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Archaeometric evidence attesting production of indigenous archaic pottery at Monte Polizzo (Western Sicily)

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Abstract

Excavations at the proto-urban indigenous settlement of Monte Polizzo (western Sicily) have not yielded so far any evidence of in-situ ceramic production (i.e. kiln structures). However several archaeological concerns put forward to consider it as a likely production centre of pottery during the Archaic age. In this paper a first attempt to check the compositional correspondence between ceramic fabrics and local clay sources has been made. A comprehensive archaeometric investigation of indigenous pottery, mainly composed of matte-painted table ware dated from the 7th to the 4th century B.C., recovered from the Acropolis of Monte Polizzo has allowed the identification of six distinct "Paste Compositional Reference Units" (PCRUs). The six PCRUs were independently identified and confirmed through textural and mineralogical characteristics (petrographic observations) and chemical characterization (XRF analysis).

A parallel investigation of clayey raw material of Monte Polizzo's natural resources revealed two geologic formations the Terravecchia and Marnoso-Areacea del Belice (MAB). Experimental ceramic briquettes were created and petrographically and chemically characterized. A comparison between the indigenous and experimental ceramics revealed that the local potters preferred clays from the Terravecchia Formation.

The mineralogical, textural and chemical composition of the raw clays of the Terravecchia Formation resulted to be well correlated with the 92% of the indigenous ceramic artefacts recovered from Monte Polizzo. The remaining 8% are interpreted to be imported from the Sicani Mounts area.

Key words: Western Sicily; Archaic age; indigenous ceramic production; incised and matte painted tableware; thin section petrography; XRF.

Introduction

Monte Polizzo was a proto-urban indigenous settlement, dating back approximately to the 9th century B.C., active till the end of 4th century B.C., frequented again in the Middle Ages and occasionally in more recent times.

The current archaeological site lies only six kilometres northwest of Salemi, Trapani province, at 726 m above sea level, dominating a vast area of western Sicily and controlling the major trade routes to Selinunte, the greatest Greek colony in the area and Segesta, the most important Hellenised indigenous centre. The topography of the site shows clear analogies with other indigenous settlements in archaic western Sicily (Erice, Segesta, Entella, Monte Iato, Monte Adranone, Monte Maranfusa just to list the most important ones), as it is located on top of a hill in a suitable position for defence and territorial control (Figure 1). The correspondence concerns material culture as well testifying for their belonging to a unique and homogeneous civilization (Spatafora, 1996).

Investigations at Monte Polizzo can therefore spread new light on a wider area in Western Sicily that lies out of colonial (Greek and Phoenician) territories and that retained the peculiar features of indigenous civilization in archaic and classical times. First study on Monte Polizzo took place in the early 70's (Tusa, 1972). Later, several in-depth field surveys and excavations were carried out (1998-2010) within the "*Sicilian Scandinavian Archaeological Project"* (SSAP), which the Universities of Göteborg and Oslo, as well as the American Universities of Stanford, Northern Illinois and Northern Iowa are part of (Johansson and Prescott, 1999; Prescott et al., 2001; Morris et al., 2001; Kolb and Tusa, 2001; Mühlenbock and Prescott, 2001; Morris et al., 2002; Morris et al., 2003; Morris et al., 2004; Morris and Tusa, 2004). The excavations are being carried out not only on Monte Polizzo (Acropolis, House 1, Portella S. Anna) but also in the historical center of Salemi and in the site of Pizzo Mokarta (not far away).

Notwithstanding a considerable amount of ceramics imported from the Greek world (possibly through the colony of Selinus) and, on a lesser grade, from the Phoenician area, the main ceramic assemblage consists mostly of

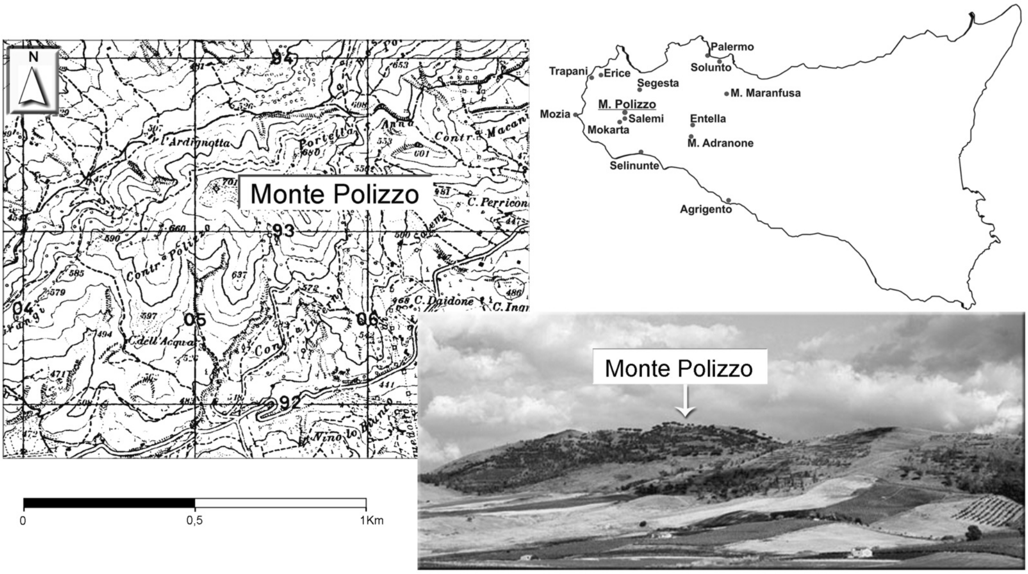

Figure 1. Map of western Sicily marking the positions of Monte Polizzo, Mokarta, Salemi, and some relevant archaeological sites.

storage and tableware decorated with incised or painted geometric patterns. This pottery is characteristic of indigenous settlements in central and western Sicily and it has even been used as marker of 'Elymian' culture, though this issue is still debated (Spatafora, 1996). The retrieving of these ceramics at Monte Polizzo is therefore obvious, but it does not give enough information about technical, productive and commercial aspects of the Monte Polizzo settlement. In fact, nowadays, nothing can be inferred about the existence of ceramic workshops at Monte Polizzo. For that reason, several important socio-economic questions, such as the capability in facing local needs or in spreading their ceramic items on a larger market, cannot be answered. Monte Polizzo differs therefore from sites like Entella (PA), where kilns, furnace separators and misfired sherds of archaic age were found, testifying for a local production of cooking ware, plain ware and vases decorated in a simple geometric style (Guglielmino, 2000). As a consequence, at Entella it was possible to clearly identify local products also following their spreading in the neighborhoods and to appreciate the ratio local vs. imported ceramics (Montana et al., 2011a).

An attempt in relating ceramics from Monte Polizzo to other fabrics in western Sicily was made in a preliminary archaeometric study involving several pottery samples collected at Monte Polizzo, published five years ago by Kolb and Speakman (2005). They analyzed a consistent number of Archaic table ware sherds (9th to the 6th century B.C.) collected from 12 indigenous settlements all located in western Sicily by means of instrumental neutron activation analysis (INAA), with the aim of studying the ceramic production centers and the exchange patterns. The chemical data obtained from INAA were evaluated using an array of multivariate statistical procedures in order to facilitate the identification of compositional groups. Up to five *chemical groups* were clearly identified suggesting an intra-regional organization of ceramic trade in western Sicily, however the source locations of raw clays and the location of the correspondent ceramic workshops remained uncertain (Kolb and Speakman, 2005). More recently, 20 ceramic samples from the areas A, B and C of Monte Polizzo Acropolis, dated to the mid 6th century B.C. and stylistically attributed to *local indigenous ware* were analyzed by thin section microscopy and ICP-AES (Brorsson, 2007). Up to 7 *groups* consisting of different temper materials and/or microfabric were described even if chemical analyses suggested only small compositional variations for the majority of the samples (Brorsson, 2007). Nevertheless, in this case the hypothesis of provenance was debated on the individual samples and the compositional and textural fingerprints of local ceramic products were only approximately described and not evaluated on a geo-lithological basis.

Such a 'knowledge plateau' concerning the Archaic ceramic production in the site of Monte Polizzo is not surprising considering that the assignment of a ceramic paste (macroscopic/microscopic fabric) to a specific workshop can be easily addressed only if kiln wasters are available. However, if we consider a consumption center the situation is radically different. In this case, a *paste compositional reference unit* or PCRU can be only formed. It can not be related to a particular workshop unless by association with already established compositional groups (Bishop et al., 1982; Rice, 1987; Buxeda et al., 1995)

Nevertheless, the comparison of the *paste compositional reference units* with local geology and clayey raw materials available in the territory can be an alternative way to establish if the settlement of Monte Polizzo - within a specific chronological interval (7th - 4th century B.C.) - was simply a centre of consumption, importing ceramics from other indigenous and coeval sites, or if - as it seems possible according to the archaeological data acquired so far - it was itself a centre of production, and to discriminate between autochthonous or allochthonous ceramic productions.

Thus, the awareness of the ceramic raw materials available in a given territory may be a correct approach for an accurate definition of ceramic provenance, by determining the mineralogical and chemical composition and also some critical textural aspects of clays (i.e. packing and size distribution of aplastic grains) and comparing them with materials retrieved from archaeological excavations (e.g. Magetti, 1982; Picon, 1992; Degryse et al., 2003; Gliozzo and Memmi Turbanti, 2004; Hein et al., 2004; Gliozzo et al., 2005; Tite, 2008).

This paper provides a detailed petrographic and chemical investigation of ceramic finds recovered from excavations at Monte Polizzo. A set of 44 ceramic samples were carefully selected on an autoptical basis by the archaeologists of the American mission. The sherds were mostly representative of small amphorae, bowls, jugs, vessels and other less distinct forms that may be classified as ‘tableware’ from a functional point of view. These samples were studied by optical microscopy (thin sections) and X-ray fluorescence spectroscopy (XRF). This archaeometric investigation of ceramic sherds was carried out in parallel with one on the raw clayey materials cropping out in the studied area (6 samples). The textural and compositional comparison between the potential raw materials and the ceramic artefacts is not easy because of the analogies, shown by the geo-lithologic contexts of the already recognized production centres situated in western Sicily (Montana et al., 2003; Montana et al., 2007; Montana et al., 2009; Montana et al., 2010; Montana et al., 2011b).

Geological outline and local raw clays

From a geologic point of view, the adjacent hinterlands surrounding Monte Polizzo and Salemi are characterized by a discontinuous sedimentary record dating from the late Triassic to the present-day. Common bedrock types include limestone, calcareous marl, shale, siltstone, sandstone, conglomerate, calcarenite, evaporitic limestone, selenitic gypsum, loose sand and clay assemblages that reveal deep to shallow marine environments and younger transitional alluvial sedimentation (Catalano and D’Argenio, 1982; Tortorici et al., 2001). Clays beds suitable for making ceramics and outcropping close to the site of Monte Polizzo (Figure 2) are those belonging to the Upper Tortonian - Lower Messinian Terravecchia Formation (Ruggeri and Torre, 1984; Butler et al., 1999) and to the Middle-Upper Pliocene Marnoso-Arenacea del Belice (MAB) Formation (Roda, 1967; Ruggeri and Torre, 1974). The Terravecchia Formation is a sequences of fluvial deltaic deposits up to 2500 m thick forming a molassic package of clastic sediments. It represents a major sedimentation period throughout Sicily with some stratigraphic unconformities. The MAB Formation is a terrigenous succession that lies discordantly on older deposits forming a characteristic polyphase thrusting (piggy-back). The MAB also contains clay-beds that contain significant concentrations of calcareous microfauna.

Terravecchia and MAB clayey raw materials are abundant in western Sicily and they have been recently characterized in terms of grain size distribution, mineralogical and chemical composition (Montana et al., 2006; Montana et al., 2011b).

Materials and methods

Description of ceramic samples and clays

Forty-four ceramic samples were subjected to textural and compositional analytical methods. These samples were recovered from Stanford University’s excavations, under the direction of Dr. Ian Morris, on Monte Polizzo’s Acropolis.

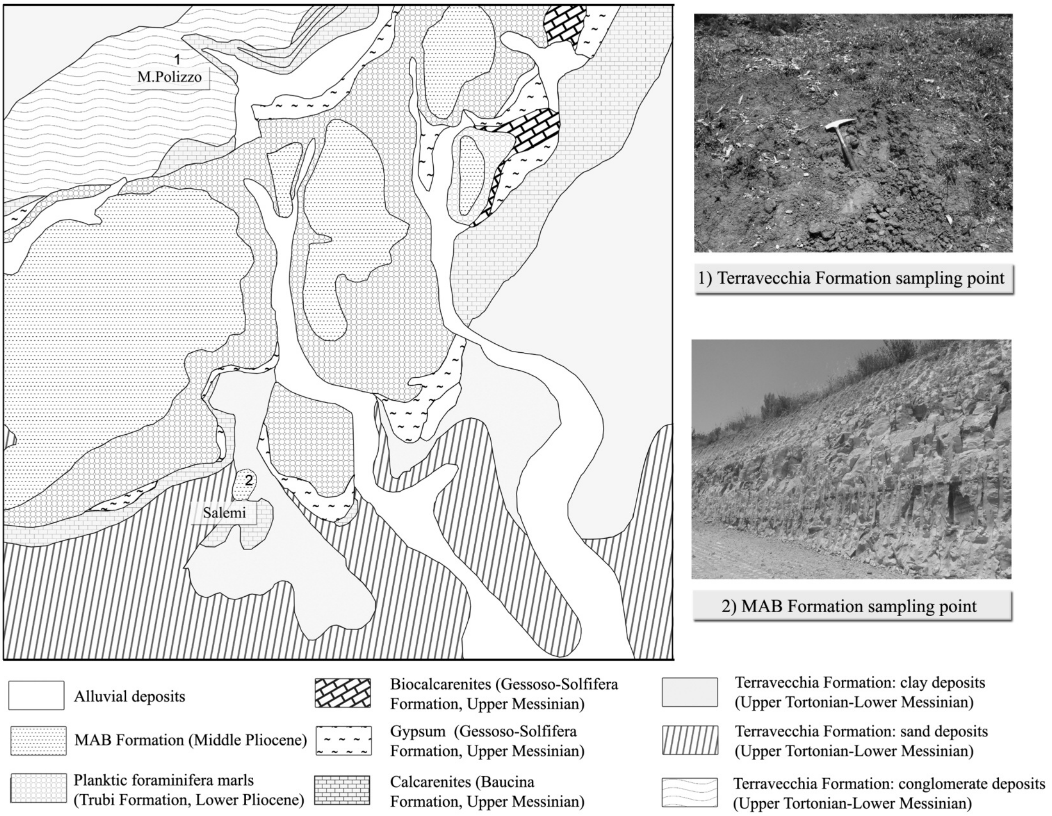

Figure 2. Lithologic map of the area between Monte Polizzo and Salemi.

Dr. Emma Blake (Tufts University) organized the excavation's recovered material culture. Dr. Blake by means of careful naked-eye observations identified three major macrofabric groups: F24, F7 and F54 (Table 1). These groups were schematically classified into chronological groups (detailed descriptions of the different chronological phases are provided in Morris et al., 2004), macrofabric, typology and surface treatments.

F24 macrofabric (3 samples) was by far the least common in the studied set of ceramic sherds (Blake, personal communication). F24 represents diagnostic undecorated/handmade large storage vessels, *pithoi,* (average thickness between 15-20 mm). This macrofabric was also characterized by a temper frequency greater than 10% (area) as well as the presence of coarser sand grains (maximum grain size, MGS, up to 3 mm).

Macrofabric F7 (Figure 3a) was well-represented (18 samples) in the available set of ceramic samples. F7 samples represent smaller diagnostic wheel-made tableware forms (e.g. bowls) having the external surface decorated with incised geometric patterns (mainly horizontal lines). F7 is classified as a fine to very-fine paste (MGS around 0.5 mm) with a greyish surface colour, average thickness up to 5 mm and temper

Table 1. Chronology, macrofabric (see text), type, thickness and surface treatment of the studied ceramic samples from Monte Polizzo.

Samples	Chronology	Fabric	Vessel Type	Thickness (mm)	Surface Treatment
PLZ26	late 4th century B.C. (Phase III)	F 7	bowl	5	incised
PLZ33	late 4th century B.C. (Phase III)	F 7	small table ware	4.5	incised
PLZ46	late 4th century B.C. (Phase III)	F 7	small table ware	4.5	incised
PLZ4	6th century B.C. (Phase II)	F 7	small table ware	6	incised
PLZ14	6th century B.C. (Phase II)	F 7	open vessel	5.5	incised
PLZ25	6th century B.C. (Phase II)	F 7	bowl	5	incised
PLZ40	6th century B.C. (Phase II a)	F 7	small table ware	5	incised
PLZ44	6th century B.C. (Phase II a)	F 7	bowl	6	incised
PLZ34	6th century B.C. (Phase II b)	F 7	small table ware	6	incised
PLZ36	6th century B.C. (Phase II b)	F 7	closed vessel	5	incised
PLZ29	6th century B.C. (Phase II b)	F 7	open vessel	6.5	incised
PLZ1	7th-6th century B.C. (Phase I-II)	F 7	small table ware	6	incised
PLZ15	7th-6th century B.C. (Phase I-II)	F 7	closed vessel	7	incised
PLZ18	7th-6th century B.C. (Phase I-II)	F 7	jug	3	incised
PLZ19	7th-6th century B.C. (Phase I-II)	F 7	closed vessel	6	incised
PLZ28	7th-6th century B.C. (Phase I-II)	F 7	open vessel	5	incised
PLZ31	7th-6th century B.C. (Phase I-II)	F 7	small table ware	4.5	incised
PLZ37	7th-6th century B.C. (Phase I-II)	F 7	jug	4	incised
PLZ16	late 4th century B.C. (Phase III)	F 24	pithos	16	undecorated
PLZ47	late 4th century B.C. (Phase III)	F 24	pithos	23	undecorated
PLZ12	6th century B.C. (Phase II a)	F 24	pithos	20	undecorated
PLZ43	late 4th century B.C. (Phase III)	F 54	open vessel	9	matte painted
PLZ9	late 4th century B.C. (Phase III)	F 54	table ware	8	matte painted
PLZ32	late 4th century B.C. (Phase III)	F 54	table ware	6.5	matte painted
PLZ3	late 4th century B.C. (Phase III)	F 54	table amphora	5.5	matte painted
PLZ35	6th century B.C. (Phase II)	F 54	closed vessel	8	matte painted
PLZ20	6th century B.C. (Phase II a)	F 54	table ware	11	matte painted
PLZ21	6th century B.C. (Phase II a)	F 54	table ware	8	matte painted
PLZ24	6th century B.C. (Phase II a)	F 54	table amphora	7	matte painted
PLZ10	6th century B.C. (Phase II b)	F 54	table ware	6	matte painted
PLZ17	6th century B.C. (Phase II b)	F 54	bowl	8	matte painted
PLZ39	6th century B.C. (Phase II b)	F 54	table ware	6	matte painted
PLZ41	6th century B.C. (Phase II b)	F 54	table ware	6	matte painted
PLZ42	6th century B.C. (Phase II b)	F 54	table amphora	9	matte painted
PLZ2	7th-6th century B.C. (Phase I-II)	F 54	table ware	7.5	matte painted
PLZ6	7th-6th century B.C. (Phase I-II)	F 54	closed vessel	6	matte painted
PLZ7	7th-6th century B.C. (Phase I-II)	F 54	table ware	8	matte painted
PLZ8	7th-6th century B.C. (Phase I-II)	F 54	table ware	7	matte painted
PLZ22	7th-6th century B.C. (Phase I-II)	F 54	table ware	10	matte painted
PLZ23	7th-6th century B.C. (Phase I-II)	F 54	table amphora	9	matte painted
PLZ27	7th-6th century B.C. (Phase I-II)	F 54	table ware	9	matte painted
PLZ30	7th-6th century B.C. (Phase I-II)	F 54	closed vessel	7	matte painted
PLZ38	7th-6th century B.C. (Phase I-II)	F 54	closed vessel	5	matte painted
PLZ45	7th-6th century B.C. (Phase I-II)	F 54	table ware	7	matte painted

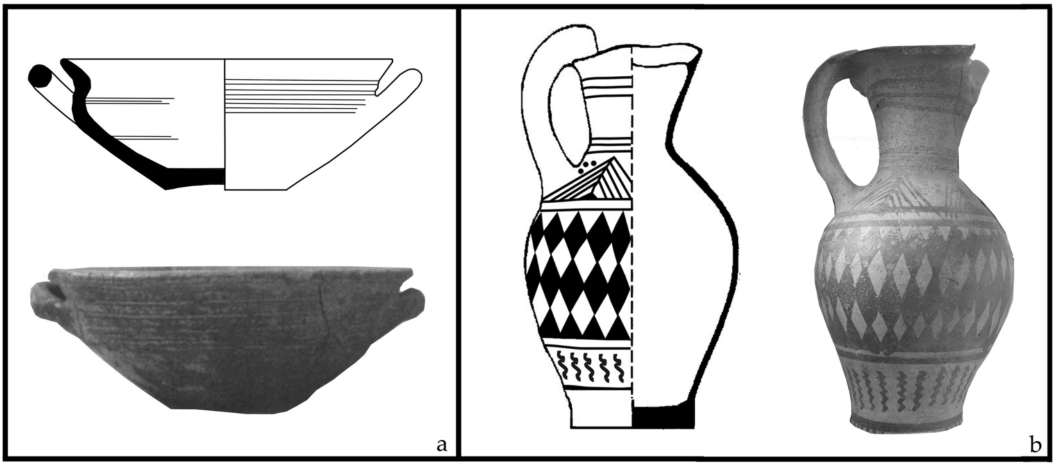

Figure 3. Examples of the indigenous matte painted ceramics found at Monte Polizzo (Acropolis) and others sites of western Sicily: a) bowl with incised decoration; b) table amphora with matte painted geometric decoration.

packing always less than 5% (area). The macrofabric F54 (Figure 3b) was the most frequent within the studied ceramics (23 samples) and characteristic of matte painted (geometric decoration) wheel-made tableware (e.g. table amphorae). It presents mainly very fine-fine sand grains (sporadic medium-coarse) with MGS up to 1 mm. F54 is also characterized by a pale reddish-yellow surface and a greyish core. The average thickness was about 6 mm and the temper packing more abundant than the 5% (area).

Potential local ceramic raw materials representative of the Terravecchia Formation were found along the slopes of Monte Polizzo with complications mainly due to the rarity of exposed clay beds under soil horizons and the presence of thick vegetation. A silty-clay (sample SALT 11: sand content around the 13% wt) and a silty-clayey sand (sample SALT 10: sand content around the 55% wt), the latter utilizable in its natural state only for mixing and tempering purposes, were collected. Concerning the MAB Formation, because of the extensive occurrence of cultivated fields in its outcrop area, 4 uncontaminated samples composed of silty clayey material (SALT1, SALT3, SALT4, SALT6: mean sand content around 15% wt) were collected in the urban centre of Salemi in a clean and deep excavation for a building foundation. We are aware that the number of the collected clay samples, even considering the above stated logistic difficulties, could be considered inadequate to represent well enough both chemical and mineralogical composition of local clays, specially if the analysis are aimed to make a distinction between handmade artefacts. However, it has to be considered that a large number of analysis have been carried out recently in the whole territory of western Sicily on both Terravecchia Formation (159 clay samples) and MAB Formation (48 clay samples), many of which refers to clay samples collected within a radius of 50 km respect the site of Monte Polizzo, being now available and actually significant for comparative purposes (Montana et al., 2011b).

Analytical methods

Clay briquettes of the locally sampled raw materials (small bars of 9 cm width, 2 cm length and 0.5 cm thick) were moulded and fired in a muffle furnace at 900 °C with soaking time maintained for 3 hours. Furthermore, the Terravecchia Formation clay raw materials, due to their varying sand concentrations, were used to prepare an additional briquette (coded MIX1): 3 parts in weight of SALT11 were mixed with 2 parts of SALT10.

Microscopic observations of thin sections were performed by a Leica DM-LSP polarizing microscope equipped with a digital photographic camera. The ceramic artefacts were characterized in terms of the mineralogical and textural features of their aplastic inclusions and accordingly categorized into *fabrics* if showing apparent similarities. The experimental/fired briquettes were petrographically assessed using the same methods used to characterize the artefacts from the ceramic manufactures.

The chemical composition of ceramic samples and local raw clays were determined using a Rigaku ZSX Primus wavelength dispersive X-ray fluorescence spectrometer (XRF), equipped with four diffracting crystals: LiF (200), LiF (220), PET (002), and TAP (100). A small portion of powdered and homogenised samples (around 2 g) was dried at 100°C for 24 h. Each specimen, previously mixed with two drops of a 3% water solution of Mowiol N50-98, was compressed on a base of ultrapure H_3BO_3 at about 5 tons/inches^2 by a hydraulic press to obtain a circular powder pellet (4 cm in diameter). A Rh tube anode routinely running at 4 kW was used for the major elements analysis as well as for minor and trace elements. The quantified elements (major and minor elements recorded as oxides, wt.% while trace elements given as ppm) were the following: Fe_2O_3 (as total Fe), Al_2O_3, MgO, MnO, P_2O_5, TiO_2, CaO, Na_2O, K_2O, SiO_2, V, Cu, Zn, Rb, Sr, Zr, Ba, La, Ce. The loss on ignition (LOI) was determined by firing at least 0.5 g of dried specimen, at 1000 °C for 3 h. Elemental concentrations were quantified using calibration lines up to 52 standard reference materials (SRM). The average relative standard deviations evaluated (RSD) on seven runs of the SRMs IAEA/Soil-7, IAEA/SL-1, NIST/BC-679 were: SiO_2 = 0.64%, TiO_2= 0.97%, Al_2O_3 = 0.89%, Fe_2O_3 = 0.92%, MnO = 1.22%, MgO = 1.38%, CaO = 1.19%, Na_2O = 1.91%, K_2O = 0.83%, P_2O_5 = 1.10%, V = 2% , Cu = 2%, Zn = 1%, Rb = 2%, Sr = 1%, Zr = 3%, Ba = 4%, La = 8%, Ce = 12%.

The analysis of each element was fully corrected for line interference and matrix effects of all the other analysed elements and the results were normalised on a dry-weight basis (Hein et al., 2002).

Multivariate statistic methods such as Principal Components Analysis (PCA) and Multiple Correspondence Analysis (MCA) were carried out through the commercial software S-Plus (Mathsoft 1999).

Results and discussion

Petrography of the ceramic samples

The petrographic analysis of the 44 ceramic samples from Monte Polizzo's Acropolis has facilitated the identification of six *fabrics* (FBRs). The essential characteristics: mineralogical composition, packing, sorting and grain size, for every FBR, were schematised and summarized.

FBR 1a (samples: PLZ1; PLZ4; PLZ15; PLZ18; PLZ19; PLZ22; PLZ25; PLZ28; PLZ29; PLZ31; PLZ33; PLZ34; PLZ37; PLZ44; PLZ46)

It shows a clear prevalence towards a sandy/silicoclastic temper rather than carbonatic, which is nearly absent or not significantly represented, like in the case of sample PLZ15 (Figure 4a). It is characterized by homogeneous texture and quite high packing estimated within 20-30% (area). Temper consists predominantly of fine sand (0.125-0.25 mm), very fine sand (0.06-0.125 mm), and coarse silt (< 0.06 mm). The sand grains are predominantly represented by sub-angular or angular monocrystalline

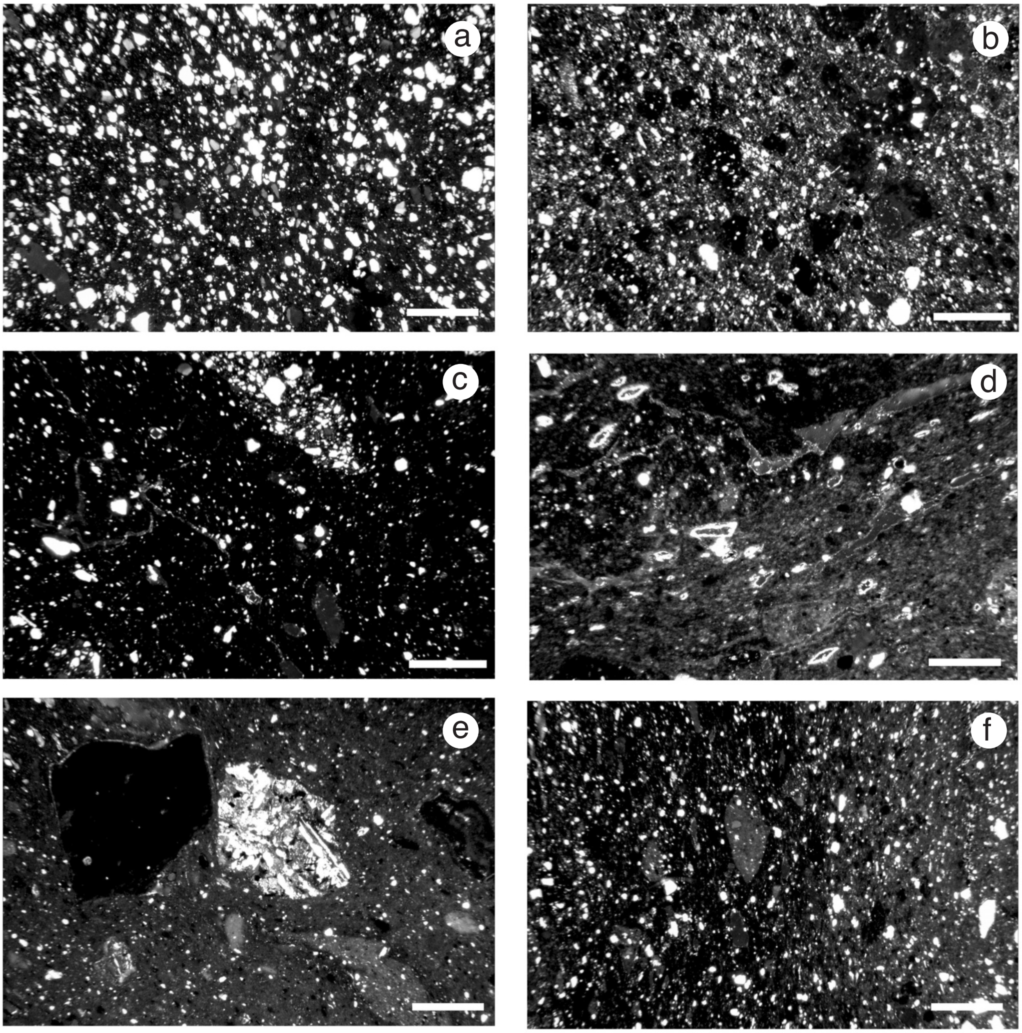

Figure 4. Representative thin section microphotographs of the defined fabrics (FBR): a) FBR 1a; b) FBR 1b; c) FBR 2; d) FBR 3; e) FBR 4; f) FBR 5 (crossed polars; scale bar width = 0.5 mm).

quartz (size < 0.2 mm), only sporadically subrounded (size > 0.2 mm). FBR 1a contained subordinate components including: K-feldspar, chert, quartzarenite fragments, mica flakes (fine fraction) and zircon grains. Micritic clots, formed from the thermal decomposition of calcite (Cau et al., 2002), were estimated sporadic to rare. The groundmass generally shows weak birefringence except for the sample PLZ28. All samples exhibited a characteristic *black core* that indicates an abrupt passage from a reducing atmosphere, at least in the final part of the firing process, to an oxidant cooling phase atmosphere. The iron oxides particles are diffused in the groundmass and they also assemble in small round or irregular clots (varying dimensions from 0.1 to 0.6 mm). The pores mainly exhibit an irregular or vesicular form range in size from 0.1 to 1 mm.

FBR 1b (samples: PLZ8; PLZ30; PLZ38; PLZ39)

It exhibited intermediary characteristics between FBRs 1a and 2. It was characterized by a medium temper packing (10-15%) with fine sand size (Figure 4b).

Sample PLZ8 primarily contained very fine subangular or angular grains of monocrystalline quartz (0.06-0.125 mm); while K-feldspar, polycrystalline quartz, quartzarenite fragments and tiny mica flakes and micritic clots were sporadic to rare components. Samples PLZ30, PLZ38, PLZ39 exhibited an increase in the relative abundance of calcareous grains although the majority of temper grains remained silicoclastic.

The groundmass appeared to be rather non-homogeneous (lumpy texture) and not birefringent except for sample PLZ39 (weak birefringence). Pores mainly expressed irregular shapes and sizes ranging between 0.1 and 1 mm.

FBR 2 (samples: PLZ2; PLZ3; PLZ6; PLZ10; PLZ12; PLZ14; PLZ16; PLZ17; PLZ20; PLZ21; PLZ23; PLZ24; PLZ27; PLZ40; PLZ41; PLZ42; PLZ43; PLZ45; PLZ47)

All of the samples grouped within FBR 2 were characterized by a distinctive lumpy texture and medium-low temper packing (ranging between 5-10%). Coarse silt (< 0.06 mm) and very fine sand grains (0.06-0.125 mm) are prevailing. Medium sand temper (0.25-0.5 mm) was rare or sporadic. Compositionally this microscopic fabric contained, subangular to angular monocrystalline quartz grains, while K-feldspar, polycrystalline quartz, quartzarenite fragments, and mica flakes were subordinate temper components (Figure 4c). It appears that the calcareous microfossils more or less decomposed after the firing process and micritic clots (in the samples fired at higher temperature) are relatively more abundant respect FBRs 1a and 1b.

The FBR 2 groundmass was not birefringent. Pores exhibited an irregular or vesicular shape, with size widely ranging between 0.1 and 1 mm.

FBR 3 (samples: PLZ7; PLZ36)

This fabric is represented by only two samples. It is characterized by a low packing (around 3% area) and a heterogeneous distribution of the aplastic inclusions with a clear prevalence of coarse silt (0.04-0.06 mm) and very fine sand (0.06-0.125 mm) grains.

The temper was composed mainly of angular or subangular monocrystalline quartz, but calcareous microfossils, occasionally well-preserved and more frequently in the form of subrounded or vesicular cast, were identified as common constituents (Figure 4d). Feldspars grains (orthoclase and plagioclase) and mica flakes were sporadic.

It showed a birefringent groundmass except for the samples PLZ36 (weakly birefringent) and PLZ7 (not birefringent). Pores showed irregular or vesicular shape with average size widely spread between 0.1 and 1 mm. Each sample was characterized by a *black core*.

FBR 4 (samples: PLZ32; PLZ35)

This fabric is composed of only two samples which contain few aplastic inclusions, predominantly represented by coarse silt (0.04 - 0.06 mm) and very fine sand (maximum grain size or MGS = 0.15 mm). Temper packing was low (around 3% area) if referred merely to the detritic siliceous components, hence not considering the clay lumps and micritic clots similarly deriving from the manufacture process.

The temper was essentially composed of monocrystalline quartz with a lesser amount of mica and K-feldspars. Micritic clots were common only in sample PLZ35. Minor quantities of volcanic lithic fragments and minerals (clinopyroxene, alkaline feldspar, hornblende, and glass) were recognized in both samples and can be considered a distinctive "marker" of this fabric (Figure 4e).

The groundmass showed a distinct birefringence typically yellowish brown to brown (crossed polars). Texture was manifestly non homogeneous with frequent clay lumps and a *black core*. Pores were mainly irregular or vesicular shaped and the size was highly variable from 0.1 to 1 mm.

FBR 5 (samples: PLZ3; PLZ26)

This fabric was once again represented by only two samples (PLZ3, PLZ26). Each sample was characterized by a medium temper packing (higher than10% area) with the aplastic inclusions distributed uniformly (Figure 4f). Temper size was predominantly fine-medium (0.2-0.5 mm) with tails toward coarse sand (0.5-1 mm) and silt (< 0.06 mm).

From the point of view of mineralogical composition each sample exhibited a prevalence of monocrystalline quartz, with subordinate to rare K-feldspar, polycrystalline quartz, chert, quartzarenite fragments and mica flakes. Each calcareous lithoclasts and microfossils are common constituents as well.

The groundmass was optically active and the texture homogeneous even with the *black core*. Pores show irregular or vesicular shape and many of them represent casts of decomposed calcareous microfossils. Pore size ranged widely between 0.1 and 1 mm.

Chemistry of the ceramic samples

The raw chemical data concerning the ceramic samples collected at Monte Polizzo are shown in Table 2. They have been carried out by XRF spectrometry and arranged in succession according to the above described *fabrics* recognized after petrographic observations. In fact, the first aim of the XRF analysis, in this case study, was to verify if the petrographically delineated *fabrics* (FBR 1a, FBR 1b, FBR 2, FBR 3, FBR 4, FBR 5) were still evident when viewed by chemical composition and categorizable just like *Paste Compositional Reference Unit* (PCRUs). At first sight it is possible to notice that for the studied samples there is a very good correlation between petrographic classification of microscopic fabrics and chemical data. Therefore, PCRU 1a, PCRU 1b, PCRU 2, PCRU3, PCRU 4, PCRU 5 can be easily distinguished by means of major and trace elements concentrations, respectively corresponding to FBR 1a, FBR 1b, FBR 2, FBR 3, FBR 4 and FBR 5.

In particular, PCRUs 1a and 1b differ from all the other paste compositional reference units by a larger SiO_2 abundance (in particular PCRU 1a) and, in contrast, really lower amounts of CaO and Al_2O_3. On the contrary, PCRU 2 was characterized by a relatively higher CaO concentration with respect to PCRU 1a, and also by higher abundances of Al_2O_3, TiO_2, MgO, Fe_2O_3. Particularly, the inverse correlation between SiO_2 and CaO, distinguishing PCRU 1a and 1b from PCRU 2, can be interpreted like an effect due to greater relative occurrence of sand grains largely made of quartz and/or to a correspondent minor incidence of the calcareous bioclasts already detected under the petrographic characterization. The inverse correlation between SiO_2 and Al_2O_3, then again, reveals the different relative frequency of sand inclusions (packing assessed at the polarizing microscope and given in % area). In fact, Al_2O_3, TiO_2, MgO, Fe_2O_3 resulted relatively higher concentrated in the less tempered PCRU 2 reflecting the more relevant contribution of the mineralogical/amorphous constituents that compose the groundmass in comparison with the aluminium-silicates of the sand fraction. In addition, the samples petrographically attributed to the PCRU 1a showed a marked dispersion of SiO_2 concentration (from the 64% to around the 74% wt), causing also a sort of "dilution effect" on CaO abundance and of the geochemically correlated Sr which is fairly higher in PCRU 2. In fact, with the increase of quartz grains content - both in terms of their relative abundance

Table 2. Concentration of major elements (% weight, after normalization against LOI) and trace elements (ppm) of the studied ceramic samples from Monte Polizzo.

Samples	SiO_2	TiO_2	Al_2O_3	P_2O_5	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	Rb	Sr	Zr	Ba	La	Ce	V	Cu	Zn	PCRU
PLZ 1	68.29	0.91	17.57	0.14	7.84	1.52	0.07	1.70	0.25	1.71	71	93	496	256	25	61	117	18	101	1a
PLZ 4	67.71	0.92	17.63	0.13	7.60	1.64	0.04	2.31	0.28	1.74	78	98	499	253	25	64	119	15	105	1a
PLZ 15	65.19	1.01	18.43	0.21	7.75	1.27	0.05	3.87	0.29	1.92	69	123	412	302	27	64	121	21	112	1a
PLZ 18	73.84	0.79	14.69	0.11	5.97	1.26	0.03	1.59	0.18	1.54	58	82	612	228	22	52	103	14	97	1a
PLZ 19	71.06	0.88	16.40	0.14	6.77	1.37	0.04	1.55	0.22	1.58	61	86	584	241	24	55	104	16	98	1a
PLZ 22	65.62	0.89	18.36	0.28	7.50	1.81	0.08	3.27	0.29	1.9	87	124	400	317	26	62	125	18	116	1a
PLZ 25	69.58	0.86	16.51	0.12	6.49	1.88	0.06	2.37	0.30	1.85	81	105	475	251	29	70	106	20	105	1a
PLZ 28	68.67	0.86	17.91	0.31	6.33	1.45	0.06	2.35	0.28	1.79	76	105	534	284	27	69	105	20	102	1a
PLZ 29	71.60	0.84	16.54	0.12	5.93	1.32	0.04	1.79	0.19	1.63	64	92	602	231	22	48	101	17	105	1a
PLZ 33	65.12	0.98	18.22	0.17	8.08	1.99	0.09	3.16	0.33	1.86	82	116	476	293	28	68	126	21	114	1a
PLZ 34	63.96	1.14	18.74	0.13	8.09	1.77	0.07	3.55	0.43	2.12	96	127	420	324	29	69	113	24	122	1a
PLZ 37	65.02	0.94	18.43	0.17	8.25	1.73	0.15	3.13	0.30	1.89	85	113	512	292	28	65	120	22	119	1a
PLZ 44	64.98	1.08	19.56	0.26	7.79	1.77	0.04	2.14	0.39	1.97	95	112	533	301	23	58	118	23	113	1a
PLZ 46	64.90	0.99	19.08	0.19	7.59	1.83	0.10	2.93	0.41	1.98	91	110	555	322	25	61	110	24	117	1a
Mean	67.54	0.94	17.72	0.18	7.28	1.62	0.07	2.55	0.30	1.82	78	106	508	278	26	62	113	20	109	
Max	73.84	1.14	19.56	0.31	8.25	1.99	0.15	3.87	0.43	2.12	96	127	612	324	29	70	126	24	122	
Min	63.96	0.79	14.69	0.11	5.93	1.26	0.03	1.55	0.18	1.54	58	82	400	228	22	48	101	14	97	
PLZ 8	61.58	1.00	19.82	0.27	8.02	1.72	0.10	5.04	0.30	2.15	110	152	381	373	31	71	121	25	128	1b
PLZ 30	61.82	1.04	19.51	0.20	7.40	1.77	0.06	5.78	0.29	2.13	108	185	370	382	28	68	119	28	135	1b
PLZ 38	62.25	1.06	18.73	0.17	8.05	2.09	0.06	5.22	0.27	2.09	108	165	412	352	26	66	127	26	132	1b
PLZ 39	61.29	1.04	19.87	0.15	7.84	1.81	0.08	5.69	0.25	1.98	97	181	394	341	29	70	121	29	136	1b
Mean	61.74	1.04	19.48	0.20	7.83	1.85	0.08	5.43	0.28	2.09	106	171	389	362	29	69	122	27	133	
Max	62.25	1.06	19.87	0.27	8.05	2.09	0.10	5.78	0.30	2.15	110	185	412	382	31	71	127	29	136	
Min	61.29	1.00	18.73	0.15	7.40	1.72	0.06	5.04	0.25	1.98	97	152	370	341	26	66	119	25	128	

Table 2. Continued...

Samples	SiO_2	TiO_2	Al_2O_3	P_2O_5	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	Rb	Sr	Zr	Ba	La	Ce	V	Cu	Zn	PCRU
PLZ 2	58.05	1.13	21.63	0.22	9.03	2.12	0.06	4.90	0.49	2.36	122	145	397	370	32	73	155	27	127	2
PLZ 3	58.84	1.20	21.20	0.19	9.45	1.73	0.07	4.66	0.41	2.24	109	139	376	376	28	67	145	26	122	2
PLZ 6	58.29	1.09	19.97	0.18	8.24	2.10	0.06	7.29	0.37	2.40	137	218	382	449	31	69	122	34	149	2
PLZ 12	55.92	1.25	22.84	0.19	9.65	1.94	0.06	5.58	0.38	2.19	102	173	349	388	31	71	146	29	134	2
PLZ 14	55.61	1.29	22.80	0.41	9.07	2.34	0.06	6.01	0.32	2.09	98	197	372	411	27	66	173	32	140	2
PLZ 16	56.81	1.03	20.63	0.22	8.31	2.29	0.06	8.11	0.37	2.16	116	245	365	452	23	50	129	39	161	2
PLZ 17	58.69	1.10	20.66	0.16	8.93	1.86	0.08	5.80	0.45	2.26	121	191	393	391	26	54	130	30	134	2
PLZ 20	57.06	1.17	21.50	0.18	8.14	1.61	0.07	7.70	0.35	2.21	111	215	384	463	24	57	121	36	149	2
PLZ 21	57.89	1.18	22.12	0.25	8.50	1.65	0.06	5.59	0.40	2.36	124	167	393	391	31	70	137	33	134	2
PLZ 24	56.46	1.35	22.19	0.28	9.40	1.81	0.07	5.47	0.47	2.50	131	155	330	379	24	52	162	34	131	2
PLZ 27	56.41	1.05	20.27	0.23	8.08	2.14	0.08	8.90	0.46	2.39	120	264	361	427	26	59	113	38	168	2
PLZ 40	57.42	1.27	22.09	0.25	9.18	1.60	0.07	5.11	0.53	2.49	141	153	374	368	22	48	125	26	133	2
PLZ 41	56.85	1.21	22.36	0.17	9.69	2.38	0.07	4.46	0.47	2.34	127	147	383	356	27	61	152	25	128	2
PLZ 42	55.96	1.10	21.60	0.18	9.22	2.89	0.09	5.92	0.66	2.39	130	187	319	379	25	57	141	29	137	2
PLZ 45	58.49	1.10	21.37	0.22	8.77	2.05	0.08	4.98	0.44	2.51	148	158	388	371	28	57	145	28	126	2
PLZ 47	57.81	1.09	21.34	0.22	8.88	2.47	0.08	4.95	0.68	2.49	142	165	372	368	25	61	143	28	129	2
Mean	57.29	1.16	21.54	0.22	8.91	2.06	0.07	5.96	0.45	2.34	124	182	371	396	27	61	140	31	138	
Max	58.84	1.35	22.84	0.41	9.69	2.89	0.09	8.90	0.68	2.51	148	264	397	463	32	73	173	39	168	
Min	55.61	1.03	19.97	0.16	8.08	1.60	0.06	4.46	0.32	2.09	98	139	319	356	22	48	113	25	122	
PLZ 7	53.14	1.07	20.14	0.27	7.59	2.40	0.06	12.15	0.61	2.58	130	332	185	785	28	70	96	22	190	3
PLZ 36	53.24	1.07	20.24	0.25	8.42	2.07	0.10	11.74	0.57	2.30	115	319	187	757	29	73	104	32	179	3
Mean	53.19	1.07	20.19	0.26	8.00	2.23	0.08	11.94	0.59	2.44	123	326	186	771	29	72	100	27	185	
Max	53.24	1.07	20.24	0.27	8.42	2.40	0.10	12.15	0.61	2.58	130	332	187	785	29	73	104	32	190	
Min	53.14	1.07	20.14	0.25	7.59	2.07	0.06	11.74	0.57	2.30	115	319	185	757	28	70	96	22	179	
PLZ 32	54.62	0.92	20.53	0.08	9.01	4.03	0.14	7.34	0.70	2.54	128	233	206	493	17	44	120	79	146	4
PLZ 35	55.33	0.86	20.17	0.08	8.52	4.16	0.13	7.20	0.75	2.80	178	211	221	527	14	39	117	74	140	4
Mean	54.98	0.89	20.35	0.08	8.77	4.10	0.14	7.27	0.73	2.67	153	222	214	510	16	42	119	77	143	
Max	55.33	0.92	20.53	0.08	9.01	4.16	0.14	7.34	0.75	2.80	178	233	221	527	17	44	120	79	146	
Min	54.62	0.86	20.17	0.08	8.52	4.03	0.13	7.20	0.70	2.54	128	211	206	493	14	39	117	74	140	
PLZ 9	58.84	0.89	18.57	0.23	7.88	2.01	0.06	9.08	0.34	2.10	102	269	189	599	35	82	90	20	156	5
PLZ 26	58.63	0.87	18.87	0.24	7.37	2.18	0.05	9.43	0.37	1.98	91	283	177	646	40	96	86	21	159	5
Mean	58.74	0.88	18.72	0.24	7.63	2.10	0.06	9.26	0.36	2.04	97	276	183	623	38	89	88	21	158	
Max	58.84	0.89	18.87	0.24	7.88	2.18	0.06	9.43	0.37	2.10	102	283	189	646	40	96	90	21	159	
Min	58.63	0.87	18.57	0.23	7.37	2.01	0.05	9.08	0.34	1.98	91	269	177	599	35	82	86	20	156	

(packing) and/or average size - an equivalent variation of SiO_2 (wt%) is expected. On the other hand this aspect does not invalidate the consistency of PCRU 1a as it could be also considered a natural variation of the quartz sand content in the exploited clay sources rather than due to potter's premeditated technological actions. Concerning the other trace elements, Zr resulted clearly more abundant in the ceramic samples assigned to PCRU 1a being correlated to the higher detritic siliciclastic sand grains frequency characterising this paste, while Rb and Sr resulted relatively enriched in the samples belonging to PCRU 2 in agreement with the correspondent presence of feldspars and mica flakes in the very fine sand and silt fractions. Also V, Cu and Zn seem to be slightly more concentrated in PCRU 2 ceramic samples with respect to PCRU 1a, while no relevant differences were found concerning La and Ce abundances.

Few comments can be made for the remaining PCRUs 3, 4 and 5 due to their scarce representativeness in terms of number of samples. In general, they show compositional characteristics relatively closer on the whole to PCRU 2, apart of PCRU 3 that has a clearly higher CaO content.

To further test the reliability of the delineated PCRUs from Monte Polizzo, involving all the determined major, minor and trace elements, Principal Components Analysis (PCA) was applied to chemical data. Figure 5 exhibits the distribution of the considered ceramic samples in the plane defined by the first two principal components (C1 and C2), which collectively represent up to the 78% of total variance. Well-defined chemical groups, especially those constituted by the greatest number of samples, PCRUs 1a, 1b and 2, were clearly recognized. As it can be derived by the graph of factor loadings (histogram in the right part of Figure 5) the component C1 is positively influenced by the most part of the considered elements (especially CaO, K_2O, Rb, Sr, Ba, Cu and Zn) while both SiO_2 and Zr have negative loadings. In addition, Zr is the only element having a noteworthy negative loading. C2 appears to have a negligible influence in the differentiation of the PCRUs 1a, 1b and 2. The consistent negative contribution on C2 of Cu separates the two samples classified in the PCRU 4 very well. Samples PLZ32 and PLZ35 (PCRU 4) were the only ones that contained a temper with volcanic granules and they had double the concentration of Cu in comparison with the other ceramic samples. Moreover, the positive contribution given to the same component C2 by P_2O_5 separates, in the upper right hand part of the graph, pastes 5 and 3.

Petrography and chemistry of local clays

Sample SALT11, an experimental briquette fired at 900 °C, represents the locally available clays of the Terravecchia Formation. Thin section observations using a polarizing microscope revealed that SALT11 possessed a texture of coarse silt-very fine sand temper with a packing around the 15% (area). The siliceous granules were mainly composed of monocrystalline quartz and to a lesser degree polycrystalline quartz and K-feldspar (Figure 6a). Mica flakes were also common constituents within the finest fraction, while calcareous microfossils (even if decomposed after firing) were sporadic.

The additional experimental briquette MIX1 (2 parts weight of SALT10 mixed with 3 parts of SALT11) was characterized by a greater incidence of the siliceous temper with a resulting average packing around the 25-30% area (Figure 6b). The experimental fired MAB Formation clay briquettes contained a greater relative abundance of calcareous microfauna (mainly planktonic foraminifera) with respect to the Terravecchia Formation. Investigating the fossil content within briquettes is not easy due to the rarity of well-preserved fossil remains as a consequence to the firing and soaking, 900 °C,

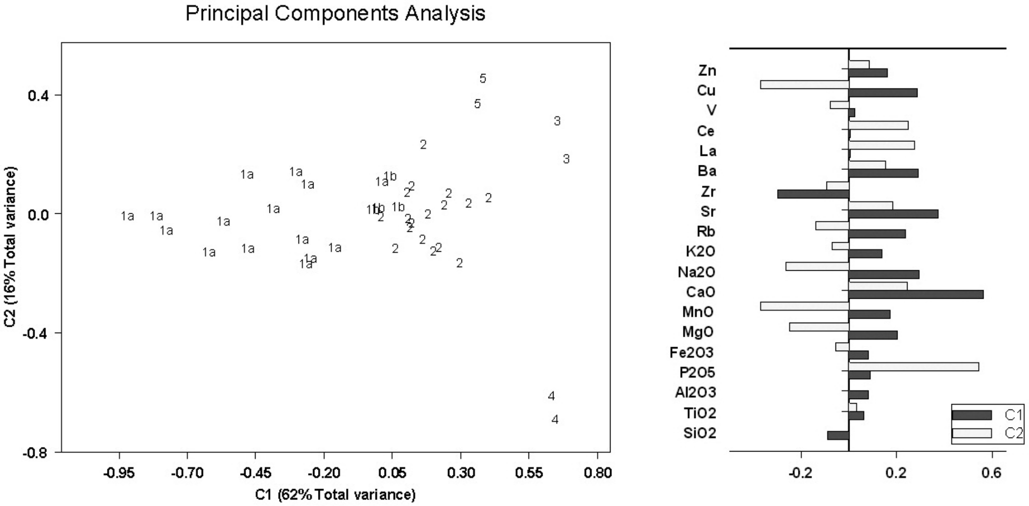

Figure 5. Plot of factor scores concerning all ceramic samples categorized within the PCRUs (1a, 1b, 2, 3, 4, 5) in the plane of the first two principal components C1 and C2. Histogram at the right shows factor loadings on chemical variables on the two considered principal components.

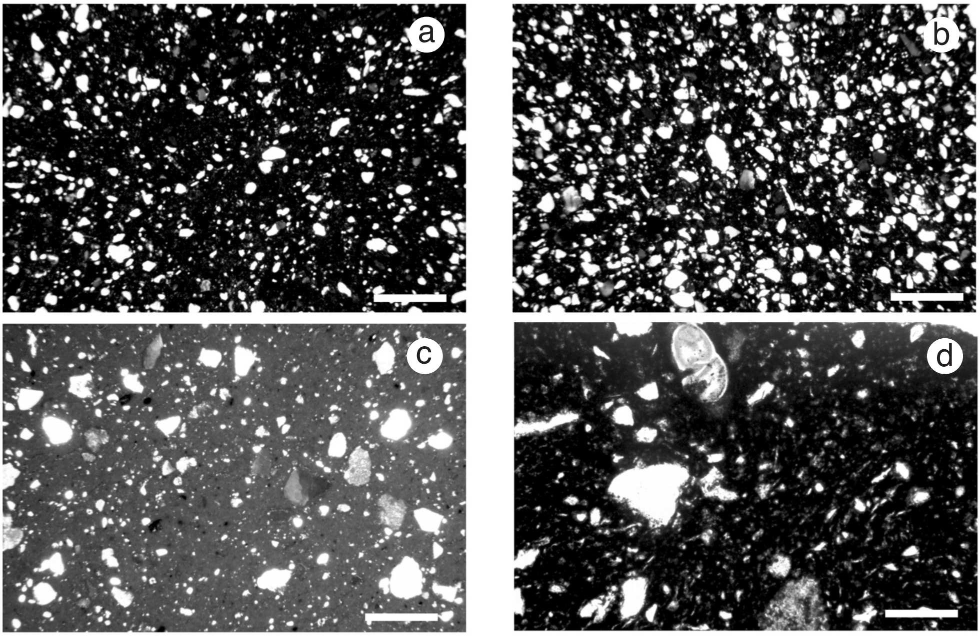

Figure 6. Thin section microphotographs of Monte Polizzo's raw materials after experimental firings at 900°C: (a) Terravecchia Formation (sample SALT 11: crossed polars; scale bar width = 0.5 mm); (b) Terravecchia Formation (sample MIX 1: crossed polars; scale bar width = 0.5 mm); (c) MAB Formation (sample SALT 1: crossed polars; scale bar width = 0.5 mm); (d) MAB Formation (sample SALT 1: parallel polars; scale bar width = 0.2 mm).

process (Figure 6c, d). Monocrystalline and polycrystalline quartz were still the most abundant temper components while feldspars and mica were sporadic to rare. Temper packing was between 15 and 20% (area) and fine sand grains (up to 0.25 mm) were quite common.

Table 3 describes the chemical composition of local clay samples obtained by XRF analysis. The maximum, minimum and average values concerning 47 additional clay samples (belonging to 7 different outcrops of the Terravecchia Formation in the territory of western Sicily within a radius of 50 Km from the settlement of Monte Polizzo were also reported for comparative purposes (data after Montana et al., 2010b). The outstanding discrepancy between the two representative local samples belonging to the Terravecchia Formation is undoubtedly due to the difference in the relative abundance of the sand fraction. In fact, SALT10 (sand = 55% wt) was characterized by a higher SiO_2 concentration (quartz grains) and lower contents of all the other oxides of major and minor elements (especially true for CaO). The same was observed in all of the trace elements apart from Zr ($ZrSiO_4$, zircon, was a common accessory mineral relatively enriched in the sand fraction of Neogene sedimentary deposits in Sicily). Elemental abundances of sample SALT11, on the contrary, were in good agreement with those detected for the clays of the Terravecchia Formation in other areas of western Sicily (Montana et al., 2006; Montana et al., 2011b). The Al_2O_3 content was also found to be relatively high and positively correlated to K_2O content. This can be explained by the abundance of mica flakes which were found especially enriched in the coarse silt fraction. CaO concentration was found to be the 7% weight (the average value found in western Sicily is a little bit higher = 7,68% wt), due to the relatively limited presence of calcareous microfauna. With reference to concentrations of Ba and Rb, both geochemically related to potassium, mica flakes and K-feldspar characterize the very fine sand and coarse silt fractions.

The bulk chemistry of the MIX1 sample (Table 3) reflects precisely the relative amounts of SALT10 (2 parts) and SALT11 (3 parts) used in the experimental mixing procedure.

All the samples belonging to the MAB Formation (SALT1, SALT3, SALT4, SALT6) showed quite comparable bulk chemical compositions. They are interpreted as being ‘very calcareous clays’ with remarkable CaO concentrations, up to 25% (wt) which is very likely related to the abundant calcareous microfauna. From a comparative point of view, despite the CaO concentration, several significant differences between major and trace elements in the local clayey materials representative of Terravecchia and MAB formations were recognized also in the relative abundances of Fe_2O_3, Al_2O_3, Na_2O, K_2O, Rb, Ba, Sr.

Petrographic comparison between ceramic samples and local clays

In order to ascertain the petrographic markers of Monte Polizzo’s productions within the studied set of ceramic samples, already divided into the previously described *fabrics*, it was assumed important to make a quantitative comparison amongst significant textural and mineralogical features derived from thin sections observation both on ceramic samples and briquettes deriving from the experimental firing of representative samples of the exploitable clays deposits. Useful variables for this purpose are represented by sand inclusions packing (% area) and size, presence (with estimation of relative abundance) or absence of specific rock fragments, presence (with estimation of relative abundance) or absence of specific minerals. Then, the Multiple Correspondence Analysis (MCA), a methodology of multivariate statistical analysis (Baxter, 1994), was used with the aim of providing a quantitative

Table 3. Concentration of major elements (% weight, after normalization against LOI) and trace elements (ppm) of the considered raw clay samples. The maximum, minimum and average values concerning clay samples representative of Terravecchia Formation (52 samples collected from 8 sites) and MAB Formation (48 samples collected from 5 sites) in the territory of western Sicily within a radius of 50 Km from Monte Polizzo were also reported (after Montana et al., 2011b).

	SiO_2	TiO_2	Al_2O_3	P_2O_5	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	Rb	Sr	Zr	Ba	La	Ce	V	Cu	Zn	
SALT1	51.43	0.77	16.09	0.09	5.41	1.52	0.07	22.68	0.05	1.90	85	886	148	298	20	71	75	15	78	MAB
SALT3	55.94	0.63	12.53	0.07	4.55	2.35	0.06	22.40	0.13	1.34	57	959	68	238	19	65	52	18	84	MAB
SALT4	56.62	0.69	13.49	0.10	5.91	1.33	0.13	20.02	0.15	1.65	80	746	125	290	26	78	79	14	72	MAB
SALT6	55,21	0.60	12.08	0.14	5.71	2.44	0.08	22.01	0.19	1.57	83	900	180	292	19	63	62	13	71	MAB
SALT10	75.17	0.66	13.27	0.07	7.11	1.37	0.02	0.53	0.15	1.59	55	74	669	153	21	51	97	14	92	TV
SALT11	56.39	1.04	21.14	0.14	8.47	1.98	0.06	7.01	0.85	2.37	123	249	370	375	26	63	154	35	148	TV
MIX1	64.16	0.92	18.11	0.10	7.70	1.60	0.06	4.66	0.49	2.20	101	163	448	291	25	60	135	30	127	
								Terravecchia Formation												
Mean	57.56	1.09	19.56	0.17	8.22	2.40	0.10	7.68	0.65	2.57	99	274	317	317	35	91	154	24	108	
Min	52.17	0.90	15.73	0.08	6.34	1.46	0.04	3.35	0.21	1.57	66	150	160	179	18	32	99	14	78	
Max	62.89	1.26	23.69	0.27	10.22	3.20	0.87	13.04	1.50	3.14	123	469	646	489	56	172	194	41	138	
								MAB Formation												
Mean	48.19	0.71	14.86	0.15	5.55	2.61	0.08	25.78	0.27	1.90	58	753	200	209	25	67	88	16	59	
Min	40.66	0.50	11.60	0.07	3.30	1.33	0.04	13.80	0.13	1.34	29	479	68	141	15	44	47	10	27	
Max	57.43	0.96	18.20	0.26	7.75	3.75	0.16	34.16	0.74	2.25	108	1153	453	362	40	94	160	36	107	

TV = Terravecchia Formation; MAB = Marnoso-Arenacea del Belice Formation; MIX1 = experimental mixing (see text).

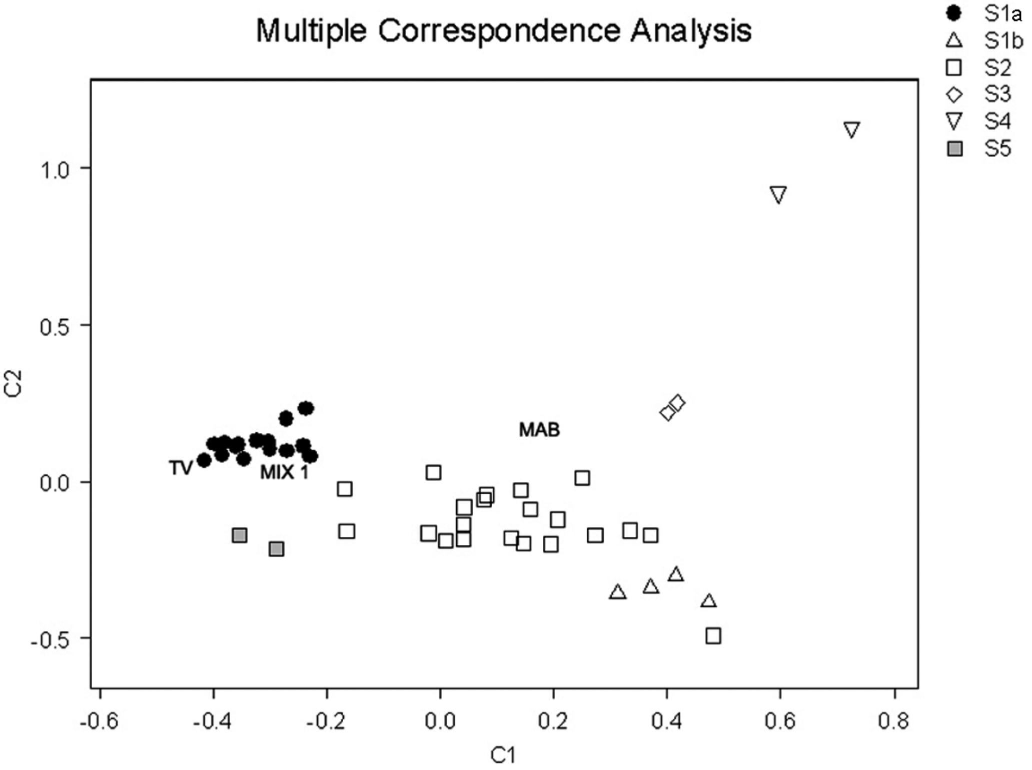

Figure 7. Biplot of MCA scores of transformed textural and compositional parameters derived from thin section microscopy (see text). Legend: S1a = FBR 1a; S1b = FBR 1b; S2 = FBR 2; S3 = FBR 3; S4 = FBR 4; S5 = FBR 5; TV = Terravecchia Formation; MIX1 = experimental mixing of two different samples of Terravecchia clays (see text); MAB = Marnoso-Arenacea del Belice Formation (average values obtained from the 4 samples analyzed).

and straight comparison between ceramic samples and local raw clays. This method was already successfully tested for the petrographic characterization of archaeological ceramics (Cau et al., 2004; Baxter et al., 2008; Montana et al., 2010; Montana et al., 2011b). The petrographic data (both compositional and textural) deriving from the analysis with the polarizing microscope of the ceramic samples and the selected raw materials (average values for the MAB Formation and Terravecchia Formation as well as experimental mixing MIX1) were thus categorized and converted in a binary form (entries 0/1). A list with all the considered variables, categories and conversion values of "qualifiers" was reported in detail (Appendix A). The numerically transformed data (Appendix B) have been treated with the MCA.

Figure 7 projects the petrographic binary scores in the plane represented by the first two components (C1 and C2) that together represent a substantial portion of the total variance (70%). The interpreted FBRs seem to form homogeneous and separated clusters. A clean convergence between FBR 1a and both the experimental test-pieces from the Terravecchia

Formation materials (SALT11 and MIX1) is also recognizable. Samples belonging to FBRs 2 and 1b appear to be split from the FBR 1a cluster and the Terravecchia clays. Therefore, even if FBRs 1b and 2 are both thought to also represent local productions, following the archaeological classification (use type, form, nature and style of external ornamental patterns), they do not correspond exactly with the textural features of the raw materials supplied from local Terravecchia Formation's outcrops (specially quartz temper relative abundance and packing). On the other hand, is very clear that clays belonging to the MAB Formation are not petrographically similar to any of the specific fabric groups achieved from the petrographic observations. In fact, they do not fit FBR 1a or FBR 2 which together represent the mineralogical and textural features of the most part of the studied ceramic samples. Similar considerations can be made for the remaining FBRs (FBR 3, FBR 4 and FBR 5) that, in fact, could be considered imported ceramic products. FBR 4 is also clearly distinct from the others in the upper right part of the graph likely due to the peculiar presence of volcanic minerals and lithic fragments. Consequently, this approach demonstrated that the textural aspects like temper packing and average size could have a considerable effect in both the macroscopic and microscopic appearance of the fabric, and that, sometimes, they may also become misleading for classifying purposes in terms of provenance attribution.

Chemical comparison between ceramic samples and local clays

In the light of the complexities just verified with comparing only by textural and mineralogical features ceramic artefacts and clayey raw materials, it is important to reconsider the level of chemical compatibility between the Monte Polizzo's Archaic pottery and the local clay outcrops. The end goal remains to identify the archaeological site at Monte Polizzo as a ceramic production centre versus a consumption centre.

Thus, the multivariate method of the Principal Components Analysis (PCA) was applied for a second time to further corroborate the estimated correspondence between the ceramic pastes and local clay materials. This analysis was only applied to the PCRUs 1a, 1b and 2 (respectively corresponding to FBR 1a, FBR 1b, FBR 2), because they contained the most part of individuals. Figure 8 projects the factor scores in the plane corresponding to the first two principal components (C1 and C2) together representing the 82% of the total variance. Once more it appears very evident that the clays of the MAB Formation are clearly separated from the PCRUs 1a, 1b and 2, which in turn are quite homogeneously clustered. This evident separation from MAB Formation clays may be explained by taking into account the histogram of factor loadings (in the right part of Figure 8), where the negative load on component C1 is strongly influenced by CaO and Sr. A good correlation was once again recognized between PCRUs 1a, 1b, 2 and the clays of the Terravecchia Formation. This PCA correlation also exhibits an opposing chemical "dilution effect" that can be interpreted as complementary to the relative abundances of SiO_2 and CaO along the line identifiable by the two clay samples representative of the Terravecchia Formation (SALT10 = TVS and SALT11 = TV), and clearly enhanced by the strong divergence of the C2 component.

Taking note of the large natural variability within clayey materials of the local beds of the Terravecchia Formation, it is necessary to obtain a further verification of their possible use for this specific ceramic production. Therefore, an additional comparison between PCRUs 1a, 1b and 2 against the briquette MIX1 produced by the experimental combination of the Terravecchia Formation samples SALT10 (2

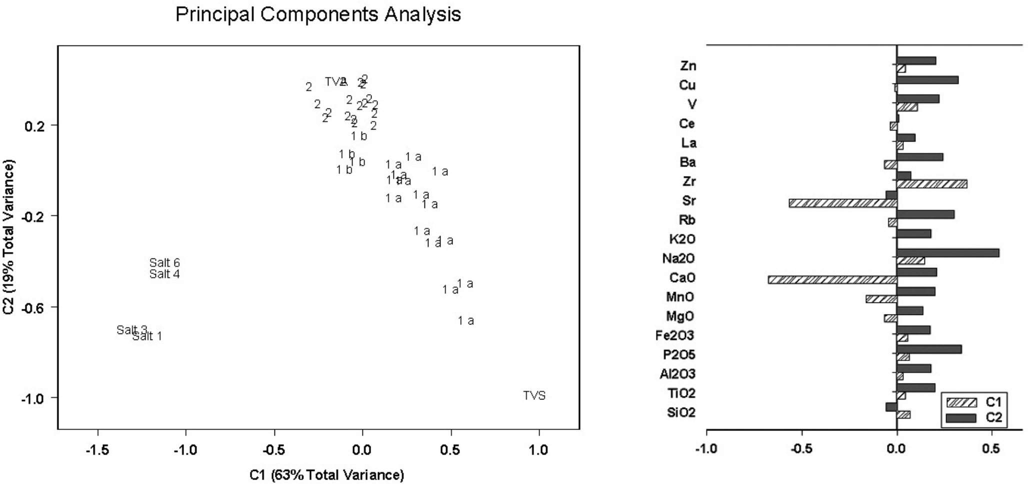

Figure 8. Plot of PCA scores in the plane of the first two principal components C1 and C2 concerning the ceramic samples belonging to the PCRU's 1a, 1b, 2, the MAB Formation clays (SALT 1, SALT 3, SALT 4, SALT 6) and the Terravecchia Formation clays (TVA= SALT 11; TVS = SALT 10). Histogram at the right shows the loadings of chemical variables on the two considered principal components.

parts weight) and SALT11 (3 parts weight) was made. The extremely different content of quartz sand (SALT10 reached 53% wt of quartz-bearing sand while SALT11 reached only 13% wt of quartz-bearing sand) plays indirectly for "dilution effect" mainly in the correspondent abundance of CaO. Figure 9, a composed binary graph, exhibits the values of SiO_2, Al_2O_3, CaO and K_2O found in the samples belonging to the PCRUs 1a, 1b and 2 projected together with the samples representative of the local beds of the Terravecchia Formation (SALT11 with a standard content of sand and SALT10 with an extreme content of sand) and the experimental mixture made with them. Through this representation it is possible to recognize that the very most part of the ceramic samples classified into PCRU 1a are delimited by the potential raw materials SALT10 and MIX1 (relatively lower CaO, Al_2O_3, K_2O and relatively higher SiO_2), while the ceramic finds classified in the PCRUs 1b and 2 are delimited by MIX1 and SALT11 (relatively lower SiO_2 and increasing CaO, Al_2O_3, K_2O. This compositional features could be interpreted either as a result of technological choices inductively pursued by the local craftsmen (selection of specific clay beds and/or mixture of clays with different content in sand), to a pure chance linked to the natural variability of the clayey outcrops along the stratigraphic column (intra-deposit natural variability) or to a change over time in the exploitation of local clayey materials.

Concluding remarks

The mineralogical-petrographic and chemical study of 44 ceramic artefacts obtained from the Acropolis of Monte Polizzo allowed the identification of 6 primary different 'Paste Compositional Reference Units' (PCRUs). These PCRUs were recognized and independently confirmed by their textural and mineralogical characteristics (*fabrics* or FBRs by petrographic observations) and chemical composition (XRF

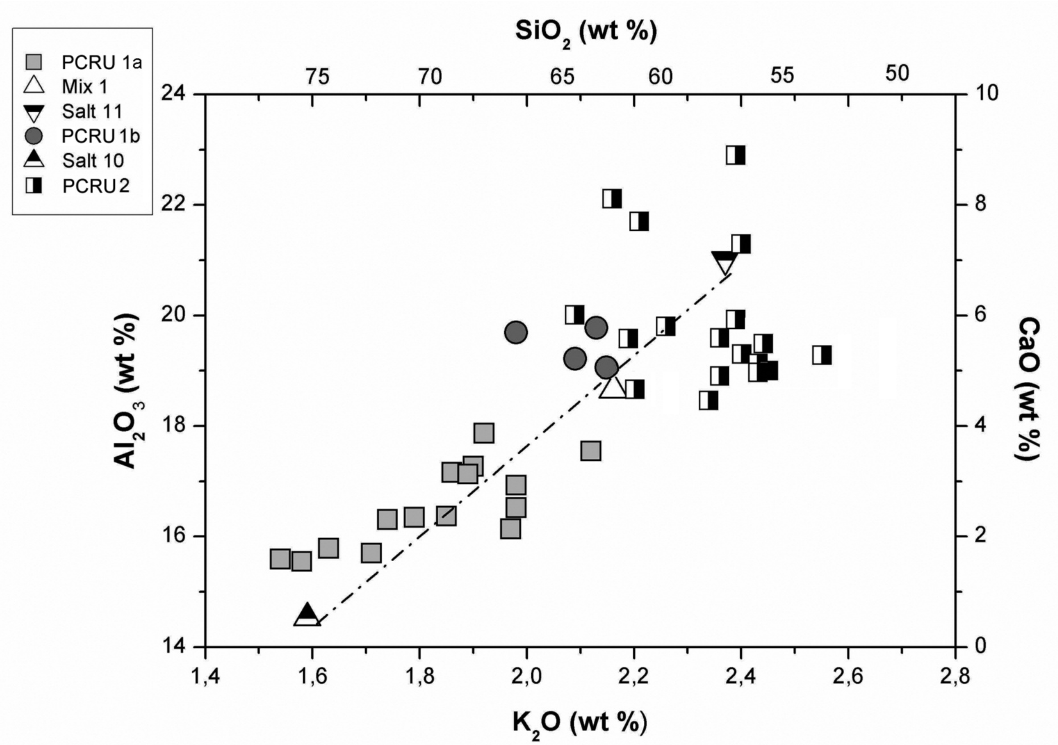

Figure 9. Composite binary plot (SiO_2, Al_2O_3, CaO and K_2O) that exhibits PCRUs (1a, 1b and 2) with clay samples from the Terravecchia Formation.

analysis). In order to support the identification of local production we chose to study also the available clay-sized raw materials in the area surrounding the archaeological site, belonging to the Terravecchia Formation (Upper Tortonian-Messinian) and to the Marnoso-Arenacea del Belice or MAB Formation (Middle-Upper Pliocene). Several ethnographic proofs recently acquired provide evidence that clays from Terravecchia and MAB Formations were utilized extensively for indigenous ceramic production in western Sicily (Montana et al., 2006; Montana et al., 2011b). Representative samples of these clays were thus investigated from a mineralogical-petrographic point of view (by firing the test pieces of the original raw materials or of artificial mixtures in a muffle kiln) and from the chemical one, and subsequently compared with the ceramic artefacts object of the study.

The cross comparison of the mineralogical-petrographic and chemical data allows the confirmation that, among the available raw materials near Monte Polizzo, the local workers preferred clays from the Terravecchia Formation. The mineralogical composition of the Terravecchia Formation correlated well with PCRUs 1a, 1b and 2 that represented 92% of the investigated ceramic finds.

Afterwards, the mineralogical, textural and chemical markers of the ceramic vessels for food consumption and storage, corresponding to macrofabric F7 (incised open or closed small pots), macrofabric F54 (matte painted small amphoras and other nonspecific table ware) and macrofabric F24 (pithoi) produced in the indigenous settlement of Monte Polizzo in a wide chronological interval between the 7th and the 4th century B.C. were archaeometrically ascertained. Archaeometric investigations accordingly allowed to declare Monte Polizzo a ceramic production centre, together with other Sicilian anhellenic sites where positive evidence for pottery workshops was also retrieved. Clay resources used at Monte Polizzo lay in the neighbourhood of the settlement and do not need long range road transport.

The remaining 8% of the investigated ceramic findings, samples PLZ7 and PLZ36 (PCRU 3, macrofabric F54 and F7), PLZ32 and PLZ35 (PCRU 4, both macrofabric F54), PLZ3 and PLZ26 (PCRU 5, both macrofabric F7), have been interpreted to be most likely regional imports from other coeval production centres located in western Sicily. In fact, in the settlements of Entella and Adranone, both sited in the Sicani area, were recently established coeval productions of incised, impressed and matte painted tableware typologically fitting with those produced at Monte Polizzo (Montana et al., 2007; Montana et al., 2010; Montana et al., 2011a). PCRU 4 was characterized by minor quantities of basic volcanic rock fragments and minerals in the temper, nevertheless the stratigraphic successions of the Jurassic deep sea limestone outcropping in the area of Sicani Mounts often exhibit pillow lavas of basaltic nature. Though a wider selection could partly change these results, the limited amount of imported indigenous pottery at Monte Polizzo suggests that local workshops were able to yield the bulk of coarse and decorated pottery commonly used in the settlement.

In conclusion, new inferences useful for the archaeological/historical reconstructions of Archaic Sicily may possibly develop from this archaeometric study, concerning the trade patterns of incised and matte painted tableware between Monte Polizzo and the main indigenous centres located in the Sicani Mountains area (e.g. Adranone, Entella and Maranfusa) as well as interactions with Selinunte and Segesta.

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