact, the Syracuse Hellenistic-Roman fine pottery production was characterized by micaceous and fossiliferous groundmass and inclusions formed mainly by fine quartz; the used clay pastes were more or less purified through the removal of the sandy-to-coarse silty granulometric fraction (Barone *et al.,* 2014). Gela fine potteries production was characterized by fine micaceous and fossil-rich groundmass and low amount of inclusions consisting in dominant quartz and rare feldspars (Aquilia *et al.*, 2012).

The Catania production (Barone *et al.*, 2005) showed a matrix with common mica and fine-grained aplastic inclusions predominantly formed by quartz, common volcanic rock fragments and rare feldspar. Finally, the Lentini potteries were characterized by an homogeneous matrix with low optical activity and fine-grained aplastic inclusions mainly formed by mono- and polycrystalline quartz, rare feldspar and volcanic rock fragments (Barone *et al.*, 2005).

For the aforementioned, with the aim to determine provenance of studied samples and characterize raw materials, chemical results have been compared with reference ceramics and clays from Syracuse, Gela, Catania and Lentini (Barone *et al.*, 2005; Aquilia*et al.*, 2012; Barone *et al.*, 2014). In detail, a principal component analysis (PCA) has been carried out using major (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, K_2O) and trace elements (Sr, V, Cr, Ni, Rb, Y, Zr, La, Ce) data.

The obtained first three principal components (PC) explain the 68.9% of the total variance. For the evaluation of provenance, data treatment has been performed by using bivariate boxplot namely bagplot (Rousseeuw *et al.*, 2012). It's composed by a bag containing the 50% of data points (darker area), a fence that separates inliers from outliers (line) and a loop (lighter area) in which are plotted liers that are outside the bag but inside the fence. The white square inside the bag represent the depth median, namely the point with the highest density of probability.

Table 3. Chemical data of studied samples grouped on the basis of petrographic fabrics. Major elements are reported in wt%, minor elements are in ppm. The chemical data reported have been recalculated to 100% on volatile-free basis.

Sample ID	Fabric	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Sr	V	Cr	Co	Ni	Zn	Rb	Y	Zr	Nb	Ba	La	Ce	Pb	Th
327/13	**Fabric 1**	58.31	1.05	17.69	7.08	0.12	2.92	8.52	1.09	2.93	0.30	353	152	127	14	54	121	122	32	203	24	344	51	101	20	12
332/13	**Fabric 1**	63.57	0.91	15.63	6.28	0.09	2.33	7.54	0.74	2.51	0.39	275	113	112	10	51	115	82	18	160	10	361	39	101	18	11
113/13	**Fabric 1**	60.04	0.99	17.23	6.69	0.12	2.91	7.89	0.79	2.97	0.37	289	147	124	13	58	118	108	22	158	14	330	50	99	19	10
387/13	**Fabric 1**	63.57	0.91	15.52	6.48	0.11	2.55	7.19	0.81	2.47	0.39	330	115	108	12	51	113	97	30	238	18	323	46	92	27	11
388/13	**Fabric 1**	62.99	0.93	15.81	6.51	0.11	2.53	7.60	0.72	2.51	0.29	342	120	112	12	52	110	107	31	239	20	373	44	107	22	13
339/13	**Fabric 1**	55.89	0.70	15.92	4.52	0.10	3.33	13.99	0.97	4.36	0.23	633	94	107	12	67	91	177	24	160	13	776	47	100	36	18
331/13	**Fabric 2**	56.20	0.71	13.05	4.31	0.05	1.78	21.32	0.43	1.75	0.41	338	95	76	8	41	73	69	28	279	16	383	30	54	19	11
99/13	**Fabric 2**	61.67	0.87	14.65	5.36	0.07	2.04	12.10	0.59	2.31	0.36	280	104	95	6	39	105	79	19	199	9	356	38	79	15	10
100/13	**Fabric 2**	60.48	0.88	15.51	5.67	0.06	1.94	12.51	0.42	2.15	0.37	406	109	97	7	40	107	92	28	219	16	401	38	96	25	10
101/13	**Fabric 2**	60.12	0.92	15.36	5.71	0.07	2.18	12.01	0.69	2.36	0.56	378	112	104	12	43	100	106	32	272	19	350	39	95	21	14
102/13	**Fabric 2**	59.93	0.85	14.32	5.21	0.07	1.89	14.46	0.62	2.23	0.44	313	93	88	7	39	90	76	20	208	10	391	36	73	18	10
349/13	**Fabric 2**	57.97	0.89	14.45	5.92	0.07	2.25	15.09	0.96	2.01	0.39	372	117	104	11	47	97	85	30	283	20	325	34	90	32	9
355/13	**Fabric 2**	59.99	0.81	13.88	5.05	0.08	1.89	15.22	0.58	2.07	0.44	296	108	85	12	37	87	70	22	227	8	348	29	78	18	9
375/13	**Fabric 2**	60.85	0.90	15.03	5.70	0.07	1.85	12.46	0.52	2.24	0.38	351	132	99	6	40	90	98	29	254	17	363	36	104	23	13
377/13	**Fabric 2**	60.82	0.93	15.22	5.61	0.07	1.97	11.56	0.77	2.66	0.41	208	127	104	8	43	87	52	14	118	1	333	46	63	7	15
378/13	**Fabric 2**	60.17	0.90	15.11	5.60	0.07	2.09	12.46	0.72	2.40	0.49	374	114	103	10	42	101	96	30	238	17	345	41	104	22	13
383/13	**Fabric 2**	59.61	0.91	15.34	5.47	0.06	2.16	12.80	0.59	2.58	0.47	327	127	105	9	43	100	89	22	196	11	316	43	103	33	12
393/13	**Fabric 2**	59.63	0.88	14.94	5.49	0.07	2.16	13.18	0.75	2.35	0.54	382	111	96	6	39	101	102	33	279	20	344	36	77	22	14
394/13	**Fabric 2**	59.41	0.92	14.85	5.66	0.09	2.15	13.61	0.65	2.10	0.55	357	104	95	9	44	98	91	31	294	19	390	44	108	21	14
400/13	**Fabric 2**	60.07	0.85	14.42	5.23	0.07	2.06	14.33	0.51	2.17	0.30	340	119	96	8	40	89	87	29	265	16	333	31	94	19	11
424/13	**Fabric 2**	60.70	0.87	14.50	5.43	0.06	2.25	13.03	0.57	2.25	0.34	332	107	95	7	38	94	82	22	224	13	332	41	86	26	10
435/13	**Fabric 2**	59.48	0.96	15.80	5.88	0.07	2.42	11.82	0.58	2.58	0.40	356	131	118	12	51	103	90	22	185	12	337	46	99	19	9
436/13	**Fabric 2**	59.50	0.90	15.37	5.57	0.08	2.24	12.97	0.60	2.34	0.44	377	114	101	6	43	101	101	31	257	19	325	37	82	21	10
437/13	**Fabric 2**	59.37	0.90	15.18	5.47	0.06	2.14	13.10	0.72	2.53	0.52	356	114	103	10	41	102	91	25	220	15	352	41	79	20	11
438/13	**Fabric 2**	59.44	0.82	15.14	5.02	0.06	2.16	14.96	0.36	1.79	0.26	276	91	91	7	38	85	52	14	140	5	368	31	63	12	7

444/13	**Fabric 2**	59.37	0.93	15.55	5.60	0.06	2.21	12.94	0.50	2.42	0.42	342	137	109	9	44	100	95	24	196	15	373	54	73	20	13
324/13	**Fabric 2**	60.71	0.92	14.69	5.83	0.07	1.93	12.41	0.73	2.25	0.45	381	114	104	9	40	96	90	30	271	18	465	44	102	21	11
114/13	**Fabric 2**	58.35	0.76	13.57	4.54	0.06	1.99	17.05	0.71	1.91	1.05	232	92	82	4	46	72	28	9	77		363	33	74	8	13
351/13	**Fabric 2**	60.67	0.84	14.64	5.25	0.06	2.02	13.25	0.54	2.06	0.67	376	99	90	10	36	100	83	27	252	14	436	37	85	24	9
374/13	**Fabric 2**	60.70	0.85	15.60	5.60	0.07	1.82	12.62	0.36	1.91	0.46	357	103	90	7	38	111	88	28	239	16	377	41	67	35	11
392/13	**Fabric 2**	58.24	0.93	15.71	5.63	0.08	2.27	13.33	0.62	2.61	0.58	404	114	104	11	44	100	99	31	241	19	353	44	86	24	11
284/13	**Fabric 2**	56.82	0.83	14.21	5.35	0.06	2.61	15.90	1.15	2.33	0.73	473	91	99	8	39	98	94	30	235	17	296	43	90	16	11
285/13	**Fabric 2**	58.19	0.97	15.93	5.99	0.08	2.15	12.79	1.01	2.54	0.36	510	139	97	11	42	97	99	30	236	21	356	45	88	24	14
293/13	**Fabric 2**	59.93	1.11	14.56	7.03	0.10	2.64	10.41	1.28	2.09	0.85	572	147	114	19	56	84	80	29	249	18	593	47	97	2184	30
550/13	**Fabric 2**	56.69	1.16	15.51	6.91	0.11	2.91	12.33	1.66	2.26	0.45	666	139	90	13	47	95	76	32	258	34	522	53	126	24	12
326/13	**Fabric 2**	60.21	1.04	15.16	6.21	0.08	2.57	11.31	0.52	2.52	0.36	364	119	124	12	54	102	99	31	260	19	341	42	102	21	12
329/13	**Fabric 2**	59.42	1.04	15.30	6.33	0.08	2.53	11.98	0.47	2.54	0.32	318	126	127	10	58	101	98	31	257	19	360	42	81	19	12
306/13	**Fabric 2**	62.30	0.94	16.16	0.31	0.07	2.49	14.51	0.61	2.07	0.54	282	103	93	65	37	75	71	26	249	15	438	39	81	18	9
328/13	**Fabric 3**	54.93	0.98	15.64	5.51	0.08	3.05	16.05	0.62	2.53	0.60	654	116	124	7	56	97	98	33	205	23	347	43	101	20	12
333/13	**Fabric 3**	62.60	0.84	14.64	5.25	0.06	1.61	12.18	0.42	1.94	0.47	372	97	86	8	37	93	79	23	261	13	450	40	84	31	9
336/13	**Fabric 3**	49.51	0.68	13.51	3.37	0.04	2.01	28.93	0.26	1.42	0.27	347	64	69	6	34	83	47	16	130	8	382	27	57	11	5
529/13	**Fabric 3**	51.46	0.75	13.62	4.22	0.06	2.11	24.93	0.35	1.91	0.59	422	83	91	7	39	83	74	26	184	15	369	41	74	14	10
353/13	**Fabric 3**	59.64	0.75	14.08	4.74	0.05	1.72	16.59	0.39	1.62	0.42	350	88	81	8	35	101	65	25	236	12	453	33	73	20	9
386/13	**Fabric 3**	60.69	0.91	15.12	5.68	0.07	2.12	11.95	0.70	2.31	0.44	340	124	106	10	42	101	93	25	238	13	365	47	78	20	10
301/13	**Fabric 4**	66.13	0.68	11.23	4.60	0.07	2.02	11.98	0.73	2.09	0.47	428	83	77	5	34	76	70	20	257	9	368	39	82	13	10
305/13	**Fabric 4**	41.31	0.60	14.62	3.44	0.05	1.88	35.42	0.25	1.94	0.50	924	68	82	13	57	78	54	20	67	9	292	41	74	27	5
342/13	**Fabric 4**	57.07	0.97	16.48	6.11	0.07	2.10	13.17	0.92	2.68	0.45	756	132	90	15	49	110	95	31	199	22	438	59	88	22	12

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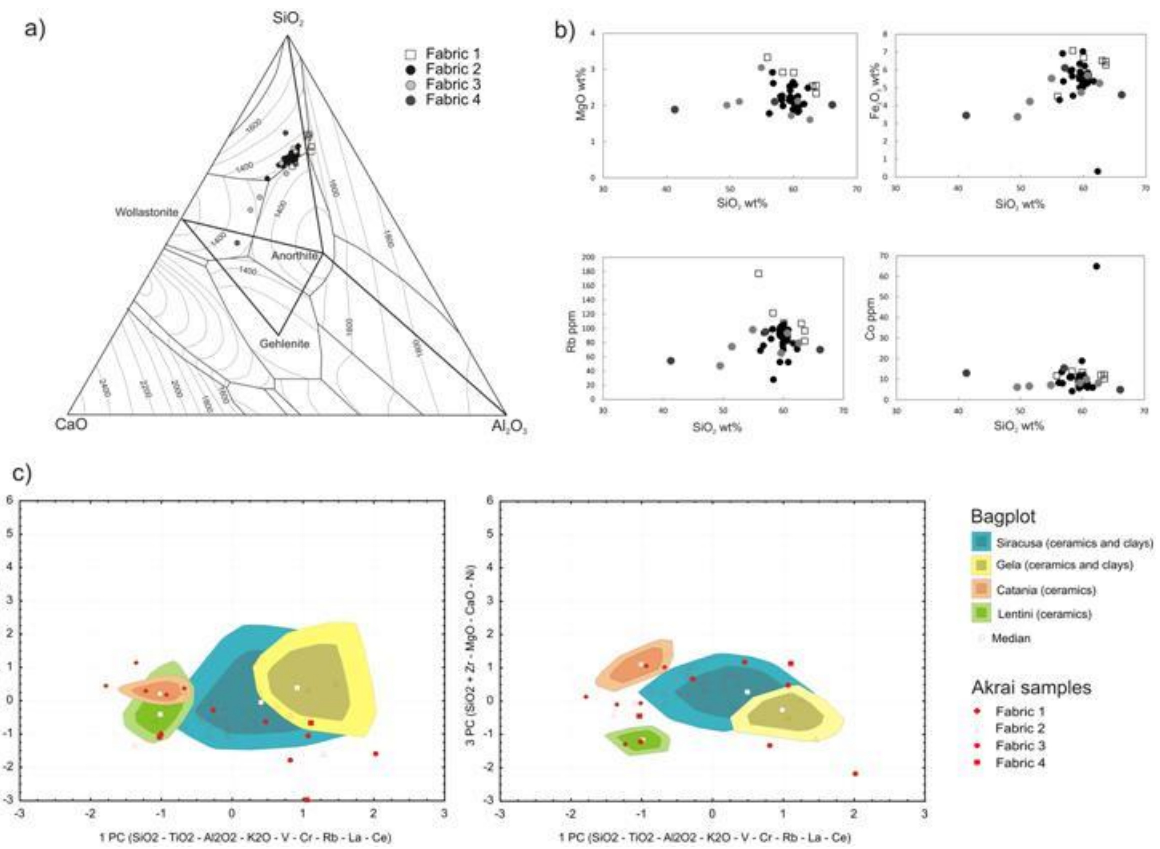

Figure 3. (a) SiO_2–CaO–Al_2O_3ternarydiagram. (b) Binary diagrams of MgO (wt%), Fe_2O_3 (wt%), Rb (ppm) and Co (ppm) vs. SiO_2 (wt%). (c) Bag plots of the reference datasets (Siracusa, Gela, Catania and Lentini) and studied samples from Akrai distinguished on the basis of petrographic fabrics identified.

An inspection of the bag-plots reported in Figure 3(c) highlights the formation of clusters in good accordance with petrographic groups. In detail, a good correspondence between Fabrics 2 and 3 (*e.g.*, small vessels, fine wares, micaceous, fossil-rich groundmass and mainly without inclusions) and Hellenistic and Roman fine ceramic production from Syracuse can be established. Noteworthy is that the diagrams show an overlapping between Syracuse and Gela ceramics and clays, so that for samples plotted in this field no certainly attribution can be supplied.

Samples with volcanic inclusions (typologically classified as big basins and jugs and mainly belonging to Fabric 1 with some samples of Fabric 2) are plotted in the areas of Catania and Lentini ceramic productions, according to petrographic features of reference data. Finally, for samples of Fabric 4, characterized by high CaO levels and fossil-rich groundmass, no correspondence has been found, excepting for 342/13 specimen with volcanic inclusions, plotted in Catania production cluster.

4. CONCLUSIONS

The archaeometric investigation carried out on plain table-ware samples from the ancient city of Akrai allow to obtain information on the technology and provenance of pottery productions. In spite of a slight heterogeneity in term of inclusions, the whole of petrographic, mineralogical and chemical data highlights a quite homogeneity of all the studied materials. As far as the technological point of view, the use of high depurated clay sediments and the medium-high firing temperature esteemed (in the range of 850-900 °C) suggest a good technological level of the production, with a clear differentiation of manufacture among the different typology of vessels. In fact, samples typologically classified as vessels devoted to serving and consuming food are mainly included in petrographic fabrics characterized by absence of inclusions, micaceous and fossiliferous groundmass and highly depurated clays; otherwise, bigger shapes used for holding liquids, such as jugs and basins, are characterized by the presence of volcanic inclusions and a slightly coarser grain clay paste. On the basis of the comparison with reference data, these two main categories can be also attributed to different Sicilian workshop centres, namely the Hellenistic and Roman fine ceramic production from Syracuse (Fabric 2 and 3 samples), and Catania and Lentini productions (Fabric 1 and some specimens of Fabric 2), respectively.

Therefore, the plain table-wares from Akrai can be defined as a rather regional than local manufacture and a Sicilian provenance can be assessed, without a substantial change of artifacts supplying over the stratigraphic range investigated. In fact, the different pottery productions are equally testified along the stratigraphic units explored during the archeological excavation, dated back from the 3rdcentury B.C. to 5thcentury A.D.. It seems to be very important to stress that plain table-wares present in Akrai could be described as a good quality products, regardless of the period of production.

It could be also observed that the pottery production centres were continued their manufacture and, most probably, did not change the technology and materials when the Romans appeared on the island.

Generally, the Sicilian case could be considered an excellent example of mixing of experiences of different people and blending of culture and manufacture, also in pottery production, while the centuries.

In conclusion, considering the start point of the research, *i.e.* the use of material culture to monitor cultural and political changes in ancient cities, the obtained results highlight how beside the political and economical changes that have interested the town of Akrai during the Romanization process, a continuity in commercial exchanges has been maintained over the time. So far the archaeological together with the archaeometric studies have testified that no abandonment of town and urban decline after 212 B.C. has been occurred, as well as the continuation of life and vigorous development of trade exchanges.

The continuation of this research is very important and should bring the knowledge not only about the preferences in local products or imported pottery, but also about the economy of the ancient town in Hellenistic and Roman periods.

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REFERENCES

Aitchison, J. (1986)*The statistics analysis of compositional data London*, UK, Chapman and Hall.

Alcock, S.E. (1989) Archaeology and Imperialism. Roman Expansion and the Greek City, *Journal of Mediterranean Archaeology*, vol. 2/1, pp. 87–135.

Aquilia, E., Barone, G., Mazzoleni, P. and Ingoglia, C. (2012) Petrographic and chemical characterisation of fine ware from three Archaic and Hellenistic kilns in Gela, Sicily, *Journal of Cultural Heritage*, vol. 13, pp. 442–447.

Barbera, G., Barone, G., Crupi, V., Longo, F., Maisano, G., Majolino, D., Mazzoleni, P., Teixeira, J. and Venuti, V. (2013) Small angle neutron scattering study of ancient pottery from Syracuse (Sicily, Southern Italy), *Journal Archaeological Science*, vol. 40, pp. 983-991.

Barone, G., Lo Giudice, A., Mazzoleni, P. and Pezzino, A. (2005) Chemical characterization and statistical multivariate analysis of ancient pottery from Messina, Catania, Lentini and Siracusa (Sicily), *Archaeometry*, vol. 47(4), pp. 745-762.

Barone, G., Mazzoleni, P., Spagnolo, G. and Aquilia, E. (2012) The Transport Amphorae of Gela: A Multidisciplinary Study on Provenance and Technological Aspects, *Journal of Archaeological Sciences*, vol. 39, pp. 11-22.

Barone, G., Mazzoleni, P., Aquilia, A. and Barbera, G. (2014) The Hellenistic and Roman Syracuse (Sicily) fine pottery production explored by chemical and petrographic analysis, *Archaeometry*, vol. 56(1), pp. 70-87.

Buscemi, F. (2007) Architettura e romanizzazione nella Sicilia di età imperiale gli anfiteatri, *Archivio Storico Siracusano*, vol.III XXI, pp. 7–53.

Chowaniec, R. (2013) Ancient Akrai in the light of new researches. Non-invasive researches in PalazzoloAcreide, south-eastern Sicily, *SOMA 2012 Identity and Connectivity, Proceedings of the 16thSymposium on Mediterranean Archaeology*, L. Bombardieri, A. D'Agostino, G. Guarducci, V. Orsi and S. Valentini, Oxford, pp. 965–971,.

Chowaniec, R. (2014)PalazzoloAcreide, Sicily, Italy. Excavations in 2013, *Światowit fasc. A. Mediterranean and Non-European Archaeology*,vol. XI (LII), fasc. A.

Chowaniec, R. (2015a) The Sicilian world after the Punic Wars: the Greek colony in a new reality, *Interdisciplinary Perspectives on Colonisation, Maritime Interaction and European Cultural Integration*, H. Glørstad, L. Melheim and Z. Glørstad, Sheffield.

Chowaniec, R. (2015b) Comments on the history and topography of Akrai/Acrae in the light of new research, *Unveiling the past of an ancient town. Akrai/Acrea in south-eastern Sicily*, R. Chowaniec,Warsaw,pp. 43-78.

Cultrone, G., Rodriguez-Navarro, C., Sebastian, E., Cazalla, O. and De la Torre, M. J. (2001) Carbonate and silicate phase reactions during ceramic firing, *European Journal of Mineralogy*, vol. 13, pp. 621–634.

Cultrone, G., Molina, E. and Arizzi, A. (2014) The combined use of petrographic, chemical and physical techniques to define the technological features of Iberian ceramics from the Canto Tortoso area (Granada, Spain), *Ceramics International*, vol. 40, pp. 10803–10816

Dearden, C. (2004) Sicily and Rome. The Greek context for roman drama, *Mediterranean Archaeology*, vol. 17, pp. 121–130.

Hayes, H.W. (1997) *Handbook of Mediterranean Roman Pottery*, London, UK.

Hill, T. and Lewicki, P. (2007)*Statistics: Methods and Applications*, StatSoft, Tulsa, Oklaoma, USA.

Hollegaard, O.C., A. Rathje, C. Trier and C. Winther (1995)*The Roman domus of the Early Empire. A Case Study: Sicily in Ancient Sicily*, T. Fischer-Hansen, Danish Studies in Classical Archaeology. ActaHyperborea6, pp. 209–261.

Kiiskinen, H. (2013)*Production and Trade of Etrurian Terra Sigillata Pottery in Roman Etruria and beyond between c. 50 BC and c.150 CE*, University of Turku, Turku.

Maggetti, M. and Küpfer, T. (1978) Composition of the terra sigillata from La Péniche (Vidy/Lausanne, Switzerland), *Archaeometry*, vol. 20(2), pp. 183–188.

Maggetti, M. (1982)*Phase analysis and its significance for technology and origin, in Archeological Ceramics*, J.S. Olin, A.D. Franklin, Smithsonian Inst. Press, Washington, pp.121–133

Malfitana, D. (2004) Italian Sigillata Imported in Sicily: the evidence of stamps, in Early Italian Sigillata. The chronological framework and trade patterns. *Proceedings of the First International Conference ROCT-Congress Leuven*, J. Poblome, P. Talloen, R. Brulet and M. Waelkens, Leuven-Paris, pp. 295-323.

Młynarczyk, J. (2015)Plain Table Ware from Akrai. Preliminary approach, *Unveiling the past of an ancient town. Akrai/Acrea in south-eastern Sicily*, R. Chowaniec, Warsaw, pp. 295-310.

Munsell Color (2000)*Munsell soil color chart*, Gretag, Macbeth, New Windsor.

Olcese, G. (2011-2012) *Atlante dei siti di produzione ceramica (Toscana, Lazio, Campania e Sicilia) con le tabelle dei principali relitti del Mediterraneo occidentale con carichi dall'Italia centro meridionale (Immensa Aequora 2)*, Edizioni Quasar, Roma.

Picon, M., Carre, C., Cordoliani, M.L., Vichy, M., HernandezAndj, J.A. and Mignard, L. (1975)Composition of the La Graufesenque, BanassacandMontansterra sigillata, *Archaeometry*, vol. 17(2), pp. 191–199.

Polito, A. (2000) La circolazione della sigillata liscia in Sicilia, *Quaderni di Messina*, vol. 1(2), pp. 65-102.

Riccardi, M.P., Messiga, B. and Duminuco, P. (1999) An approach to the dynamics of clay firing, *Applied Clay Science*, vol. 15, pp. 393–409.

Rousseeuw, P.J., Ruts, I. and Tukey, J.W. (1999) The Bagplot: A Bivariate Boxplot, *The American Statistician*, vol. 53(4), pp. 382-387.

Thió-Henestrosa, S. and Martín-Fernández, J. A. (2005) Dealing with compositional data: the freeware CoDaPack, *Mathematical Geology*, vol. 37, pp. 773-793.

Tukey, J. W. (1977)*Exploratory data analysis*. Reading, MA, Addison-Wesley.

Whitbread, I. K. (1995)*Greek transport amphorae: a petrological and archaeological study*, Fitch Laboratory Occasional Paper, 4, British School at Athens, Athens.

Więcek, T., Chowaniec, R. and Guzzardi, L. (2014) Greek Akrai and Roman Acrae. New numismatic evidence. Polish-Italian archaeological excavations 2011-2012, *Archeologia*, vol. 62-63, pp. 19–30.

Wilson, R.J.A. (1988) Towns of Sicily during the Roman Empire, *Aufstieg und Niedergang der römischen Welt (eds. H. Temporini), vol. II. Prinzipat. B. 11. Politische Geschichte (Provinzen und Randvölker: Sizilien und Sardinien; Italien und Rom; Allgemeines). 1. Teilband: Sizilien und Sardinien*, Berlin-New York: Walter de Gruyter., pp. 90–204.

Wilson, R.J.A. (1990)*Sicily under the Roman Empire: The Archaeology of a Roman Province*, 36 B.C.–A.D. 535. Warminster.