The Argaric pottery from burial at Peñalosa (Jaén, Spain): production technology and functionality

Laura Vico Triguero[1], **Jesús Gámiz Caro**[1], **Francisco Martín Peinado**[2], **Alejandra García García**[1], **Eva Alarcón García**[1], **Francisco Contreras Cortés**[1], **and María Auxiliadora Moreno Onorato**[1]

1 Department of Prehistory and Archaeology, University of Granada, Granada, ES
lvico@ugr.es; jegamiz@ugr.es; alejandragarcia@ugr.es; eva@ugr.es; fccortes@ugr.es; auxiliomoreno@ugr.es

2 Department of Edaphology and Agricultural Chemistry, University of Granada, Granada, ES
fjmartin@ugr.es

ABSTRACT – *The interpretation of the manufacture and function of Argaric burial potteries has not been subject to a global and systematic study. As such, this paper has reconstructed the sequence of ceramic production of burial potteries of Peñalosa using analytical techniques (stereomicroscopy, X-ray diffraction and optical petrography). Ceramic ware technological features, as well as other indicators of use and repair, indicate that the pottery was used prior to the burial either in domestic contexts or during funerary rituals. This finding contrasts with data obtained at other Argaric sites, where technological and formal features point to pottery production specifically intended for burials.*

KEY WORDS – *ceramic production technology; burial pottery; Argaric Culture; Peñalosa; Bronze Age*

Argarska lončenina iz grobišča Peñalosa (Jaén, Spain): proizvodna tehnologija in funkcionalnost

IZVLEČEK – *Razlaga izdelave in namembnosti lončenine v argarskih pokopih še ni bila predmet celovite in sistematične študije. V članku predstavljamo rekonstrukcijo sekvence keramične proizvodnje lončenine iz grobov na najdišču Peñalosa, in sicer z različnimi analitskimi tehnikami (stereomikroskopija, rentgenska difrakcija in optična petrografija). Tehnološke značilnosti keramičnih posod, pa tudi drugi kazalniki njene uporabe in popravil, kažejo, da je bila lončenina pred pokopom uporabljena bodisi v gospodinjskih kontekstih bodisi med pogrebnimi rituali. Ti rezultati so v nasprotju s podatki, ki so znani na drugih argarskih najdiščih, kjer tehnologija in oblika posod kažejo na lončarsko proizvodnjo, posebej namenjeno pokopom.*

KLJUČNE BESEDE – *proizvodna tehnologija keramike; grobna lončenina; argarska kultura; Peñalosa; bronasta doba*

Introduction

Traditionally, the forms and production of funerary pottery in the Argaric Culture have been considered homogeneous both diachronically and spatially throughout archaeological culture (*Contreras* et al. *1987–88; Cámara* et al. *2005; Milá* et al. *2007; Aranda, Molina 2005; Aranda 2004; 2010; Albero, Aranda 2014*). Nonetheless, archaeometric studies in recent years reveal the existence of the fragile nature and low potential durability of certain types of vessels recovered in funerary contexts, features that are in turn closely related to low firing temperatures and friable character of the fabric, features

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linked to a type of manufacture exclusively destined for burials that differs from those intended for domestic contexts (*Cámara* et al. *2005*).

Little archaeometric research has been carried out in the field of Argaric pottery. More traditional studies have focused on the formal features to define the production of funerary and domestic pottery of this period (*Schubart 1975a; 2004; Contreras* et al. *2000*). The methodology applied in these studies was to resort to statistical analyses to define their morphometric variability, and also to determine their degree of formal standardization (*Lull 1983; Contreras 1986; 2000; Contreras* et al. *1987; Van Berg 1988; García López 1992; Arteaga, Schubart 2000; Aranda 2001; 2004; 2010*). However, very little research has focused on the technological characterisation of these vessels, and what exists tends to be biased. The most complete technological study in this regard was carried out on pottery of the Cuesta del Negro settlement (Purullena, Granada) (*Contreras* et al. *1987*), and the remaining studies are approaches to pottery manufacture. This is the case for Los Cipreses (Murcia) (*Milà* et al. *2000*) and prior analyses on a small sampling from Peñalosa (*Cámara* et al. *2005*), the object of the current study. A more recent study was carried out for the assemblage of Cerro San Cristóbal (Granada) (*Albero, Aranda 2014*), although with limited pottery sampling linked to a single funerary context. It is for this reason that new contributions such as the current study are essential to identify patterns of ritual in Argaric Culture from the technological point of view, even more so when bearing in mind that death and the passage to the next life have a strong symbolic value in these early societies (*Lull 1997–1998*).

The study of the assemblage of the archaeological site of Peñalosa goes further and reveals evidence of much more elaborate circumstances of the manufacture of funerary pottery. These items present technical evidence that make them functional for food consumption and processing, which we will address in this work. This suggests ceramic funerary grave goods were used prior to their deposition in the grave. These features are similar to those found on pottery from Cuesta del Negro (*Contreras* et al. *1987*). However, other studies propose the non-functional manufacture of these vessels, and suggest that they were only created to be part of graves (*Milá* et al. *2007; Aranda, Molina 2005; Aranda 2004; 2010; Albero, Aranda 2014*). This indicates that there are at least two types of ceramic production in the graves of Argaric contexts. This indicates that are at least two types of ceramic production in the graves of Argaric contexts, as also the Cuesta del Negro study reveals (*Contreras* et al. *1987*). We thus hypothesize that these technological differences in grave goods may respond to a hierarchical scale which exists between different sites of this culture.

Earlier research has highlighted these differences. Concentrations of prestige goods among certain groups of burials at the settlement of Cerro de la Encina (Granada) (*Aranda* et al. *2008*) contrast with finds at other Argaric sites, such as Cuesta del Negro (Granada) (*Molina* et al. *1975; Contreras* et al. *1987*) or Castellón Alto (Granada) (*Molina* et al. *1986*), that in a certain sense places these latter locations at a lower secondary settlement hierarchical level (*Aranda* et al. *2008.251*). It is in this second group of settlements where Peñalosa would be placed.

In this study we have applied stereomicroscopy (ST), X-ray diffraction (XRD) and optical petrography (OP) to characterise pottery fabrics and reconstruct certain aspects of their manufacture. Moreover, the examination of surface features, such as perforations for vessel repair or traces of burning indicating exposure to fire, provide data regarding their use and reuse.

Finally, this study attempts to identify the symbolic value afforded to ceramic grave goods in the Argaric Culture and determine if there are any variations of funerary rites between settlements in the southeast Iberian Peninsula, based on analyses of Peñalosa's funerary vessels. Only from a specific study, starting from a local or regional scale, can the role of this type of funerary material be defined in the Argaric ritual.

Geological context of Peñalosa

The archaeological site of Peñalosa is located in the Upper Guadalquivir, in the heart of the eastern Sierra Morena mountains, in the municipality of Baños de la Encina (Jaén, Spain).

At Peñalosa, mainly Carboniferous, Triassic and Miocene materials emerge (Fig. 1). The prehistoric settlement is located on a schist base from the Carboniferous, the most abundant material in this area. Two kilometres west there is an area of arkose, metarkose, metaquartz, and sandstone. Parallel to these metaquartzites and Triassic sandstones, Miocene materials of marine deltaic facies appear. Igneous materials also appear in the local context in the form of granodiorites, granites, aplites, pegmatites, and granite porphyry. The granodiorites outcrop appears 4km east and northwest from Peñalosa, in a remarkable extension that forms the 'Cerro de Galjarda' and the 'Peña de la Reina'. The granites emerge to a lesser extent, located 6km northeast of the settlement. In these materials, a mineralogical composition of quartz and feldspar predominates, with the presence of hornblende and biotite phenocrystals. The intrusions of igneous rocks appear in the surrounding of the site as pegmatite aplite dykes and granitic porphyry, which are found in the schist of the Carboniferous. In the Quaternary, the geological formations have alluvial origin, formed by clasts of quartzites, grauvacas, and clasts of schist, arkose and igneous rocks, where silt materials predominate (*García González* et al. *2010*).

Archaeological context of Peñalosa

Peñalosa is dated to the Bronze Age Argaric Culture (Fig. 2), which developed in the southeast Iberian Peninsula between 2200 and 1550 cal BC (*García-García 2018*). It is characterized by the location of hill settlements, funerary contexts under the subsoil of the villages, as well as the uniqueness of their artefacts (*Lull* et al. *2009*), whose typology is repeated throughout the Argaric territory (as seen in Argaric chalices, carinated vessels, daggers with rivets, punches, flat axes, halberds, gold rings, cooper or silver bracelets, or bone bead necklaces) (*Schubart 1975b*).

The settlement is distributed in four large units (Acropolis, Lower, Middle, and Upper Terraces) and is delimited to the east by a wall. The numerous mines (copper and silver) in the vicinity, which were exploited during the Argaric period (*Contreras* et al. *2000, Contreras, Moreno 2015; Hunt 2011*) indicate that the site played a major role as a mining centre, with metallurgy as its main economic activity. Radiocarbon dating carried out on remains of charred wood place it between 1850 and 1450 BC (*Contreras* et al. *2014*).

Peñalosa's funerary record comprises 32 graves (Fig. 3) that fall in line with the structural and distributive patterns characteristic of burials of the Argaric Culture (*Lull 1983; Contreras* et al. *1987; 1997; Aranda, Molina 2005; Aranda* et al. *2008; 2012*). These consist of inhumations placed in cists, *pithoi*, natural or artificial hovels, and masonry features that are always beneath domestic dwellings. Although usually single burials, some are known to contain two or three individuals (*Contreras* et al. *1995; Contreras 2000*).

Materials and methods

The assemblage of grave goods at Peñalosa comprises 34 well-preserved vessels that are either complete or can be reconstructed based on their morphometry, allowing typological classification (Fig. 4). The assemblage comprises a chalice-shaped vessel called a *copa*, bottles, bowls (hemispherical, spherical, carinated, and parabolic), carinated and minute vessels traditionally associated with the practice of ceramic craft (*Contreras* et al. *2000; Alarcón 2010*). Other ceramic groups consist of ovoid and globular cooking vessels (*ollas*) and storage pots (*orzas*) serving as burial containers (*pithoi*).

Decorative motifs among the funerary ware of Peñalosa, as is typical in the Argaric Culture in general (*Lull 1983*), are rare (approx. 2%). Only one ovoid pot (BE-14546) bears incisions on its rim, a recur-

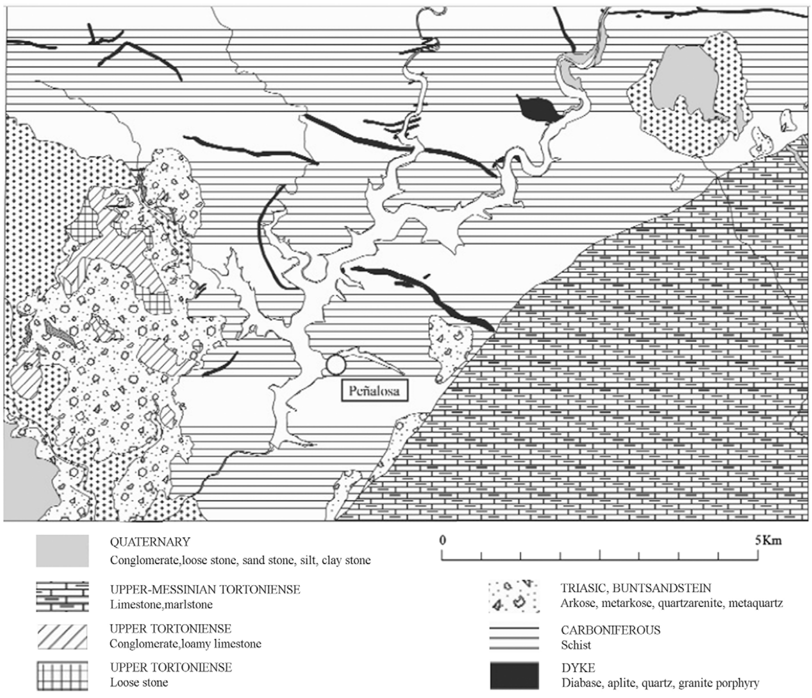


Fig. 1. Geological map of the area surrounding Peñalosa (from* García-González *et al.* 2010*).

Fig. 2. Map of Spain with the position of Peñalosa and the other Argaric sites cited in the text.

rent motif common to domestic ware of the Argaric Culture (*Contreras* et al. *2000*). Lugs near the rims are present in three cases: a bowl (BE-10312), a pot (BE-14546), and a chalice (BE-14601).

The pottery assemblage from the Peñalosa funerary record was selected for the current archaeometric study. The vessels were first described to identify evidence of some of the technological choices applied during their production (surface treatments, forming techniques, firing atmosphere), use and maintenance (Tab. 1). These processes were observed through certain marks on the pottery surface (coils marks, spatula marks, cracks, *etc.*), which were observed on a macroscopic level or through a stereomicroscope in those cases where such marks were difficult to identify because intense treatments had homogenized the surface (*Rafferty* et al. *2015*).

Then, three analytical techniques (stereomicroscopy, X-ray diffraction, and petrographic characterization) were applied to characterise the operational sequence of the analysed pottery. All samples were subjected to a stereomicroscopic examination that enabled us to classify the ceramics from the identification of technological features. These features were the criterion for selecting samples for more specific analytical techniques.

X-ray diffraction (XRD) was used to study the mineralogical composition of the samples. The selection of XRD samples was made based on technological groups (TG), excluding samples the analysis of which would be too destructive. Finally, for optical petrography we selected samples with peculiar technological and mineralogical characteristics, and which had been previously analysed by XRD. Samples of all the TG established by stereomicroscopy were represented in this analysis.

Stereomicroscopy (ST)

This first analysis (n = 34 vessels) had a double function: to characterize the technological evidence and create technological groups (TG). TG are groups of ceramic samples which have common physical features identified by stereomicroscopy (*Gamiz* et al. *2013; Gamiz 2018.314*), and this facilitates the subsequent representative sampling of each group with regard to other analytical techniques.

Stereomicroscopic examinations were carried out with a Leica L80 stereomicroscope (7.5X–60X magnification), Leica EC3 camera and a Leica Achro 0.5x objective. Images were captured with the Leica Application Suite software. This analysis enabled

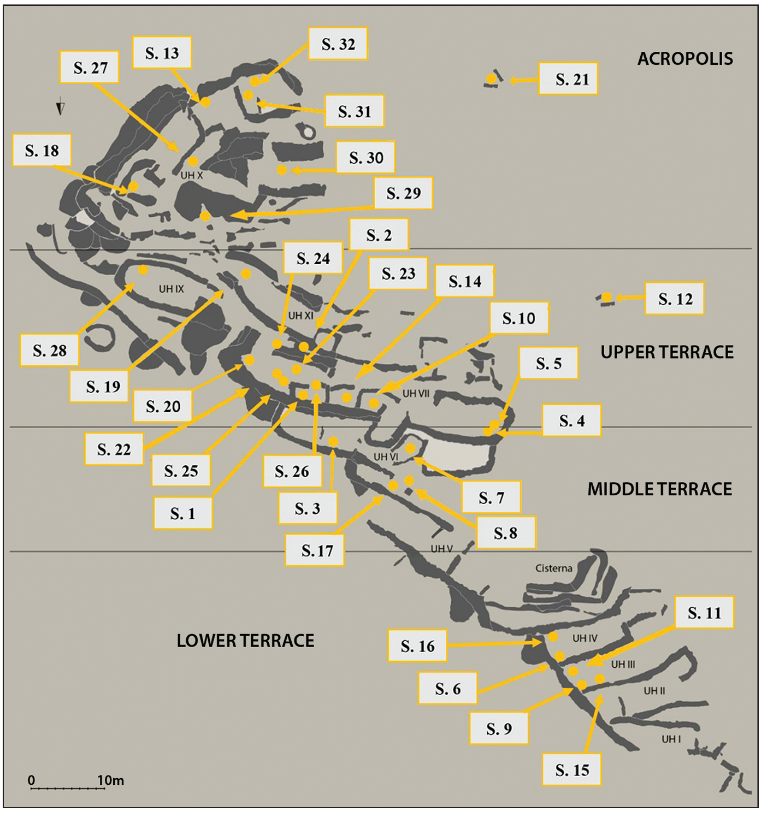


Fig. 3. Map of the site of Peñalosa and the position of the burials (from* García-García 2018a*).

the characterisation of pottery manufacture to differentiate TG. The TG are created from variables which describe the technical capacities of pottery items and their links to a specific use. The evidence which enables the description of these variables is the result of gestures and techniques that were used by the potters who made these objects. Therefore, the compactness of the ceramic paste is used to define the intensity and time of raw material preparation. Compactness is measured by the presence/absence of striae in the matrix, as well as the physical appearance of the pottery. According to the size, shape and frequency of grains of the same mineral that appear in the paste, we can determine if these grains were intentionally added by the potter (*Maggetti 1982; Gibson, Woods 1990; Spataro 2002; Gámiz 2018*), and these particles are called 'temper' (*Whitbread 1995; Gámiz* et al. *2013*). However, the angularity variable was not used to define the creation of TG due to the homogeneity of the results. The description of these variables follows the qualitative methods and reference tables published in other studies (*Castro 1989; Gámiz* et al. *2013*).

Colour of the ceramic surface and matrix was not used to define TG due to the homogeneity of the results, but it was important to define the firing atmosphere (reducing, oxidizing, or mixed). The description of the colours considered first tonality (dark, medium, and light) and secondly colour (black, beige, brown, orange, grey, or white). All these data is shown in the following table along with the visual analysis (Tab. 1).

Statistical treatment of data

In order to obtain technological groups which present technological similarities or variables obtained through stereomicroscopy, a cluster statistical analysis was employed to create the TG and TG subgroups. Three variables were taken into account in this analysis: paste compactness, grain size, and grain percentage.

Cluster analysis identifies the degree of similarity between different variables among all cases and groups them in two-dimensional graphs (dendrograms) (*Shennan 1992*). Clusters are formed either by scanning the matrix for the most similar entities and joining them, or by successively subdividing the matrix (*Rice, Saffer 1982*). These groups were established with a degree of similarity above 95%, and Ward's method with the 'squared Euclidean distance' and 'between-groups linkage' method was used in the statistical analysis, which was carried out with the program IBM SPSS Statistics Version 21.0.

X-ray diffraction (XRD)

X-ray diffraction analysis used 28 representative samples from all the TG obtained by stereomicroscopy. XRD characterises the mineralogical composition of pottery, not only for estimating the firing temperature but also shedding light on the potential provenance of the raw materials (*Quinn, Benzonelli 2019*). The pottery analyses were coupled with the sampling of two local geological outcrops in the area of Peñalosa, potential sources of the raw materials used to make the pottery. This raw material

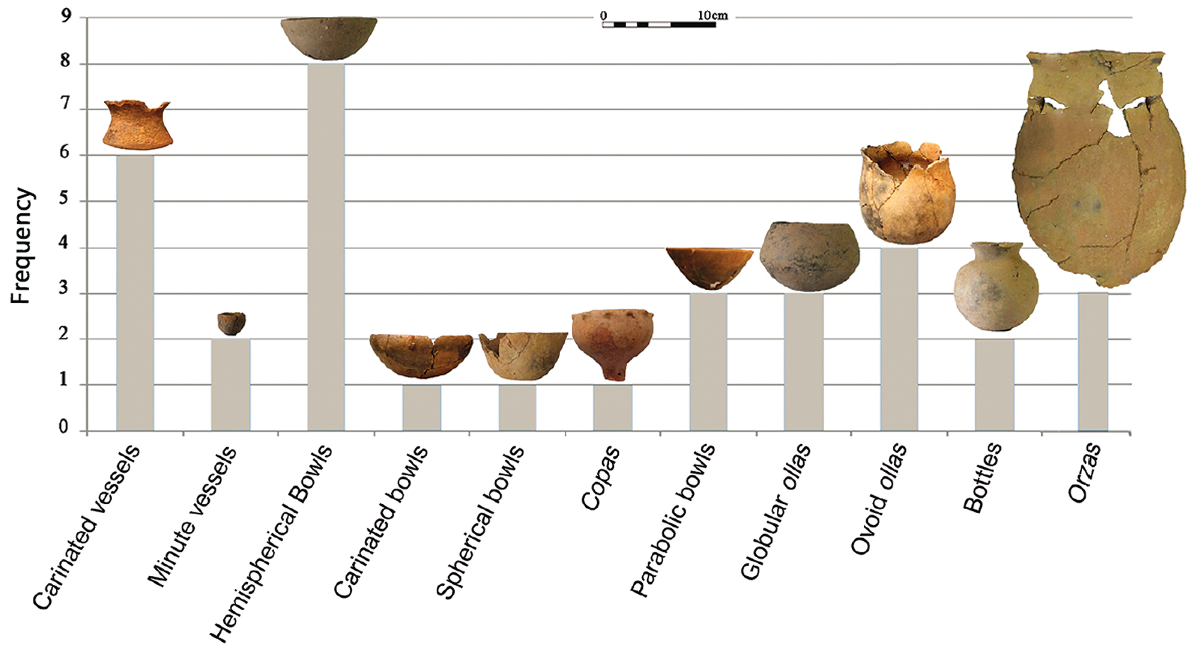


Fig. 4. Histogram of the predominant pottery forms of the burials of Peñalosa.

samples were lower Carboniferous source rocks (*García González* et al. *2010*).

The samples were reduced to fine powder (10μm) and analysed for provenance in the Centre of Scientific Instrumentation of the University of Granada (Spain) with a BRUKER D8 ADVANCE diffractometer with Cu radiation (sealed tube) with a LINXEYE detector. The parameters of measurement were 2s per scanning step, with 0.0393766 increments, with a limit of 2 theta starting at 3 and stopping at 70.0108 at a power of 40Kw and 40mA. The data was obtained by DIFRAL plus XRD Commander software. The peaks of the diffractograms were read through the XPowder 12 Version 2014.04.37 software, where the different crystalline phases of the minerals that make up the ceramic matrix were characterized by consulting the Difdata database, before contrasting the results with those of the rruff.info project database which comprises a semiquantitative characterization (Tab. 2). The RIR (Reference Intensity Ratios) (*Chung 1974; Martín 2004*) method was then applied to identify each of the mineral phases of the samples.

Sample	Quartz	Microcline	Albite	Diopside	Smectite	Hornblende	Cummingtonite	Illite-Muscovite	Orthoclase	Amorphous
9323	66.4	1.7	1.5	0	0	0	0	28.2	0	2.3
281110	77.6	0	3.5	0	0	0	0	16.8	0	2.1
10356	67.1	3.3	11.1	2.2	1.9	5.7	4.7	0	0	3.9
10312	64.1	7.7	9.2	0	5.4	4.6	0	0	0	6
10156	80.1	7.1	5	0	4.7	0	0	0	0	3
12163	86.8	0	0	0	0	0	0	10.4	0	2.8
14584	82.8	2.8	8.8	0	0	0	0	2.6	0	2.9
9526-1	92.3	2.6	2.8	0	0	0	0	0	0	2.3
12130	85.8	0	6	0	0	0	0	5.4	0	2.8
3070	94.3	0.4	0	0	0	0	0	3	0	2.3
14546	75	4.4	13.1	0	0	0	0	4.4	0	3.1
3075-2	70.6	10.5	14.6	0	0	0	0	1.9	0	2.5
20129	83.7	1.4	10.1	0	0	0	0	2.6	0	2.3
20149	76.3	6	13.3	0	0	0	0	3.6	0	1.9
20367	84.7	2.6	8.2	0	0	0	0	1.9	0	2.6
20369	84.6	4.5	5.4	0	0	0	0	3	0	2.5
3069	87.3	1.7	5.6	0	0	0	0	3.1	0	2.2
3075-1	88	2.6	5.5	0	0	0	0	1.4	0	2.5
6066	88.8	4.2	3.1	0	0	0	0	1.8	0	2
14601	87.7	3.3	4.4	0	0	0	0	1.8	0	2.7
15211	82.7	0	5.9	0	0	0	0	0.9	6.9	3.6
20128	92.2	0	2.9	0	0	0	0	2.9	0	2
281111	91.7	2.2	2.3	0	0	0	0	1.7	0	2.1
281112	81.2	4.7	5.3	0	0	0	0	6.5	0	2.4
10361	90.7	0	3.2	0	0	0	0	4.2	0	1.9
10349	75.8	14.5	5	0	0	0	0	3.5	0	1.2
10329	79.7	8.3	6.4	0	0	0	0	3.8	0	1.8
12127	69.2	7.6	12.3	0	0	0	0	2.7	4.8	3.5
50898	73.8	5.2	10.6	3.5	0	0	0	2.6	0	4.2

Tab. 1. Semiquantitative percentages obtained of X-ray diffraction analyses through RIR method of funerary grave goods of Peñalosa.

Petrographic analysis

The vessels analysed by thin section were BE-50898 (carinated bowl), BE-10361 (hemispherical bowl), BE-3070 (bowl), BE-10349 and BE-10329 (storage vessels). This method offers information concerning the fabric, defining 'fabric' as the physical link between the grains and ceramic matrix (*Castro 1989*), and allows evaluation of other aspects of the structure of the ceramic matrix (*e.g.*, presence of vitreous phases). The information obtained from this technique also serves as a complement to results obtained by ST and XRD. A Nikon Eclipse 6400 POL mounted with x4, x10 and x20 lenses served to carry out the thin section analyses. This methodology used some of the variables proposed by Ian Whitbread (*1995*), Bruce Velde and Isabelle Druc (*1999*) and Antonio Castro (*1989*), as detailed below.

The analytical technique applied to the current study takes into account the following variables: proportion of fine (<10μm) and coarse (>10μm) fractions and pores/striae, minerals, degree of compactness, vitrification (originated by ceramic firing or cooking), optical activity, pore and inclusion orientation, particle morphology. These factors serve to define the different pottery fabrics of the Peñalosa funerary assemblage, and comprise its characterization and description. The matrix texture and chemical structure of the grains could provide thermal shock resistance and mechanical properties to the final product.

The analytical procedure therefore served to characterise the technological level of Peñalosa's funerary pottery, assigning each technological feature to a sequence of concrete production sequences divided into the following concatenated phases: raw material procurement, clay preparation, kneading, forming, surface treatment, drying and firing.

Results

Pottery surface analysis

The Peñalosa funerary vessels reveal that potters took special care in preparing their surfaces, most often in the form of burnishing (27 vessels). This technique produces a homogeneous, fine metallic effect. Only the surfaces of very small cups (up to 3cm high and 4cm wide) received just a smoothing treatment. Furthermore, the surfaces of storage vessels (BE, 10349, BE-10329, BE-12127) and three cooking vessels (BE-14546, BE-3070, BE-20149) show signs of smoothing with a spatula, a procedure that served as a base for a subsequent slip.

The pottery forming marks preserved in eleven vessels surfaces (Tab. 1) make it possible to define at least three different forming techniques in Peñalosa, identifiable through the roughness and marks of these surface treatments, as well as the orientation of the matrix grains (*Gamiz* et al. *2013*). These techniques are: basketry moulding (Fig. 5), pinching, and coiling or slabbing. Coiling is identified in large vessels (up to 42cm long and 23cm wide) such as storage vessels, and slabbing in two bowls. These forming techniques consist of the superposition of coils (coiling) or slabs (slabbing) which are subsequently joined with some surface treatment to form the body of the vessel (*Heras 1992; García, Calvo 2013*). More complex forms such as carinated ware, in turn, were made with a mixed technique with their bases fashioned by pinching or moulding and their upper bodies made from coiling or slabbing. Finally, there are small vessels manufactured by pinching rounded clay masses.

Surface colours alternating between dark (black or brown) and light (beige or orange) indicate a predominately mixed firing atmosphere combining phases of reduction and oxidation in 31 samples. Some vessels (*e.g.*, BE-10156, and BE-281111) have homogeneous hues (usually black) on both their outer and inner surfaces, indicative of a reduction atmosphere.

We also observed some surface marks suggesting vessel reuse. Pot BE-6066, for example, bears soot or a cooking marks along its base, indicating a culinary use (*Skibo 1992; Rafferty* et al. *2014*) before being used as a burial pot. Furthermore, certain vessels reveal signs of repair. This is the case with a hole on the stem of a chalice (BE-14601) (Fig. 6) and the body of a bowl (BE-20369). The perforations served to fasten broken fragments together by means of some type of organic cord. This fact reflects an interest by Peñalosa human groups in preserving specific ceramic shapes. These items were likely endowed with symbolism for this culture, as detailed below.

Characterization of the pottery fabric

Stereomicroscopic results

The stereomicroscopic analyses yielded three TG based on the criteria of compactness, grain size and percentage. These can be further divided into subgroups based on their grain quantity. The groupings were carried out by means of multivariate statistical analyses and illustrated by a cluster diagram (Fig. 7).

The main difference between TG is the grain percentage. Groups 1 and 2 are characterized by a medium to high grain percentage (30–50%), and a low one in the case of group 1a (10–20%). Subgroups are differentiated by compactness and grains size. All of them present compact fabrics while that of Group 1a, made up mostly of storage vessels, is less compact. The size of the grains is variable throughout the assemblage, 50% of groups contain fine grains and the other 50% medium grains.

Beside the main variables, other characteristics such as particle shape as well as the colours of the ceramic matrix and surface were taken into account. The tendencies of grain form and size can be ascribed to specific vessel forms. Subangular and rounded particles are most often associated with bowls or cups, that is, the smaller-sized pottery group (up to 14cm wide and 10cm high). Angular grains, in turn, are most common to medium-sized vessels and linked to larger forms such as cooking pots and storage vessels. This leads to the notion that the potters only added temper in certain cases, conditioned by the

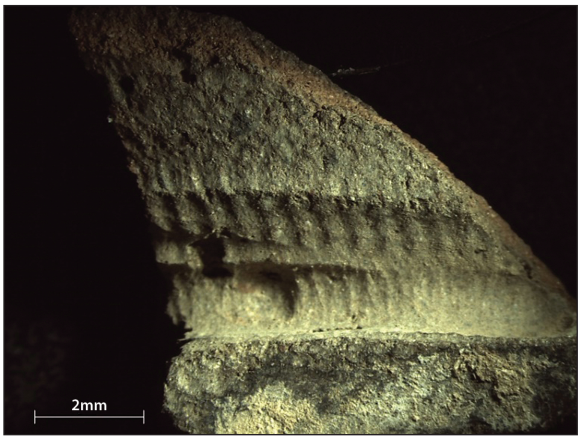


Fig. 5. Microphotography of impressions of basketry moulding from a carinated ware.

intended use of the vessel. In fact, the vessels with angular grains coincide with forms typically linked to cooking pots and storage vessels, a correlation that is not accidental as the addition of temper to the matrix is intended to strengthen the mechanical and thermal resistance of vessels (*Steponatis 1984; Gámiz* et al. *2018*).

It is also noteworthy that the inner cores of the vessels, like their surfaces, tend to have a double colouration. This reflects mixed firing that, as noted above, combined oxidizing and reducing atmospheres. Moreover, certain samples (BE-20129) also bear traces indicating reduction over practically all of their surface.

Fig. 6. Copa (chalice) with a repair hole on its stem.

Mineralogical characterization

X-ray diffraction analyses reveal that quartz, present in a high proportion (between 67 and 97%), is the main mineral phase shared by all the samples. Other minerals such as plagioclase (1.5–14.6%), feldspars (1.3–10%), and phyllosilicates (2–28%) also appear, but in lesser proportions (Tab. 2; Fig. 8A).

Differentiating the samples is conditioned by the presence of alkaline feldspars (microcline) and plagioclases (albite). However, these minerals are absent from one sample (BE-12163) which contains only quartz and a high concentration of phyllosilicates. This absence could be linked to the raw material extraction zone, as detailed below.

Most cases reveal an illite-muscovite phase that is possibly thermally altered, as can be seen by the

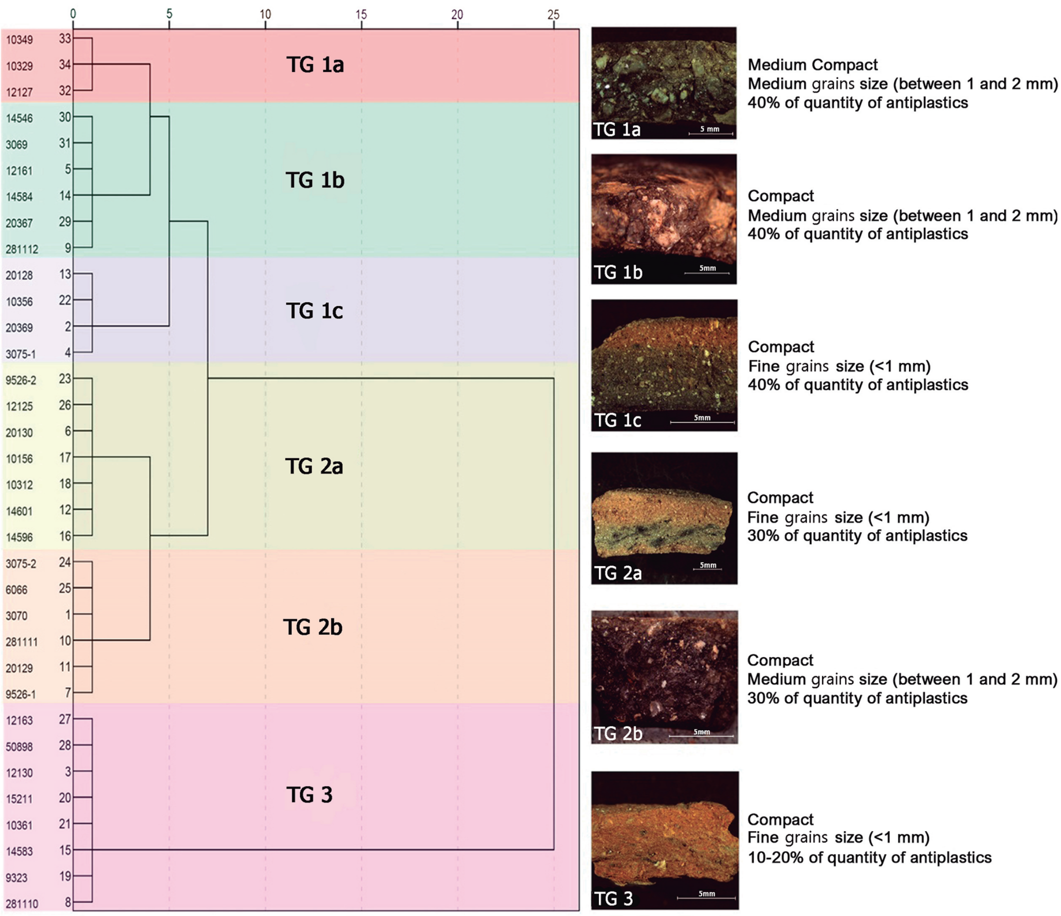


Fig. 7. Dendrogram of the technological groups gleaned from the statistical analysis.

peaks in the diffractogram attain the level of 4.49Å. Smectite was also detected in three of the samples (BE-10312, BE-10356 and BE-10156), while potassium feldspars appear to be rare (BE-15211 and BE-12127). Although there are two cases (BE-10356 and BE-10312) revealing amphiboles, specifically hornblende and cummingtonite, they bear mineralogical characteristics common to the others (quartz, feldspars and plagioclases). A small fraction of pyroxenes is only observed in two samples (BE-10356 and BE-50898). As their percentage is below 3.5%, they may originate from the sediment itself.

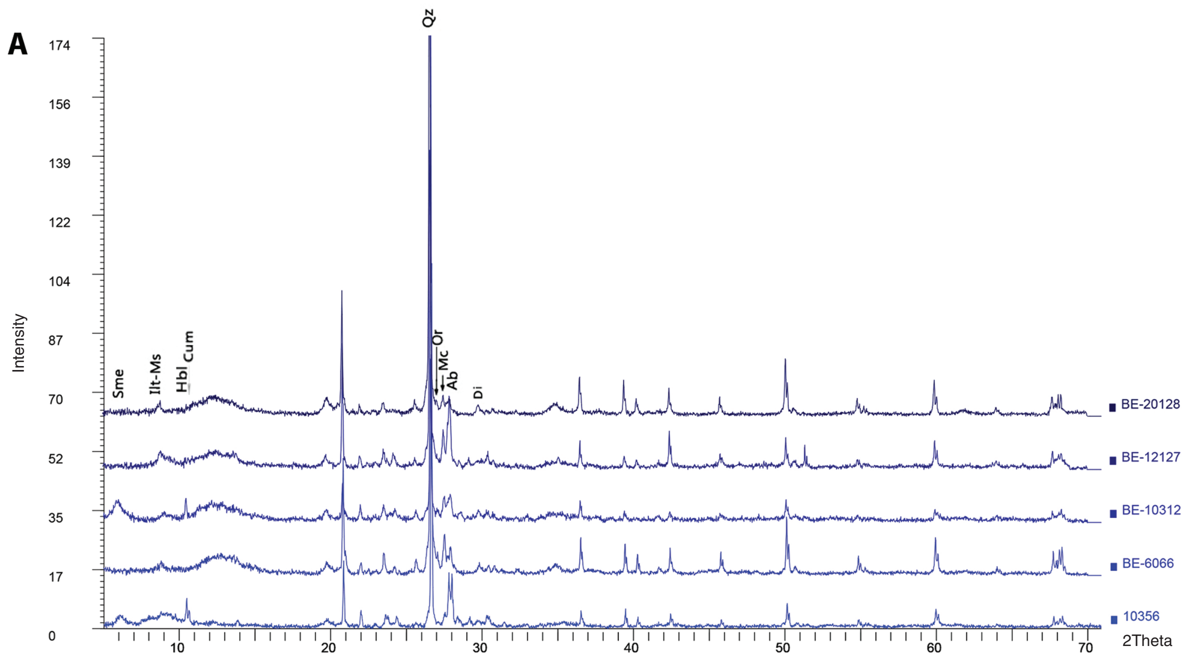
Sediment analyses were carried out on two samples from an area abounding with sandstones (S-3), a potential source of amphiboles, and on samples of clays extracted near the archaeological site (S-11). The results of these analyses (Fig. 8B) indicate a mineralogical composition similar to that of the Peñalosa funerary pottery, with the only anomaly being the presence of chlorite and cinnabar. However, the absence of these minerals in pottery can be explained by their destruction when exposed to temperatures above 500°C (*Schultz 1964; Linares* et al. *1983*). On the other hand, the sandstone sample (S-3) does not reveal evidence of amphiboles, which suggests the exogenous origin of items with this type of composition, or another raw material from other geological areas not yet determined.

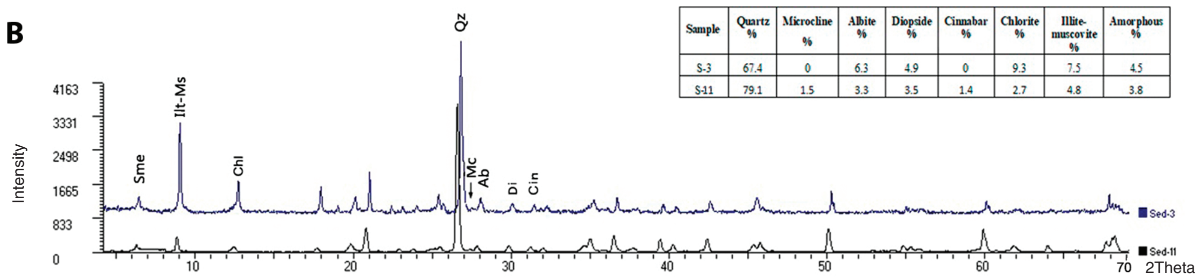
Optical petrography

According to this analysis, three fabric types were differentiated (Fig. 9 and Fig. 10):

● Fabric 1, represented by a carinated vessel and a hemispherical bowl, bears a fine texture (90%) with few pores and striae (10%), and small subrounded grains (< 1mm). Both the grains and the pores/striae are arranged obliquely in the ceramic matrix.

● Fabric 2, represented by a bowl, is medium compact and characterized by equal coarse (35%) and





Sample	Quartz %	Microcline %	Albite %	Diopside %	Cinnabar %	Chlorite %	Illite-muscovite %	Amorphous %
S-3	67.4	0	6.3	4.9	0	9.3	7.5	4.5
S-11	79.1	1.5	3.3	3.5	1.4	2.7	4.8	3.8

Fig. 8. **A** ***Main peaks identified by C-ray diffraction of the funerary pottery of Peñalosa;*** **B** ***main peaks identified by X-ray diffraction among the sediment samples of Peñalosa.*** **Sme** ***Smectite,*** **Ilt-Ms** ***Illite-Muscovite,*** **Hbl** ***Hornblende,*** **Cum** ***Cummingtonite,*** **Qz** ***Quartz,*** **Or** ***Orthoclase,*** **Mc** ***Microcline,*** **Ab** ***Albite,*** **Di** ***Diopside,*** **Cin** ***Cinnabar,*** **Chl** ***Chlorite.***

Sample	Grave	Shape	Sur. Treatment		Matrix				Sur. Color			% Grains	Angulosity Grains	Shape grains	Compact-ness	Forming techniques
			Ext	Int	Core	Ext	Int	Mar	Ext	Int	Spot Col.					
10349	23	Storage vessel	SS	SS	DG	MG	LBR	EDG	LBR	LBR	DBR	40 %	Angular	Medium	Medium	Coiling
10329	23	Storage vessel	SS	SS	DG	MG	LG	EDG	DG	DG	LG	40 %	Angular	Medium	Medium	Coiling
12127	4	Storage vessel	SS	SS	LBR	LBE	LBE		DBR	DBR	DBL	30 %	Angular	Medium	Medium	unidentified
14546	16	Cooking vessel	SS	SS	LBR	LBR	LBR		DG	DG	DBR	40 %	Angular	Medium	High	Basketry moulding
3069	1	Bowl	B	B	MBE	MBE	MBE	ILG	MBE	MBE	BL	40 %	Angular	Medium	High	unidentified
12161	5	Bowl	B	B	MG	MG	MG		DG	DG	BL	30 %	Angular	Medium	High	unidentified
14584	6	Bottle	B	B	MBE	MBE	LBR		MBE	LBR	BL	40 %	Angular	Medium	High	unidentified
20367	15b	Chalice	B	B	LG	MBE	MBE	IBL	DG	DG	BL	40 %	Angular	Medium	Medium	unidentified
281112	18	Bowl	B	B	LBR	LG	DG	IDB	DG	DG	GL	20 %	Angular	Medium	High	unidentified
20128	9	Bowl	B	B	DB	DG	LBR	EDB-IDB	DBE	DBE	BL	40 %	Angular	Small	High	Slabbing
10356	25	Carinated vessel	B	B	MG	LBR	DG	EDG	DG	DG	BL	30 %	Angular	Small	High	Mixed technique (basketry moulding and slabbing)
20369	15b	Carinated vessel	B	B	LBR	LBR	LBR		DG	DG	BL	30 %	Angular	Small	High	unidentified
3075-1	2	Carinated vessel	B	B	MG	MG	MG		DG	DG	BL	40 %	Rounded	Small	High	unidentified
9526-2	18	Cooking vessel	B	B	MO	MO	MO		DO	DO	Br	30 %	Subrounded	Small	High	Mixed technique (pinching and coiling)
12125	4	Carinated vessel	B	B	DO	DO	DBE	EBL	DG	DG	BL,W	30 %	Rounded	Small	High	unidentified
20130	4	Bowl	B	B	MG	MG	MG		DG	DG	DBR	30 %	Rounded	Small	High	Slabbing
10156	24	Bottle	B	B	DBR	DG	DG	IBL	DG	DG		30 %	Angular	Small	High	unidentified
10312	25	Bowl	B	B	LG	DBE	LG	EMG-IDO	DBE	DBE	BL	30 %	Subrounded	Small	Medium	unidentified
14601	6	Chalice	B	B	MO	MO	MO		DO	DO	BL	30 %	Rounded	Medium	High	unidentified
14596	6	Minute vessel	S	S	MBE	MBE	MBE		DBE	DBE	BL	30 %	Rounded	Small	High	Pinching
3075-2	2	Carinated vessel	B	B	LBR	LBR	LBr	EDO	LBR	DG	BL	30 %	Rounded	Medium	High	unidentified
6066	3	Cooking vessel	B	B	LBR	LBR	LBr		MBE	DG	BE	30 %	Angular	Medium	High	Coiling
3070	1	Cooking vessel	SS	SS	LBE	LBE	LG		LBE	LG	BL	30 %	Angular	Medium	High	unidentified
281111	18	Bowl	B	B	LBR	LBR	LBR		DG	DG		30 %	Angular	Medium	High	unidentified
20129	9	Cooking vessel	B	B	LG	MG	LG	EBL-IBL	DB	DBE	BL	30 %	Angular	Medium	High	unidentified
9526-1	18	Cooking vessel	B	B	DO	DO	DG	EDG-IDO	DBE	DBE	BE	20 %	Subrounded	Medium	High	unidentified
50898	31	Carinated vessel	B	B	DO	DB	MG	EBL-IDG	MBE	DG	BL	10 %	Rounded	Small	High	Mixed technique (basketry moulding and coiling)
12130	9	Carinated vessel	B	B	LBE	DG	LBE	EDG-ILBE	MBE	DG	Bl	10 %	Subrounded	Small	High	unidentified
15211	7	Bowl	B	B	MBE	MBE	MBE		DB	DBR	Bl	10 %	Rounded	Small	High	unidentified
10361	22	Bowl	B	B	MBE	MBE	MBE		DBE	DBE	Br	20 %	Rounded	Small	High	Pinching
14583	6	Minute vessel	S	S	MG	MG	MG		DG	DBE		20 %	Rounded	Small	High	Pinching
9323	13	Cooking vessel	B	B	DBR	DO	DBE		DB	DG	Bl,Br	20 %	Angular	Small	High	unidentified
281110	18	Bowl	B	B	DO	DB	DR	IDG	DG	DG	Bl	10 %	Rounded	Small	High	unidentified
12163	18	Carinated vessel	B	B	DO	DB	DG	IDG	DO	DO	Bl,Br	10 %	Rounded	Small	High	unidentified
20149	15a	Cooking vessel	SS	SS	LBR	LBR	LBE	EDB-IDB	DG	DG	Bl	30 %	Angular	Medium	Medium	unidentified

Tab. 2. Technological features of ceramic assemblage under study. **Sur** ***surface*****, Ext** ***exterior*****, Int** ***interior*****, Mar** ***marge*****, SS** ***smoothing spatulate*****, B** ***burnishing*****, S** ***smoothing*****, D** ***dark*****, M** ***medium*****, L** ***ligth*****, G** ***grey*****, BL** ***black*****, O** ***orange*****, BE** ***beige*****, BR** ***brown*****, E** ***external*****, I** ***internal*****, W** ***white.***

fine fractions (35%) and pores/striae (30%). Their grains are small (< 1mm), arranged obliquely, and their fabric is medium compact.

● Fabric 3, represented by *orzas*, is dominated by a coarse fraction (40%) over a fine fraction (30%) that bears a high proportion of pores and striae (30–50%). The grains are medium-sized (> 1mm) and angular-shaped, indicating they correspond to added temper (*Maggetti 1982*). Moreover, the temper is arranged in a chaotic and non-oriented manner.

Additionally, the three different types bear optical activity fabrics resulting from firing. The absence of full vitrification, that would be confirmed by absence of cracks and pores (*Cultrone* et al. *2001; Pavía 2006*), indicates that firing temperatures were below 800°C, although these clays show optical activity or isotropy, so could be in a first stage of vitrification (*Shapiro 2012*).

The thin section analyses corroborate the presence of minerals obtained by XRD, as well as other phases that could not be identified by this method. This is the case of iron oxides and oxyhydroxides that impregnate pottery fabrics and may derive from natural clay or have formed during the firing process. The coarse fraction is formed by metamorphic rocks, associated mainly with micaschists. Quartz is the predominant mineral in the fabrics, as indicated by XRD, and appears in different sizes and shapes (monocrystalline and polycrystalline). Plagioclases (albite) and feldspars (microcline), in turn, appear in less quantity. There are also occasional fragments of mafic minerals such as micas or amphiboles. These different elements indicate that the vessels are of micaceous, not calcareous, fabric. Finally, the matrices reveal the sporadic presence of graphite plant inclusions which probably come from where the clay was extracted.

Discussion

Origin of the raw material

The pottery's mineralogical composition (which includes quartz, plagioclase, feldspars, and phyllosilicates) is characteristic of sedimentary and metamorphic rocks, types of outcrops that are characteristic of Peñalosa's surroundings (Fig. 1) (*IGME 1974; Jaramillo 2005; García González* et al. *2010*). These comprise mainly quartzitic sandstones, mica-schists and quartzites whose alteration processes can yield clay bearing a mineralogical composition similar to that identified from the samples of pottery.

Therefore, the pottery's mineral phases point to local production. Moreover, their mineralogical composition suggests a catchment area extending to a radius of 5km around the Peñalosa, where the potters took advantage of the natural resources offered by the environment.

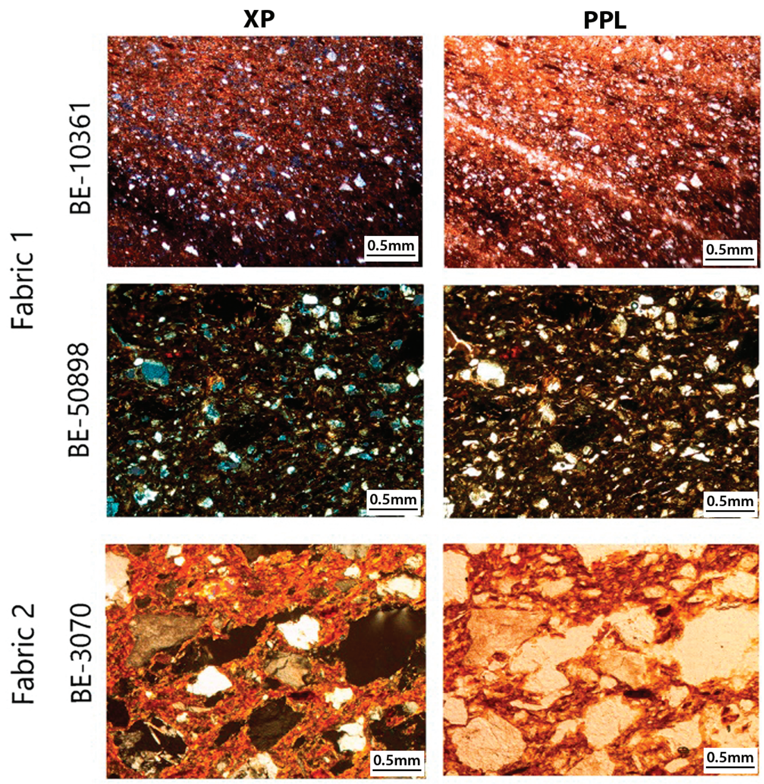


Fig. 9. Petrographic fabrics (Fabrics 1 and 2) of the Peñalosa funerary pottery. Crossed-polarized (XP) and plane-polarized light (PPL).

The two cases bearing traces of amphiboles, by contrast, indicate the existence of raw materials from other geological areas not yet determined. However, other studies carried out in Peñalosa (*García Gonzalez* et al. *2010*) have identified pegmatite aplite dykes and a granitic porphyry area 4km from the archaeological site, where this type of raw material could be found.

Preparation and modelling of raw materials

The results indicate specific production strategies for specific types of pottery forms. Vessels designed for the preparation and consumption of food are compact, indicating thorough kneading of clay which yielded fabrics that are devoid of striations and pores as well as more resistant, avoiding fractures due to the elimination of surplus water during drying, firing and use (*Schiffer, Skibo 1987*). Compactness is also linked to a homogeneous distribution of temper after thorough and prolonged kneading of the clay. Moreover, these vessels are mostly characterised by obliquely arranged grains, indicating the direction of the pressure during forming (*Tite 2008*).

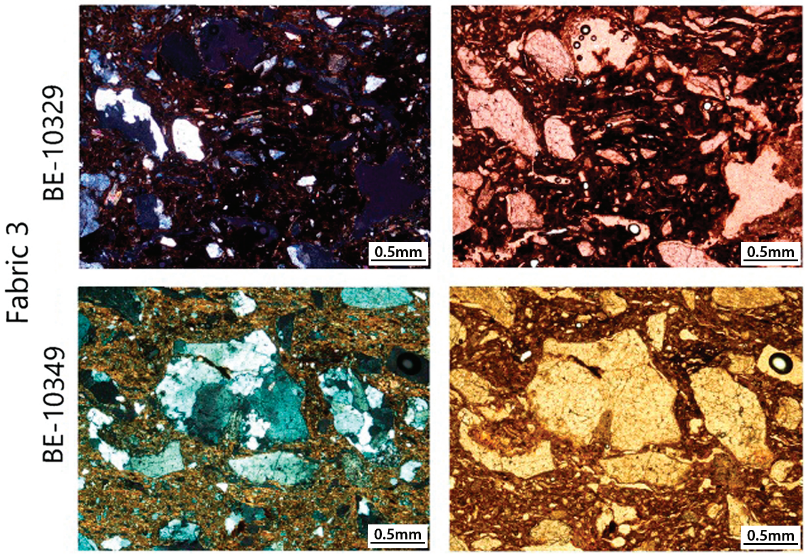


Fig. 10. Petrographic fabrics (Fabric 3) of the Peñalosa funerary pottery. Crossed-polarized (XP) and plane-polarized light (PPL).

Orzas are characterized by more porous and less compact matrices. The fabrics of vessels bearing these features are usually linked to food storage. Their porous nature makes them more efficient in preserving food (*Gámiz 2018*) in both solid and liquid form. However, the fact that their surface reveals a smoothing treatment suggests that they were not designed to contain liquids, as these are more effective when they undergo waterproofing treatments such as burnishing (*Schiffer* et al. *1994*).

In sum, different technological features take place between the phases of preparation of the clay, its kneading and the forming of the vessels. This infers that the manufacture is conditioned by the intended function of the pottery, thus differentiating between vessels serving for food preparation, consumption, and storage. This therefore suggests a well-defined strategy of manufacture denoting potters with an advanced knowledge of their craft.

Clay drying phase

A common characteristic of the different Peñalosa vessels is that their drying time appears to have been adequate, as seen through the low density of their pores and striae. The absence of fractures is also in line with a slow dehydration process. Their tempers allowed an optimal drying phase and led to greater resistance during firing (*Schiffer, Skibo 1987*). The size of the pores and cracks among storage vessels, by contrast, increases due to the thickness of their walls, factors favouring a greater capacity to contain water. Nonetheless, this has a negative effect on their compactness during the drying and firing phases, an effect that can be mitigated, as noted above, by adding temper so as to maintain the mechanical resistance of these vessels (*West 1992; Schiffer* et al. *1994*).

Once at the leather-hard phase, the vessels received the characteristic surface burnishing. In certain cases, as noted for a hemispherical bowl (*Schiffer, Skibo 1987*), the vessel was first treated with a slip layer to smooth the entire surface and eliminate any potential imperfections that could negatively affect the vessel in firing.

Pottery firing

Surface and matrix colour as well as mineralogical composition were taken into account to identify the firing strategies.

Light to dark colour variations both on surface and in the paste are due to different firing atmospheres resulting from open firings or 'firing pits', *i.e.* simple structures serving throughout the entire prehistory of the Iberian Peninsula (*García, Calvo 2006*) that do not allow the control of the firing atmosphere.

We could not firmly establish the firing temperature of the Peñalosa vessels as the mineralogical composition analysed by both XRD and thin section analysis lacks carbonates, especially calcite, a good indicator of firing temperature (*Linares* et al. *1983*).

Furthermore, there is no evidence of new mineral phases resulting from the disappearance of other minerals that are characteristic of high firing temperatures (above 850°C) (*Linares* et al. *1983*). Hence, other types of mineral associations must be taken into account when approaching the question of firing temperature. The absence of chlorite, which tends to disappear at temperatures above 500°C, as well as the appearance in all samples of thermally altered phyllosilicates, suggests a firing temperature above 500°C (*Linares* et al. *1983*). There are several factors indicating temperatures below 800°C: the absence or low bearing of pyroxenes; high percentages of albite, feldspars and smectites; and substantial presence of illite-muscovite, whose dehydroxylation is not initiated before attaining 850–900°C (*Peña-Poza 2011*). Furthermore, no signs of vitrification are visible in the thin section analyses, indicating that firing temperatures did not exceed 750–850°C (the temperature range for non-calcareous clay which depends on the firing atmosphere) (*Maniatis, Tite 1981; Pavía 2006*).

All of the preceding evidence suggests that the funerary pottery of Peñalosa was fired at temperatures ranging between 500–800°C, a hypothesis that would require confirmation from future experimentation. Nevertheless, this is a point of inflexion with regard to the hypotheses stating that Argaric vessels from these contexts were minimally fired (*Albero, Aranda 2014*), or unfired as in the case of the earlier macroscopic studies of funerary pottery from Peñalosa (*Contreras* et al. *2000*). Contreras *et al.* (*2000*) interpreted the light surface colour as a sign of non-firing (*e.g.*, sample BE-15211), while recent archaeometric analyses of the same sample reveal that it was fired. This demonstrates the nullity of the variable of external colouring to determine if ceramics are fired or not. In this sense, DRX or petrographic analyses are more reliable techniques to assess firing temperatures.

Ceramic vessels fired at the previous temperature range are endowed with characteristics that make them functional, with improved mechanical resistance and hardness (*Rye 1981; Simon* et al. *1989; Albero 2014*). The function of these vessels is linked to processing, consuming and storage. This link between technology and function is further evidenced by marks of use on the external walls (bearing soot, cooking marks or cracks).

However, another study defends the argument that this range indicates low temperatures and/or short exposure, and uses the notion of low temperatures for those oscillating between 500 and 700°C (*Albero, Albero 2014*). We think that this range is normal in prehistoric contexts (such as that of Peñalosa), due to the absence of kilns suggesting that the firing was carried out in fire-pits or open fires with limited control over temperatures and firing times. Furthermore, these firing structures could hardly attain temperatures exceeding 950°C under normal conditions (*Gosselain 1992; Tite 2008*). In fact, as evidenced by metallurgical experimentation (*Moreno* et al. *2010*), only bellows or tuyères yield such high temperatures. Therefore, we suggest that the notion of low temperatures be equated with firings below 500°C, because below this temperature the vessel would not be functional due to low resistance (*Skibo 1997*).

Evidence of pottery use and repair

It is also noteworthy that certain funerary vessels at Peñalosa bear signs of use and repair. The burn marks along the base of pot BE-6066, for example, indicate an exposure to fire. This confirms that certain vessels of Peñalosa served for cooking prior to their deposition as grave goods. The perforation through the stem of a chalice also served for its repair. This characteristic ceramic form has been, as noted above, at times associated exclusively with funerary contexts (*Torre 1974; Molina, Pareja 1975*). Signs of reuse, as well as finds of chalice-type vessels unearthed in domestic dwellings (*Contreras* et al. *2014*), lead to speculation that not only reinforces the hypothesis initially raised by Vicente Lull (*1983*) that typical Argaric chalices served in both domestic and funerary contexts, but also suggest that this form saw use in the domestic spheres before being deposited in burials. A detailed comparison of the different chalices from each context in order to assess possible techno-typological variations is nonetheless necessary to be able to offer more firm postulations on this subject.

Conclusions

The technological study of the Peñalosa funerary pottery makes it possible to delve deeper into the question of the manufacture of these types of artefacts throughout the Argaric Culture, leading to new assessments as to their use as well as to speculations about Argaric funerary rites.

Besides their characteristic typology, the homogeneous technological production features of the Peñalosa's funerary pottery suggests potters of great skill. The surface treatment (burnishing), as well as certain technological aspects (compactness of the fabric, absence of large inclusions, clear orientation of the grains, *etc.*), suggest devotion of time and effort to their manufacture. The population of this culture therefore buried their dead in the company of vessels of high quality and marked aesthetic value, a pattern observed also at other Spanish Argaric sites in the Province of Granada (*e.g.*, Cuesta del Negro, Cerro de San Cristóbal, Cerro de la Encina) as well as at the more distant site of Fuente Álamo in Almería (*Contreras* et al. *1987; Albero, Aranda 2013; Schubart 2004; Aranda* et al. *2005; 2008*).

Moreover, the great hardness and resistance of Peñalosa's ceramic fabrics differ from those recorded at other sites, suggesting vessels of low technological quality (*Contreras 1986; Aranda, Esquivel 2006*). These notions, together with the evidence of prior use before becoming grave goods, indicate they were originally intended for food processing, storage or consumption. This study suggests three possible scenarios: (1) the vessels were produced explicitly to serve in a ritual directly preceding the burial; (2) they served initially as domestic artefacts before taking on a funerary role, or (3) both. The first scenario indicates that they formed part of a funerary banquet, a hypothesis advanced by other researchers (*Aranda, Esquivel 2006*), although the hypothesis of previous use in domestic contexts is not rejected. This is indicated by finds of animal and plant remains, and traces of organic residues identified by physical-chemical techniques (*García-García 2018; García-García* et al. *2018*). The second scenario is that of reuse of domestic ware as funerary grave goods, as is the case at Cuesta del Negro (Granada) (*Contreras* et al. *1987*), a site where characteristic forms such as carinated vessels, bowls, cooking vessels are recorded in both domestic and funerary contexts. In this case it is evident that the vessels were produced for a functional use (*Contreras* et al. *2014*). Nonetheless, it must be noted that it is not possible, due to the lack of reliable data, to determine whether they served in a ritual or for everyday common domestic ware.

Our study of the Peñalosa funerary vessels also reveals differences among Argaric funerary patterns from other settlements, where the ceramic grave goods were deliberately manufactured for burials (*Milá* et al. *2007; Aranda, Molina 2005; Aranda 2004; 2010; Albero, Aranda 2014*).

Settlements such as Peñalosa could have occupied a secondary position within the hierarchy of the Argaric territory. These settlements functioned as centres of production to supply more vital centres. In this sense, Peñalosa was a metallurgical settlement centred on the extraction and production of metals (copper and silver).

Although these communities maintained traditions within the framework of a common cultural system, the archaeological record offers evidence of regional particularities. As Peñalosa was a settlement geared toward metallurgy, the wealth of its grave goods is manifested mainly through metal objects, and silver and gold jewellery (*Contreras* et al. *1995*), which does not mean that this settlement is located in a high hierarchical position due to the presence of this type of grave goods, but rather that these are present in Peñalosa for its easy acquisition. The inhabitants buried their dead with pottery that has had a previous use. For this reason, the value given to these types of elements in 'less-entity' settlements can be very different from that granted in other greater centres, where the vessels are manufactured exclusively for burials. As noted by Cesar Carreras Monfort and Jordi Nadal Lorenzo (*2003*), although an economic value can have an influence on the social importance given to objects, it is noteworthy that certain goods valued by one society may not be valued by another. Thus, lifestyles, forms of social organisation and social values within the same culture may influence pottery production from one settlement to another.

The current study has only been able to carry out a limited number of comparisons with other Argaric funerary pottery assemblages due to the general lack of technological analyses. There is a real need for future analyses along these lines in order to define more accurately the nuances of territorial funerary rites, and to question the wider character of the Argaric Culture that has been traditionally framed under the paradigm of cultural unity. Besides, the restriction of the sample to funerary contexts does not allow us to determine reliable reasons which led to certain production strategies. Therefore, current research focuses on analysing the pottery assemblage from domestic contexts of Peñalosa in order to learn more about the organisation of pottery production, and the choice of certain forms and techniques.

ACKNOWLEDGEMENTS

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