

ARCHAEOMETRIC CHARACTERISATION OF COMMON AND COOKING WARES FROM THE LATE ANTIQUE CITY OF VALENTIA (VALENCIA, SPAIN)

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ABSTRACT

This contribution presents the results of the archaeometric characterization of Late Roman pottery from the city of Valencia (Spain). The ceramic samples, including common wares, amphorae and cooking wares, have been characterized using WD-X-ray fluorescence for the chemical analysis, X-ray diffraction for the mineralogical study, and optical microscopy by thin-section analysis for the mineralogical and petrographic characterization. The results show a wide range of fabrics with cooking wares of imported origin. The most important result is, however, the identification of a possible regional ware that resembles African cooking wares but that could have been locally or regionally produced, as well as the possible production in the area of some common wares. These results provide a better insight into the production and distribution of late Roman ceramics in the area and contribute to a better understanding of trade dynamics in the Western Mediterranean for imported wares.

KEYWORDS: COMMON WARES, COOKING WARES, AMPHORAE, LOCAL, IMITATION, IMPORTED, ARCHAEOMETRY

In memoriam Sara Santoro

1. INTRODUCTION

Several archaeological excavations conducted in the last decades in the urban centre of Valencia (Spain) have uncovered large assemblages of pottery (and other materials) providing significant information on the Late Antique city and its trade networks between the 4th and the 7th centuries AD (e.g. Blasco 1989; Blasco *et al.* 1994; Pascual *et al.* 1997, 2003; Rosselló and Ribera 2005; Ribera and Rosselló 2007, 2012, 2016; Rosselló *et al.* 2010). Contexts from the area where the Visigothic Episcopal complex was located, currently the Almoina and surroundings, are particularly remarkable for the large volume and diversity of the ceramic materials (Blasco *et al.* 1994; Pascual *et al.* 1997, 2003; Marín *et al.* 1999; Ribera and Rosselló 1999, 2000). These and other contexts proved that this centre had an important role in trade activity during Late Antiquity, as indicated by the presence of numerous imported amphorae, fine wares, cooking wares and common wares.

Focusing in particular on the cooking and common wares, their macroscopic study has revealed the existence of a wide variety of fabrics and forms that, in some cases, can be associated with imported products from other regions (such as Africa, Eivissa, the eastern Mediterranean and southeastern Spain) while, in other cases, might be interpreted as local or regional manufactures. With the aim of exploring this variability and studying in further detail the diversity of products, their provenance, and some of their technical characteristics, we present the results of the archaeometric study of cooking and common wares from some Late Antique contexts of *Valentia*.

An increasing number of archaeological and archaeometric studies on Late Roman cooking wares and common wares have shown the presence of fabrics with a wide geographical distribution, across the western Mediterranean as well as a large number of local and/or regional groups with a more limited distribution. Such work has focused on centers or areas such as Carthage (Fulford and Peacock 1984) or Africa in general (Bonifay 2004), southern France (e.g., CATHMA 1991), and many other region as it can be seen in the series of volumes from the Late Roman Coarse Wares, Cooking Wares and Amphorae conferences (see Gurt *et al.* 2005; Bonifay and Trégliá 2007; Cau 2007b; Menchelli *et al.* 2010; Poulou-Papadimitriou *et al.* 2014; Dixneuf 2017). Important archaeometric work has also been developed with regional wares in different parts of Italy (e.g., Gliozzo *et al.* 2005, 2010, 2013, 2014; Grifa *et al.* 2005, 2009, 2013; Montana *et al.* 2007). In the Mediterranean coast of Spain and the Balearic Islands these wares have also been object of intensive research (e.g. Reynolds 1993; Macias 1999; Cau 2003, 2007a; Buxeda and Cau 2004, 2005; Buxeda *et al.* 2005; Macias and Cau 2012). Concerning the area of Valencia, despite the large number of archaeological studies, very little archaeometric research on Late Roman materials has been conducted so far, including the study of cooking wares from the Carrer Unió context (Cau 2003). In this way, the archaeometric analysis in the present paper, on the basis of chemical, mineralogical, and petrographic characterization of the materials, aims to shed more light on the imported wares that were

arriving to *Valentia* in Late Antiquity and their relation to wares found in other western Mediterranean contexts, as well as on the possible existence of a local/regional pottery production.

2. MATERIALS AND METHODS

A total of 42 sherds were selected for archaeometric analysis, almost all of them coming from three Late Antique archaeological contexts in Valencia (Figure 1; Table 1; Online Resource 1 and 2): Almoína (and the nearby Cárcel de San Vicente), including rubbish dumps and fillings of wells and pits from the 6th and 7th centuries (Blasco *et al.* 1994; Pascual *et al.* 1997, 2003); Plaza de Nápoles y Sicilia nº 10, with sixth and seventh century deposits related to the urban transformation of the former Roman circus (Pascual *et al.* 1997; Rosselló *et al.* 2010); and C/ Conde de Trénor nº 13-14, with a rubbish dump dated to the last quarter of the 4th century (Burriel and Rosselló 2000).

Of the selected samples, 27 are cooking wares, primarily casseroles and cooking pots (Table 1; Figure 2 and 3). These comprise, on the one hand, wheel-made pottery, with various forms and macroscopic fabrics that —according to the archaeological study— seem to be related to imports from North Africa (Fulford Coarse Ware CW—hereafter FCW— Casseroles 12.1 and 20.3; FCW Bowl 25.2?; Reynolds Ware —hereafter RW— 11G.2), the eastern Mediterranean (FCW Casserole 35.1, FCW Dish 5/RW 9.1, RW 7) and south-eastern Spain (RW 5, Cartagena 7), in addition to other indeterminate samples. On the other hand, some cooking pots that are handmade or made with slow wheel technique were also sampled, especially some forms (Reynolds Hand Made Ware —hereafter RHW— 7.1, 7.2, 8.1 and 8.2) that could have been imported from the south-eastern part of Spain, as well as some possible local products.

A number of common wares with a variety of forms were also considered for archaeometric examination (Table 1; Figure 4). Based on the macroscopic study, some of these were assigned to possible Ebusitan products, while the remaining were associated with an indeterminate provenance. In addition, eight small amphorae with a concave-convex base (Keay 72, Keay 71 or related forms) were also analyzed (Figure 4), since they seem to present fabric similarities with some of the common wares. These were related to a possible African provenance at first (Pascual *et al.* 2003), although a recent study by Ribera and Rosselló (2012) suggests —based on the distribution of the findings— an Hispanic origin, perhaps Ebusitan but not excluding a local/regional production.

For their archaeometric characterization, all the samples were analysed using a combination of techniques, including WD X-Ray Fluorescence (XRF), X-Ray Diffraction (XRD) and Optical Microscopy (OM).

The chemical characterization through wavelength dispersive XRF spectroscopy was carried out using a Panalytical-Axios PW 4400/40 spectrometer. After the removal of the surface layer, each sample was powdered in a tungsten carbide mill and dried at 100°C for 24 h. The determination of major and minor elements (Fe₂O₃, Al₂O₃, MnO, P₂O₅, TiO₂, MgO, CaO, Na₂O, K₂O, SiO₂) was done through the preparation of duplicates of fused beads, using 0.3 g of powdered specimen in an alkaline fusion with 5.7 g of lithium tetraborate at a 1/20 dilution. For the determination of trace elements (Ba, Rb, Th, Nb, Pb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni, Cr, Mo, Sn, Co, W), pressed powder pills (with 5 g of the sample) were prepared. A total of 60 International Geological Standards were used for calibration. The elements Mo and Sn were excluded from the analysis due to problems of analytical imprecision, while Co and W were also discarded due to possible contamination from the tungsten carbide cell of the mill.

The mineral phases in each sample were determined by means of XRD, using a PANalytical X'Pert PRO MPD alpha 1 diffractometer, working with the Cu-K α radiation ($\lambda = 1.5406 \text{ \AA}$). Spectra were taken from 5 to 80° 2 θ , with a step-size of 0.026°2 θ and a step-time of 47.5 s. The evaluation of crystalline phases was carried out using the software High Score Plus by PANalytical, including the Joint Committee of Powder Diffraction Standards (JCPDS) data bank. The examination of the primary and firing phases in the diffractograms allowed for an estimation of equivalent firing temperatures (EFT) (*e.g.* Roberts 1963; Maggetti 1982; Cultrone et al. 2001; Buxeda and Cau 2004; Maggetti et al. 2011), as well as for the identification of secondary phases formed during use or burial.

The petrographic analysis of thin sections was conducted using an Olympus BX41 optical microscope, equipped with a DP70 Olympus digital camera, and working with a magnification between $\times 20$ and $\times 200$. Each fabric was described using a modified version of the system proposed by Whitbread (1989, 1995; Quinn 2013).

3. PETROGRAPHIC AND MINERALOGICAL RESULTS

Petrographic analysis under the optical microscope identified eleven petrographic fabric groups (PF), the most represented being PF1, PF3 and PF9. Information on the mineral phases was obtained from XRD, allowing estimation of the EFT for each sample (Table 2).

PF 1: predominant quartz (Figure 5a-c) (VAL001, 002, 003, 004, 005, 009, 019, 020, 021, 022, 026, 028, 030, 031, 032, 033)

In the 16 samples of this fabric group, the monocrystalline quartz is clearly the predominant component, while other inclusions (in particular, calcareous and ferruginous ones and polycrystalline quartz) are very few or rare. The inclusions are abundant (20-30%), mostly equant and show poor to moderate sorting. There is an abundant fine fraction of silt and very

fine to fine sand (<0.25 mm), and a less frequent —but still important— coarse fraction (especially medium sand, more rarely coarse to very coarse sand). Quartz predominates in both fractions, and the coarser grains tend to be angular/subangular. Calcareous inclusions (limestone fragments) are usually rare, although they are slightly more present in VAL001, 009, 030 and, especially, in VAL020. In some samples (VAL026 and, to a lesser degree, VAL020, 021, 028) coarse iron nodules or argillaceous inclusions are observed. The samples VAL032 and 033 show some coarse grains of polycrystalline quartz (grading to quartzite in some case), which are few and clearly subordinate to the monocrystalline quartz. Small fragments of quartzarenite are common in VAL026. Other coarse inclusions (alkali feldspar, quartzite) can be observed in some cases, but as accessory components. Many samples (VAL002, 005, 009, 026, 030, 031, 032, 033) present very abundant elongated voids with a parallel orientation to the walls; meso-sized vughs and vesicles are usually frequent. The clay matrix is generally iron-rich, orange to red or reddish brown in color (PPL), except in VAL020 (yellowish brown), VAL028 (brown), and in some samples with a total or partial darkening of the section (VAL030, 032, 033; more partially in VAL002 and 005), due perhaps to the firing conditions. It is optically active in samples that are related to low firing temperatures (mainly <800/850°C), as indicated by XRD patterns (Table 2): VAL001, 002, 003, 004, 009, 019, 020, and 022. Conversely, the lack of optical activity of the matrix in the remaining samples suggests higher firing temperatures, in some cases over 950/1000°C (Table 2).

Based on the composition and, especially, the packing and granulometry of the inclusions, as well as on the characteristics of the matrix and porosity, some internal variability is observed in the group PF1. It is possible that VAL003 and 004 represent the same fabric (Figure 5a), while VAL001 and 022 form another one (Figure 5b). The samples VAL002, 005 and 031 (and possibly VAL032 and 033) could form a separate fabric (Figure 5c) or, maybe, more than one fabric but strongly related to each other. VAL020 and 028 seem to be related to each other, however, with clear differences in the firing temperature (Table 2).

PF 2: quartz, calcite and micas, fine fabric (Figure 5d) (VAL006)

The sample VAL006 presents a fine, elutriated fabric, with a calcareous matrix (yellowish-brown in PPL) and a predominant fine fraction (silt to very fine sand) of quartz and micas (especially muscovite). Coarser calcareous inclusions, iron nodules and clay pellets can also be found, but are very rare and do not reach large dimensions (mostly <0.5 mm); there is no evidence of tempering. The matrix displays a low optical activity, in association with a low EFT (<800/850°C). Voids are common (in particular meso-vughs and vesicles) but not very abundant.

PF 3: quartz and calcite coarse fabrics, with fine micas (Figure 5e-f) (VAL007, 015, 023, 024, 048; related: VAL047)

In the samples of this group, the sandy fraction is clearly more important than in PF2. Two fabrics can be differentiated, one (VAL023, 024, 048, probably VAL047) with lesser percentage of inclusions than the other (VAL007, 015).

In the former (Figure 5e), a reddish brown (VAL023, 024, 047) or dark brown (VAL048), calcareous matrix is observed, with no optical activity; secondary calcite is abundant in the sample VAL048. Except in this last sample, the voids are common, in particular meso-sized vughs and vesicles. The inclusions (~15/20%) are moderately to bad sorted and comprise, on one hand, a dominant fine fraction (<0.20 mm) of quartz, with common calcareous inclusions and micas (muscovite mainly; mode <0.1 mm). On the other hand, a subordinate coarse fraction is seen, including angular to subrounded quartz (mode <0.40 mm) and, in minor amounts, few limestone fragments and rare calcareous microfossils, usually not very coarse. Some rounded iron-rich clay pellets (mode <0.30 mm) can also be found. The four samples in this fabric are quite similar in their composition and texture, although the fine micas are less visible in the sample VAL023. In addition, the sample VAL047 shows, as a particular feature, the occasional presence of coarse polycrystalline quartz inclusions (2.2-2.5 mm). The XRD patterns indicate a low EFT in VAL048 (<800/850°C), while in the remaining samples it is slightly higher (850-950°C: Table 2).

The samples VAL007 and VAL015 represent another fabric (Figure 5f) that is similar in both samples, except for differences in the aspect of the clay matrix, probably due to the firing conditions, with a low-fired (EFT <800/850°C), optically active matrix in VAL015 and a high-fired (EFT ≥950/1000°C: Table 2) matrix in VAL007. The porosity is common (VAL015) to very frequent (VAL007), especially as meso-sized vughs and vesicles and, in VAL007, as parallel-oriented elongated voids. In both samples the inclusions are abundant (25-30%) and comprise a predominant fine fraction (<0.20 mm) of quartz, in addition to common calcareous inclusions and very fine micas (muscovite). A subordinate, moderately sorted coarse fraction is seen, composed of angular to subrounded monocrystalline quartz (mode <0.35 mm) and calcareous inclusions, in particular limestone fragments (usually <0.5 mm) and rare microfossils. They might represent an added temper of medium/coarse sand, but not abundant. Other rare, accessory inclusions (iron nodules, polycrystalline quartz, quartzite, schist, chert) can also be observed in this coarse fraction.

PF 4: calcite and monocrystalline quartz (Figure 5g) (VAL029)

The only sample in PF4 presents a poorly sorted fabric, with a dominant fine fraction (<0.20 mm) composed of quartz and abundant calcareous inclusions, and a subordinate coarse fraction with limestone fragments (<0.65 mm, mode <0.4 mm) and angular to subrounded

monocrystalline quartz (<0.8 mm, mostly <0.4 mm). Some coarse ferruginous inclusions (clay pellets or argillite fragments) and accessory polycrystalline quartz are also observed. Voids are abundant, including an important presence of parallel-oriented elongated voids. The matrix has a darkened core and reddish-brown surfaces in PPL, and shows no optical activity in XPL; it is a fabric with an EFT between 850-950°C (Table 2).

PF 5: calcite, mono- and polycrystalline quartz (Figure 5h) (VAL046)

The sample VAL046 presents a fabric with very abundant inclusions (35%) and a bimodal grain size distribution. The sandy coarse fraction (>0.2 mm), added as temper, is moderately sorted (mode 0.3-0.7 mm) and comprises calcareous inclusions —especially limestone fragments (<1.2 mm)—, angular/subangular grains of monocrystalline quartz (<1.8 mm) and, to a lesser degree, polycrystalline quartz (<0.9 mm), grading to quartzite in some cases, in addition to accessory alkali feldspar and chert. The fine fraction is very scarce, and is composed of quartz and calcareous inclusions. Abundant voids are observed, including meso- and macro-vughs and elongated voids. The matrix is optically inactive, with a brown to greenish brown color in PPL; the mineral phases in XRD indicate an EFT between 850-950°C (Table 2).

PF 6: calcite, quartz and vegetal temper (Figure 5i) (VAL013, 014)

This group is characterized by the presence of abundant, heterometric inclusions of quartz (silt to medium sand), in addition to a coarser fraction (added as temper) of calcareous inclusions (coarse sand to granules, <4mm; mode 1-2 mm), and carbonized or decomposed vegetal remains. The calcareous inclusions are mainly limestone fragments, but also some rare fossil remains. Mono- and polycrystalline quartz, as well as chert, are few or rare in the coarse fraction. Apart from the voids that result from the decomposition of vegetal temper, abundant meso-sized vughs and vesicles, and, more rarely macro- and mega-vughs are also seen. These samples show a heterogeneous matrix, with reddish-brown to orange-brown sectors, as well as darkened areas (in particular in the core) that seem to be related to a higher concentration of carbonized vegetal inclusions. Some optical activity is observed in the matrix, in agreement with the low EFT (<800/850°C) inferred from the XRD patterns (Table 2).

PF 7: muscovite and quartz (Figure 6a) (VAL040)

The main characteristic of this fabric is the presence of very abundant, heterometric inclusions of muscovite (<1.6 mm, frequent up to 0.5/1 mm), as well as of mono- and polycrystalline quartz (<1.6 mm, mode <0.50 mm). Some metamorphic rock fragments with quartz and muscovite are also present. Other inclusions are rare, *e.g.* garnet, plagioclase, inclusions of the sillimanite family and some large fragment of limestone. The porosity is not

high (mesovoids mainly). The matrix is red to orange in colour (PPL), optically active and low fired (EFT <900/950°C: Table 2).

PF 8: phyllite-rich fabric (Figure 6b) (VAL041, 045)

The two samples in this group show a strong bimodal distribution, with a poorly sorted coarse fraction (>0.5 mm) added as temper that comprises low-grade metamorphic rock fragments (especially phyllites, more rarely quartzite, marble and schist), with a mode of 1-2 mm (very coarse sand); they are more abundant in VAL041. Some coarse to very coarse sandy inclusions of limestone (more frequent in VAL045) are also observed, in addition to very few mono- and polycrystalline quartz and very rare chert. The fine fraction, conversely, is composed mainly of quartz (especially silt to fine sand), as well as some fine metamorphic rock fragments and (in VAL045) calcareous inclusions. The clay matrix is optically active and low fired (EFT <800/850°C: Table 2); it shows a greenish to yellowish brown (VAL045) or reddish brown (VAL041) color in PPL. Voids are frequent, as meso-sized vughs and vesicles and, in VAL041, macrovughs.

PF 9: intermediate to acidic plutonic rocks (Figure 6c-g) (VAL010, 011, 012, 034, 035, 036, 037, 038, 044)

The samples in this group are characterized by a bimodal distribution, with a dominant coarse fraction (added as temper) composed mainly of intermediate to acidic plutonic rock fragments and derived minerals (quartz, plagioclase and a variable presence of biotite, alkali feldspar and others). Four subgroups can be clearly differentiated:

PF9.1: granodiorite, abundant biotite (VAL010, 011, 012) (Figure 6c). Granodioritic or, more rarely, granitic rock fragments are the main component of the coarse fraction (<2.6 mm, mainly 0.3-1.5 mm); large, heterometric inclusions of biotite, quartz, plagioclase and alkali feldspar are also present. The fine fraction (<0.25 mm) is less important than the coarse one, but still abundant; the components are similar to those of the coarse fraction, although with a higher frequency of quartz, as well as an accessory presence of muscovite and some rare heavy minerals (amphibole, clinopyroxene, epidote). The three samples show differences in the color of the matrix, in particular in association with darkened sectors due to variable firing conditions. The matrix displays optical activity, indicating relatively low firing temperatures, as inferred also from XRD (EFT <900/950°C: Table 2). Voids are frequent, especially as parallel-oriented elongated voids, in addition to meso-sized vughs and vesicles.

PF9.2: granodiorite and granite, with abundant amphibole and plagioclase (VAL034, 035, 036). Two fabrics can be differentiated within this subgroup based on the inclusions composition (Figure 6d-e). The samples VAL034 and 035 present a similar fabric (with some minor textural differences), defined by the presence of coarse fragments (up to 3.5 mm) of

granodiorite, granite and feldspars (especially plagioclase), as well as some mono- and polycrystalline quartz, and, in lesser amount, biotite, amphibole and clinopyroxene. The fine fraction (<0.25 mm) consists of quartz, plagioclase, micas (biotite mainly) and frequent inclusions of amphibole, in addition to some clinopyroxene. A different fabric is seen in the sample VAL036, with a much higher predominance of feldspars (in particular plagioclase) over quartz, either as individual crystals or as part of plutonic rock fragments that include also few quartz and, sometimes, amphibole (granodiorite/tonalite, granite). This second fabric is somewhat better sorted than the first one, and includes mainly medium to coarse sand, even if larger fragments are also present. The main components of the fine fraction (<0.25 mm) are plagioclase, quartz, some alkali feldspar, and abundant amphibole and biotite. The abundance of amphibole in these samples is also observed in the XRD patterns; the observed mineral phases indicate firing temperatures under 900/950°C (Table 2). In the two fabrics, the matrix colour varies from dark brown to grey-black in PPL, due to the firing conditions; in general, they do not show optical activity. They are very porous fabrics, due mainly to the high presence of elongated voids with parallel orientation to the walls (more frequent in VAL034 and 035), as well as abundant meso-sized vughs and vesicles.

PF9.3: acidic, with more alkali feldspar and granite (VAL037, 038) (Figure 6f). The poorly sorted coarse fraction is composed of heterometric fragments of granitic or, more rarely, granodioritic rocks (<4.4 mm), as well as quartz, alkali feldspar, plagioclase and, more rarely, biotite and quartzarenite. The fine fraction (<0.25 mm) comprises quartz, alkali feldspar, plagioclase and, in minor frequency, micas (muscovite and biotite). The two samples in PF9.3 show a porous fabric, with some fine elongated voids (with parallel orientation) and frequent meso-sized vughs and vesicles. The clay matrix is light brown to light reddish brown in colour (PPL), with some darkened sectors due to the firing conditions. Both the optical activity of the matrix in XPL and the mineral phases observed through XRD indicate low firing temperatures (EFT <900/950°C).

PF9.4: granite, with accessory metamorphic contribution (VAL044) (Figure 6g). The coarse fraction (mainly medium sand, although coarser grains are common), poorly sorted and less abundant than in the other subgroups in PF9, includes angular monocrystalline quartz, along with subordinate plagioclase, alkali feldspar and some fragments of granitic rocks (including some rare microgranite). This coarse fraction also contains polycrystalline quartz, quartzarenite, and an accessory presence of limestone and low-grade metamorphic rock fragments (phyllite, possibly schist). The fine fraction (<0.2 mm) is composed of quartz and subordinate feldspars, in addition to other accessory inclusions. Meso- and macro-sized vughs and vesicles are common. An optical active, heterogeneous clay matrix is observed, with an orange-red to brown color in PPL. The absence of firing phases in the XRD patterns suggests a low firing temperature (<800/850°C).

PF 10: quartz, muscovite, plagioclase and volcanic rocks (Figure 6h) (VAL042)

The fabric in VAL042 is characterized by abundant, moderately to well sorted inclusions of monocrystalline quartz and frequent micas (mostly muscovite), along with common plagioclase and some basic/intermediate volcanic rock fragments with microlitic texture; other subordinate inclusions are polycrystalline quartz, chert and alkali feldspar, as well as accessory hornblende, metamorphic rock fragments (quartz micaschist, quartzite), and very rare calcite, clinopyroxene, and garnet. All these inclusions are heterometric but not very coarse, with dominant silt to fine sand and, to a lesser degree, medium sand; micas, however, are clearly more abundant in the fine fraction (<0.1 mm) than in the coarse one. The clay matrix is light brown in color (PPL) and optically active, in association with a low firing temperature (EFT <900/950°C: Table 2). Frequent fine elongated voids are seen, although without a preferred orientation.

PF 11: metamorphic rocks, with quartz, micas and fine heavy minerals (Figure 6i) (VAL008, 043)

The two samples in this group share compositional similarities but with clear textural differences, and they can be considered as separate fabrics.

VAL008 presents a coarser fabric, with abundant fine and coarse inclusions (silt to medium sand, as well as few coarse/very coarse sand). The medium/coarse sandy fractions consists mainly of angular quartz and metamorphic rock fragments (quartz micaschist, quartzite), as well as some limestone fragments, iron nodules, biotite, and rare alkali feldspar and amphibole. The fine fraction comprises quartz, micas (mainly biotite, but also muscovite) and, in minor amount, alkali feldspar, plagioclase and fine (<0.1 mm) heavy minerals (amphibole, clinopyroxene, zircon, etc.). Voids are common, in particular fine mesovoids. The matrix is dark reddish brown in colour (PPL), with low optical activity; the estimated EFT is <900/950°C (Table 2).

In VAL043, instead, a finer fabric is found, with a clear predominance of the finer fraction (silt to very fine sand) that is similar in composition to VAL008, except for a lesser frequency of biotite and a higher of plagioclase. The coarse fraction (>0.2 mm) is relatively scarce and includes angular quartz and acidic metamorphic rock fragments, in addition to rare calcareous and ferruginous inclusions, plagioclase, alkali feldspar, and chert. Abundant elongated voids with parallel orientation are observed, as well as meso-sized (and some macro-sized) vughs and vesicles. The matrix, dark brown in colour (PPL), shows no optical activity. The XRD patterns indicate a high firing temperature ($\geq 950/1000^\circ\text{C}$).

4. CHEMICAL CHARACTERISATION

The normalized chemical composition of the 42 analyzed samples is presented in Table 3. The chemical variability of this data-set has been explored through the calculation of the Compositional Variation Matrix (CVM) (e.g. Buxeda and Kilikoglou 2003). The obtained total variation ($vt = 3.57$) is indicative of a polygenic assemblage.

The CVM shows that the elements contributing the most in the variation are CaO ($\tau_{CaO} = 21.17$), Na₂O ($\tau_{Na_2O} = 20.64$) followed by Ni ($\tau_{Ni} = 10.64$), P₂O₅ ($\tau_{P_2O_5} = 9.30$), Pb ($\tau_{Pb} = 8.95$), Cr ($\tau_{Cr} = 8.81$) and MgO ($\tau_{MgO} = 7.49$). The variability in CaO must be related to the presence in the sampling of calcareous (CaO > 6.0%: VAL006, 007, 013, 014, 015, 023, 024, 029, 046, 047, and 048), border calcareous (CaO 4.0-6.0%: VAL003, 004, 020, 028, and 045), and low calcareous (CaO < 4.0%: all the remaining samples) compositions (Table 3). The large variation in Na₂O is explained by the relatively high concentrations of this element in a number of samples (VAL008, 010, 011, 012, 034, 035, 036, 037, 038, 041, 042, and 043). The high τ_i values for Ni and Cr are mainly associated with very high concentrations in a few cases (VAL008, 042, 043) and in VAL035 and 036 only for Cr. With regard to the variations in P₂O₅ and Pb, some caution should be taken in their interpretation, since these elements can be associated with possible contamination problems.

A first grouping of the samples was made by means of a cluster analysis, after an additive log-ratio (alr) transformation of the concentrations obtained by XRF (Aitchison 1986, 1992; Buxeda *et al.* 1995; Buxeda 1999). The analysis was performed using the centroid agglomerative method and the squared Euclidean distance, on the subcomposition Fe₂O₃, Al₂O₃, MnO, MgO, CaO, Na₂O, K₂O, SiO₂, Ba, Rb, Th, Nb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni and Cr, using TiO₂ as a divisor (P₂O₅ and Pb were excluded for this statistical treatment). The cluster tree in Figure 7 reveals the presence of seven chemical groups (CG1 to CG7) and some loners (VAL040, 042). The mean chemical compositions of these groups are shown in Table 4.

A first group (CG1) comprising only two samples (VAL008 and 043) is characterized by particularly high contents of Ni and Cr. The concentrations of these two elements are also high in sample VAL042, but to a lesser extent than in CG1 (Table 3); this individual corresponds to a chemical loner (Figure 7).

At the other end of the tree in Figure 7, there are three chemical groups (CG5 to CG7) that are characterized by low calcareous compositions as well as a high content of Al₂O₃ and especially Na₂O (Table 4). In CG5 the percentages of MgO are lower than in the other two groups, while CG6 presents a higher content of Zn and lower of Zr, and CG7 clearly shows higher concentrations of Cr (though not as high as in CG1) and MgO.

The majority of the analyzed samples are included in a large cluster comprising three chemical groups (CG2 to CG4) at the centre of the cluster tree (Figure 7). They are all characterized by a lower content of Na₂O than in the other chemical groups; however, this

content is somewhat higher in the few samples of the group CG2 (Figure 7; Table 4). The groups CG3 and CG4 show very low Na₂O percentages. These two groups can be differentiated on the basis of their CaO content, being CG3 a low to border calcareous group and CG4 a calcareous one (Figure 7; Table 4). The percentages of SiO₂ are higher in CG3 than in CG4. The importance of CaO and Na₂O for the differentiation between the various chemical groups is clearly seen in the biplot of the first two principal components of the PCA in Figure 8; these two elements dominate both PC1 and PC2, that together account for the 61% of the total variation.

Despite the major characteristics of CG3 and CG4, the compositional data in Table 3 and the cluster tree in Figure 7 suggest a certain internal heterogeneity in these chemical groups. Indeed, the recalculation of the CVM for each group (excluding P₂O₅ and Pb) yields a total variation (*vt*) value of 1.03 for CG3 and 0.80 for CG4, what indicates the presence of a polygenic sample in both cases. On the basis of the closer proximity among the samples in the cluster analysis, up to three subgroups maybe differentiated within both CG3 (CG3.1 to 3.3) and CG4 (CG4.1 to 4.3) (Figure 7). In the case of group CG3, the two main subgroups, CG3.1 (n = 5) and CG3.2 (n = 8), show a *vt* value of 0.32 and 0.50, respectively; the former is characterized by a lower content in Sr compared with CG3.2 and CG3.3, while the latter is differentiated by a higher content in MgO and K₂O (Figure 7; Table 3). As for chemical group CG4, three small subgroups can be differentiated based on differences in Fe₂O₃, K₂O (both higher in CG4.3), CaO (higher in CG4.2) and MgO (lower in CG4.2 and higher in CG4.3) (Figure 7; Table 3).

5. DISCUSSION

The chemical groups and subgroups defined from the results of XRF analysis show a general relation (with some exception) to the petrographic fabric groups and subgroups (Table 5). The integration of these data provides useful information for the characterization of the fabrics. The archaeometric results, in addition to the archaeological data, provide also new evidence on the provenance and some technological features of the analyzed materials.

The most represented fabric group in this study is PF1, with 16 samples that include cooking wares and small amphorae, as well as some common wares (Table 5). They form a separate group in the chemical analysis (CG3), characterized by a low calcareous composition, rich in SiO₂ (related to the abundance of quartz in thin section) and with a low Na₂O content. Some of the specific petrographic fabrics defined in this group (based on the particularities of the inclusions, matrix and porosity) tend to present a particular chemical composition as well, showing a correspondence with the subgroups identified in the cluster analysis (Figure 7).

The chemical subgroup CG3.1 is formed by five samples (VAL002, 005, 031, 032, 033) with the same fabric or, at least, related fabrics. They are all cooking wares, four of which (with the exception of VAL002) are handled cooking pots with similar morphology. Another fabric is

observed in the samples VAL003 (casserole) and VAL004 (bowl or casserole), which share a similar chemical composition (CG3.2). Conversely, the eight samples included in chemical subgroup CG3.3 (Figure 7) are associated with a variety of petrographic fabrics within group PF1. Of these samples, only for VAL001 (cooking pot) and VAL022 (small amphora), on one hand, and VAL020 and VAL028 (two small amphorae), on the other hand, there are strong chemical and petrographic similarities observed. The remaining samples included in CG3 show particular fabrics in thin section, within the petrographic group PF1.

For many of the samples included in PF1/CG3, especially for the cooking wares, an African provenance was proposed at first on the basis of the macroscopic examination (Burriel and Rosselló 2000; Pascual *et al.* 2003) (Table 1), while for the small amphorae (of type Keay 71 or related) various hypotheses —African? Ebusitan? local/regional?— were posed (Pascual *et al.* 2003; Ribera and Rosselló 2012). The petrographic composition of these samples would seem compatible with these different hypotheses. However, the lack of aeolian quartz and the general aspect of the fabrics in thin section suggest a non-African provenance for this group, or at least in an area where aeolian quartz is not common. Furthermore, comparison with the archaeometric database of Late Roman pottery (in particular coarse ware, common ware and amphorae) available at the ERAAUB in Barcelona (*e.g.* Buxeda *et al.* 1997, 1998, 2005; Cau *et al.* 1997, 2004; Cau 1999, 2003, 2007a, 2007b; Buxeda and Cau 2004; Fantuzzi *et al.* 2015a, 2015b) does not show a clear association of this group with African or Ebusitan materials but, instead, relates —both petrographically and chemically— to a series of cooking wares found in another context from Valencia analysed by Cau (2003: Fabric 6.4). This evidence might be indicative of a possible local/regional provenance for PF1/CG3, although further research is needed in order to examine this hypothesis. In any case, it is interesting, from a technological point of view, to find that some fabrics in this group are associated with different classes of pottery (*e.g.* the fabric found in the cooking pot VAL001 and the small amphora VAL022), while other fabrics are more related to a specific ceramic class.

Another fabric group in the analyzed assemblage is PF3, with six samples of common wares and small amphorae (Table 5). They form two distinctive fabrics, each with a particular chemical composition. One of these fabrics is found in samples VAL007 (jar) and VAL015 (bowl), which are included in the chemical subgroup CG4.1 (Figure 7). The other fabric corresponds to the samples of the chemical subgroup CG4.3 (VAL023, 024, 047, 048), comprising a mortar, a bowl and two small amphorae of the type Keay 72. Both fabrics in PF3 are associated with the use of a calcareous, quartz-rich and somewhat micaceous clay paste; temper was probably added in the first fabric (though not quite abundant), while this is less clear for the second fabric.

In addition to PF3, other petrographic fabrics (PF4, PF5, PF6) are also related to chemical group CG4 (Table 5). The two samples in PF6 (VAL013 and 014, both handmade or

slow-wheel made tall casseroles) present a similar chemical composition (CG4.2), while the individual samples included in PF4 (VAL029, basin) and PF5 (VAL046, cooking pot) are chemical loners within CG4 (Figure 7). The fabrics in these samples show a sedimentary composition of the inclusions, with a variable presence of monocrystalline quartz, calcite and—in some cases— polycrystalline quartz or vegetal temper. Only for PF5 and PF6 is there clear evidence of tempering.

Concerning the provenance of all these fabrics related to the chemical group CG4, the initial archaeological study suggested a possible local production for PF5 (Rosselló *et al.* 2010) and PF6 (Pascual *et al.* 2003). It also indicated that some of the common wares in PF3 (VAL007, 047) would be Ebusitan products (Pascual *et al.* 2003; Rosselló *et al.* 2010), while for the Keay 72 amphora samples in the same group an African (Pascual *et al.* 2003), Ebusitan, or local/regional provenance (Ribera and Rosselló 2012) was proposed (Table 1). An African origin was mentioned also for VAL029 (Pascual *et al.* 2003) in PF4. Nonetheless, in a similar way to the group PF1/CG3, the comparison with the archaeometric database at the ERAAUB seems to exclude an African provenance for all the fabrics in CG4, on the basis of the petrographic and chemical characteristics. The sample VAL046 (PF5) is quite similar in fabric and chemical composition to some cooking pots from another Late Roman context in Valencia (Cau 2003: Fabric 6.3); this fabric and PF6 are most probably local/regional products from the Valencia area. As for the fabric groups PF3 and PF4, their chemical compositions show partial similarities with PF5 and PF6 (all of them included in CG4), but also (in the case of PF3) with some Ebusitan products in the ERAAUB database; however, PF3 and PF4 are different in thin section to all the Ebusitan fabrics that we have documented so far (see for example Buxeda *et al.* 1997, 2005; Cau *et al.* 1997, 2004; Cau 2003, 2007a; Buxeda and Cau 2004). For this reason, as in PF1/CG3, a local/regional provenance for these fabric groups seems a plausible hypothesis, though not excluding a possible Ebusitan provenance for PF3. It can be pointed out that the chemical groups CG3 and CG4 differ, in particular, in their calcareous content, but are actually similar in their general composition (Table 4), with some particularities such as the particularly low Na₂O and high K₂O percentages.

The hypothesis of an Ebusitan provenance seems, instead, much more probable for sample VAL006, a bowl RE-0901b. The fine fabric (PF2) is clearly similar to the typical fabrics found in Late Roman common wares and other ceramics from the Balearic Islands (most probably from Eivissa), both in fabric and in chemical composition (*e.g.* Buxeda *et al.* 1997, 1998, 2005; Cau *et al.* 1997, 2004; Cau 2003; Buxeda and Cau 2004). It is a low fired, calcareous fabric, rich in fine inclusions of quartz and muscovite.

Apart from chemical groups CG3 and CG4, which are formed by cooking wares, common wares and/or small amphorae, the rest of the chemical groups identified (CG1, CG2, CG5, CG6 and CG7) are associated with cooking wares exclusively. These are small groups,

formed by two or three individuals in each case, for what their internal compositional variability cannot be thoroughly examined (Figure 7; Table 3). Nevertheless, it is significant that they show, in general, good correspondence with the petrographic fabrics (Table 5).

A well-represented fabric group in this study is PF9, with nine samples of cooking wares, in particular casseroles. Each of the four fabric subgroups (PF9.1 to 9.4) presents a distinctive chemical composition (Table 5), although a certain chemical similarity is observed between PF9.1, 9.2 and 9.3, which are related to the chemical groups CG6, 7 and 5, respectively (Figure 7). All share some technological features, such as the use of a low calcareous clay and the addition of a coarse sandy temper (even with some granules), poorly sorted, with intermediate to acid plutonic rock fragments as a main component. The chemical composition is characterized by somewhat high percentages of Al_2O_3 (16.8-19.5%) and Na_2O (1.5-2.4%, except for PF9.4), this latter in association with the abundance of plagioclase in the fabrics, both as individual crystals and as part of plutonic rock fragments. This high presence of plagioclase is also seen in the XRD pattern, even in the samples with a low EFT, suggesting its interpretation as a primary phase.

The fabric subgroups PF9.1 to 9.3 include only handmade or slow wheel-made casseroles. The three samples in PF9.1 (VAL010, 011, 012), related to the types Reynolds HW 8.1 and 8.2, form the chemical group CG6. They show in thin section a fabric that is clearly similar to the one described by Reynolds (1993) for those types, and is equivalent also to the fabric 3.2/3.3 of Cau (2003). A possible provenance in the area of Murcia or southern Alicante has been proposed for this fabric, although the lack of archaeological evidence so far does not allow us to exclude other possibilities such as some parts of the Catalan coast or the central Mediterranean (Cau 2003, 2007b).

The two tall casseroles included in PF9.3 (VAL037, 038) are related to the chemical group CG5 (Figure 7). The fabric in these samples is equivalent to the fabric 4.2/4.3 of Cau (2003, 2007b), also identified by Reynolds (1993) in his type HW 7.1. The provenance for this fabric remains uncertain, with some hypotheses (*e.g.* some parts of the Mediterranean coast in the Iberian Peninsula, or Sardinia) having been formulated on the basis of the petrographic composition (Cau 2003, 2007b; Macias and Cau 2012) without discarding a possible provenance in the area of current Catalonia.

Another three casseroles (VAL034, 035, 036) are included in the fabric subgroup PF9.2, again with a well-differentiated chemical composition (CG7). Based on the macroscopic aspect of the fabric, the initial archaeological study (Burriel and Rosselló 2000) associated these samples with the types HW7.1 and 7.2 of Reynolds (1993). However, the thin section analysis suggests a different interpretation, due to the nature of the plutonic rock fragments and, especially, the remarkable abundance of amphibole, also observed through XRD and probably related to the high percentages of MgO revealed by the XRF results. Two fabrics have been

identified from the petrographic analysis, one including two tall casseroles (VAL034, 035), while the other one is found in a short casserole (VAL036); even if they are both related to the group CG7, the chemical data also suggests this stronger relation between VAL034 and 035 (Table 3; Figure 7). This fabric might be equivalent to fabric 4.7 of Cau (2003), with an indeterminate provenance so far, due to the lack of further evidence. As for the fabric in VAL036, conversely, we have not found a clear association with any other known fabric of Late Roman cooking wares so far. As such, they must be interpreted as imports in the contexts of Valencia.

The only sample in PF9.4 (VAL044) presents, like the other samples in the group PF9, a low calcareous composition. The Na₂O percentage is lower (0.8%) than in PF9.1 to 9.3, but still high when compared to the majority of the analyzed assemblage (Table 3), and probably related, again, to the clear presence of plagioclase in thin section and in the XRD patterns (as a primary phase). Sample VAL044 is a wheel-made cooking ware that was initially classified as an eastern Mediterranean casserole of type Reynolds W7 (Rosselló *et al.* 2010), although it presents some typological particularities

The cluster analysis (Figure 7) revealed a general similarity in chemical composition between VAL044 (PF9.4) and the samples VAL041 and 045 (PF8), the three being included in a same group (CG2). In any case, the chemical data in Table 3 indicate some differences between these samples, as suggested also from the petrographic analysis. The two samples in PF8, both related to casseroles —types Cartagena 7 (Láiz and Ruiz 1988) and Reynolds W5 — show a particular fabric in each case. VAL041 is a low calcareous fabric with a higher content of Na₂O and Al₂O₃ than VAL045, this latter presenting a higher percentage of CaO; in both fabrics, high concentrations of Ba are found (Table 3). For these fabrics in PF8 the petrographic analysis reveals the addition of a temper with low-grade metamorphic inclusions, especially phyllites and meta-argillites; they are not similar to phyllitic fabric 1.1 of Cau (2003) but, instead, they resemble in fabric and chemical composition some common and cooking wares found in Tarragona.

A particular chemical and petrographic composition is observed in sample VAL040, a handmade or slow wheel-made casserole of type Fulford HMW20. It shows a compact, low-fired fabric, highly rich in muscovite (PF7). Even if various muscovite-rich fabrics have been documented in Late Roman cooking wares (Cau 2003, 2007b; Macias and Cau 2012), the fabric in VAL040 seems equivalent to fabrics 2.3 or 2.4 of Cau (2003) or fabrics 1.6/1.7 of Fulford and Peacock (1984), that have also been reported for other samples of the same type. The low calcareous chemical composition is similar, in general terms, to the one found in fabrics 2.3 and 2.4 by Cau (2003), however with some differences (*e.g.* a slightly higher percentage of Fe₂O₃, Al₂O₃ and TiO₂, and lower of Na₂O) that could be indicative of a different (but related) fabric.

So far, there is no clear evidence for the provenance area of this fabric (see discussion in Cau 2007b).

Finally, there are two samples of cooking wares (VAL008, 043) for which a provenance in the eastern Mediterranean was proposed through archaeological analysis, in addition to another sample (VAL042) with a possible Aegean or Sicilian provenance. In the three cases, the chemical composition reveals a low calcareous composition (CaO 1.8-2.4%) and high concentrations of Ni and Cr, as well as high Na₂O percentages (1.5-2.8%), especially in VAL043, that may be related to the presence of plagioclase in thin section and in the XRD patterns. Despite these similarities, a particular chemical and petrographic composition is found in each case, evidencing that three different fabrics are represented. The samples VAL008 and VAL043 are included in a same fabric group (PF11), though with some chemical and petrographic differences between them. The fabric in VAL008 is similar to fabric 3.9 of Fulford and Peacock (1984), while the fabric in VAL043 might be comparable to fabric 3.12 of the same authors. The chemical composition supports the hypothesis of an eastern Mediterranean (Aegean) provenance for these samples, which was formulated initially from the typological evidence (VAL043 is a cooking dish FCW Dish 5/Reynolds W9.1, and VAL008 a FCW Casserole 35.1). Indeed, high concentrations of Ni and Cr are fully compatible with the Aegean area, and the general chemical composition is similar to that found in Aegean cooking wares analyzed by other authors, *e.g.* Waksman and Tréglia (2007). In particular, the composition of VAL043 is similar to the “subgroup 2” of these authors, and the one of VAL008 can be related to their “subgroup 3”. With regard to this latter, the authors suggest a possible provenance in the Ephesus region, though with some caution due to the lack of reference groups from this and other possible regions (Waksman and Tréglia 2007).

As for sample VAL042, a casserole or bowl of the type FCW Bowl 35/Reynolds W6.1, the fabric (PF10) seems similar to the one described by Fulford and Peacock (1984: fabric 3.7) for this form, although with some minor differences (*e.g.* less common sanidine in VAL042). From the existing evidence, it is difficult to examine the hypotheses of an Aegean or a Sicilian provenance for VAL042, since the petrographic composition of PF10 could be compatible with both areas; however, the high content of Ni and Cr in this sample might suggest an Aegean provenance as a more plausible hypothesis.

6. CONCLUSIONS

The archaeometric analysis of a Late Antique pottery assemblage from *Valentia* provides a characterization of various types of cooking wares, common wares, and small amphorae, as well as new evidence on their provenance and some of their technological characteristics. By means of an integrated chemical, mineralogical and petrographic approach,

this study provides important information that complements the archaeological knowledge of these materials, or, in some cases, suggests their reinterpretation or reclassification.

One compelling result of this analysis is the identification of five fabric groups with a probable local or regional provenance. Particularly remarkable are two well-represented groups (PF1 and PF3) with an internal diversity of fabrics, including many individuals that were considered as African or Ebusitan in the initial archaeological study. The largest group, PF1, comprises cooking wares, small amphorae (of type Keay 71 or similar) and a few common wares. For many of these samples, their macroscopic aspect, with a usually orange fabric (sometimes grey or brown) and the presence, in some cases, of a grey, brown or beige patina in the surfaces, resembles African fabrics; however, the petrographic and chemical evidence presented in this study indicates a local/regional provenance as a more plausible hypothesis. In the same way, for some of the common wares and small amphorae included in PF3, an Ebusitan provenance was initially proposed on the basis of the macroscopic characteristics of the fabric; in this case, although the archaeometric evidence does not allow us to exclude this provenance, it suggests, instead, that a local/regional production could be a probable hypothesis as well. The observation of a certain chemical similarity between these two groups (despite the variations in the calcareous content) would be an additional evidence for this interpretation. This hypothesis warrants further investigation in future research.

Apart from the possible local/regional fabric groups, several imported products—especially cooking wares—have been identified and characterized. The comparison with known chemical and petrographic groups from other studies on Late Antique pottery has allowed for correspondence with some of the groups from this study. Indeed, in the analyzed assemblage from Valencia we were able to recognize some fabrics that are thoroughly documented in many other areas of the western Mediterranean during Late Antiquity (see Reynolds 1993, 2010; Cau 2007b; Waksman and Tréglia 2007; Macias and Cau 2012). Even if the provenance area of some of these fabrics is not clear so far (*e.g.* Cau 2003 fabrics 2.3/2.4, 3.2/3.3, 4.2/4.3, 4.7), the identification of their presence in Valencia sheds more light on the commercial dynamics of this urban centre with regard to the import of cooking wares in the Late Antique period, while contributing to a better understanding of the trade dynamics in the western Mediterranean.

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Figure captions

Figure 1. Map of Valencia (Spain) and the excavations treated in the text. 1. Almoína, 2. Cárcel San Vicente, 3. Cabillers, 4. Pl. Nápoles y Sicilia 10, 5. C/ Conde de Trénor 13-14.

Figure 2. Illustrations of the analyzed samples: cooking wares

Figure 3. Illustrations of the analyzed samples: cooking wares

Figure 4. Illustrations of the analyzed samples: common wares and small amphorae

Figure 5. Photomicrographs of thin sections from the fabric groups defined in this study, all taken in crossed polarized light at the same magnification (40x). (a) PF1: VAL003. (b) PF1: VAL022. (c) PF1: VAL005. (d) PF2: VAL006. (e) PF3: VAL024. (f) PF3: VAL007. (g) PF4: VAL029. (h) PF5: VAL046. (i) PF6: VAL013

Figure 6. Photomicrographs of thin sections from the fabric groups defined in this study, all taken in crossed polarised light at the same magnification (40x). (a) PF7: VAL040. (b) PF8: VAL041. (c) PF9.1: VAL011. (d) PF9.2: VAL035. (e) PF9.2: VAL036. (f) PF9.3: VAL038. (g) PF9.4: VAL044. (h) PF10: VAL042. (i) PF11: VAL008

Figure 7. Dendrogram resulting from a cluster analysis (using the centroid agglomerative method and the squared Euclidean distance) on the 42 samples, including the subcomposition Fe_2O_3 , Al_2O_3 , MnO, MgO, CaO, Na_2O , K_2O , SiO_2 , Ba, Rb, Th, Nb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni and Cr; TiO_2 , was used as divisor in the alr transformation of the data. CG: chemical group

Figure 8. PCA of the alr-transformed chemical data for the 42 analysed samples: plot PC1-PC2, based on the same subcomposition as the cluster tree in Figure 6. In the bottom right-hand corner there is a plot of the variables, labelled as elements, according to the loadings in the two first principal components. The analysis was performed on the covariance matrix

Table captions

Table 1. List of the analyzed samples, with their main archaeological information

Table 2. Mineralogical composition and equivalent firing temperature (EFT) of the 42 analyzed samples, determined from XRD. Abbreviations for minerals (based on Whitney and Evans 2010): Qz, quartz; Pl, plagioclase; Kfs, K-feldspar; Cal, calcite; Gh, gehlenite; Px, pyroxene; Hem, hematite; Ill-Ms, illite-muscovite; Spl, spinel; Amp, amphibole. The samples are organized by fabric group (PF), according to the results of the OM analysis

Table 3. Normalized chemical results (on a LOI-free basis) of the analyzed samples, determined by means of XRF. Concentrations of major and minor oxides are in %, other minor and trace elements are in ppm

Table 4. Mean composition of the chemical groups CG1 to CG7. Mean (m) and standard deviation (sd) values are given for each element. Pb values for CG 4 were calculated excluding the sample VAL013, due to its extreme Pb concentration (285 ppm)

Table 5. List of the analyzed samples, organized by petrographic fabric group (PF) and chemical group (CG), with an indication of their provenance, based on the results of this study. Some samples were reclassified, in comparison with the first archaeological classification in Table 1

Supplementary materials (Online Resources)

Online Resource 1. Additional archaeological information (macroscopic observations) for the 42 ceramic samples analyzed

Online Resource 2. Photographs of representative samples from the analyzed assemblage, including cooking wares, common wares and amphorae