Petrographic and geochemical evidence for long-standing supply of raw materials in Neolithic pottery (Mendandia site, Spain)*

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Pottery from the Neolithic Mendandia site has been studied. The radiocarbon dating of the site corresponds to a range of dates from 7488–7546 cal BC to 5283–5437 cal BC: the first occurrence of pottery is dated at 5968–6040 cal BC for the lower level III, and up to 5386–5560 cal BC for level II. The antiquity of the potsherds places them within the oldest pottery production sequences in the Iberian Peninsula, which adds to the interest of this study. Ten potsherds from level II and five from level III are analysed for their petrographic and chemical characterization. The petrographic data show two different methods of raw materials manufacture—intentionally tempered pottery (ITP), using calcite and/or limestone and grog, and naturally or non-intentionally tempered pottery (NTP). According to the matrix paste features, on the basis of the amount, shape, and average or size range of the mineral inclusions, clayed (type A) and sandy (type B) paste types were established and related to two different source areas. The chemical features also indicate two raw material sources and are in agreement with the petrographic paste types. The absence of significant chemical and mineralogical differences between the pottery from levels II and III suggests two contrasting areas for raw materials supply that lasted for at least 600 years.

KEYWORDS: POTTERY, PETROGRAPHY, TEMPERS, GROG, X-RAY DIFFRACTION, GEOCHEMISTRY, NEOLITHIC, IBERIAN PENINSULA

INTRODUCTION

The Mesolithic hunter–gatherer populations that developed prior to the Neolithic period introduced agriculture and domestication, and a sedentary lifestyle. The occurrence of ceramic pottery is one of the defining characteristics of the Neolithic period. Ceramic diffusion displays two main paths from the Near East: one along the Danube–Rhine corridor and a second from the Mediterranean coastline (D’Anna et al. 2003; Davison et al. 2006). In the Iberian Peninsula, it is

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difficult to establish the origins and development of the Neolithic, and it seems that the process of socio-economic change was not synchronous throughout the peninsula.

Archaeologically, two main cultural traditions, marked by two different pottery types, can be distinguished. The motifs on the ceramics are relatively uniform from the Danube to the Paris Basin, with linear or curved ornamentation known as the Linear Pottery culture (or LBK), whereas the distinctive Mediterranean decorative style corresponds to the Impressed wares (also called Cardial). In this context, pottery was introduced into eastern Spain during the sixth millennium BC (McClure et al. 2006), showing specifically a distinctive shell-impressed style of Cardial wares. In the Atlantic coastal regions of France and the Iberian Peninsula, numerous Neolithic pottery-bearing sites have been found. They are referred to as Epi-Cardial and Roucardou, showing early ages of 7350–6500 and 6400–5500 cal BC, respectively (Roussault-Laroque 1990). They are often viewed as related to La Hogue sites (NE France, Belgium and NW Germany) that predate the LBK and Cardial traditions (Jeunesse 1987; Van Berg 1990).

In this context, the Mendandia site corresponds to a seasonal hunting refuge of the Basque Country Mediterranean watershed. The radiocarbon dating of the site is 5968–6040 cal BC for lower level III and 5386–5560 cal BC for level II. Chronologically, pottery from level II seems to be coeval with the first Neolithic pottery (5600–5300 cal BC) from the Alcoi Basin in Valencia (Spain), although the distinctive decorative impressed Cardial style dominates (McClure et al. 2006). Therefore, pottery from level III predates the first occurrence of Cardial wares in the Iberian Peninsula. The antiquity of the Mendandia Neolithic pottery-bearing levels provides a new point of view to the neolithization process and its spread in the Iberian Peninsula.

The aim of this study is to improve the knowledge about the pottery-making in Neolithic cultural times, between c. 6000 and 5400 cal BC. The selection of raw materials, the tempering, the firing temperatures, the provenance of the raw materials and therefore the manufacturing techniques are considered. On the other hand, the endlessly debated mobility and distribution of pottery by hunter–gatherer communities is taken into consideration (e.g., Bettinger 1989, 1991; Skibo and Blinman 1999; Eerkens et al. 2002). In order to attain all these objectives, petrographic, mineralogical and chemical analyses were performed.

THE ARCHAEOLOGICAL CONTEXT

The Mendandia site (Sáseta, northern Spain) is a rock shelter of long-term seasonal occupation by hunter–gatherer groups between 7488–7546 cal BC and 5283–5437 cal BC. The absence of evidence for domestication and the large occurrence of bone remains (mainly of suckling aurochs, most of them ranging from two to three weeks old) support this model of seasonal use (Castaños 2005). It is located in a strategic narrow passage (Oquina-Sáseta, Fig. 1) that is ideal for hunting, as revealed by the macrofaunal bone remains and the lithic artefacts found. Besides aurochs, red deer and roe deer were the most hunted species, indicating both valley and montane ecological niche fauna.

The archaeological studies distinguish five levels. The sequence begins in level V with the blade-rich Mesolithic (7488–7546 cal BC), followed by a complex that is rich in notches and denticulates (6474–6623 cal BC, level IV) and continued in lower level III by a geometric complex (6397–6461 cal BC). The Neolithic elements appear early (pottery around 6000 cal BC) and continue until c. 5300 cal BC, when the site was abandoned (Alday 2007). The Mendandia site radiocarbon dating was performed on large bones, mainly of aurochs (Bos primigenius), and points to recurrent visits throughout the two millennia.
Geologically and topographically, the site is located in the Miranda–Treviño Basin. The mountains are formed by Maastrichtian limestone and dolomite outcrops, whereas the valleys are synclinal depressions filled with thick Oligocene and Miocene siltstones, sandstones and shale materials (Olivé and Ramírez 1985). The Mendandia site is situated on Miocene conglomeratic siliceous rocks on the mountainside (Fig. 2).

Mendandia pottery consists of very small potsherds (only few centimetres in size), which are difficult to attribute to a clear typological form, the wholesale reconstruction of any piece having to be avoided. In level III, the edge geometry suggests that the bowls have a unique vessel shape. In level II, bowls are by far the most common vessels although, as far as we can speculate, other shapes such as globular have been assumed. Usually, potsherds are not decorated and the motifs are mainly restricted to the rims or lips and are seldom found on the body. In level III, smooth plastic appliqué and shallow and unorganized incisions are the most common decorative techniques, while punctated decorations over plastic appliqué and at rims dominate in level II (Fig. 3). Similar decorative motifs are found in level I. In short, during the Neolithic second phase there seems to have been better control of pottery techniques, showing more complicated forms, more varied volumes and more elaborate decoration (Alday 2005).

SAMPLE SELECTION AND ANALYTICAL METHODS

Samples were selected from groups that had been clearly defined according to visual aspects, formal style and long-term continuity of pottery form, rather than on potsherd abundance in each group. Selection was conditioned by the small size of most potsherds, which is inadequate to assure their representativeness. Most potsherds are small and too friable for thin-section manu-
The crumbly nature of most potsherds indicates intensive weathering and chemical modification, precluding further chemical–mineralogical studies. Despite the limited number of samples, the antiquity of the site and the historical context of Mendandia pottery constitute the first occurrence of a continuous Mesolithic to Neolithic sequence within the Neolithic of the Atlantic coast of the Iberian Peninsula, which makes their study even more interesting.

The studied samples were selected from groups and family potsherds of the different cultural levels of the Neolithic. These samples correspond to potsherds without visible signs of burial modification. Ten pieces were collected from level II (called MD-2.x) and five from level III (called MD-3.x). Petrographic, mineralogical and geochemical studies of all samples were performed.

The petrographic characterization was carried out using a petrographic polarizing Olympus BH2 microscope, equipped with an Olympus DP-10 digital camera. Thin-section analysis allows the establishment of pottery-making techniques on the basis of the nature of the tempers, the roundness, or angularity, of the inclusions, and the grain-size and distribution within the ceramic matrix.
groundmass (Echallier 1984; Mason 1995). The thin-section component volume proportions were measured by visual estimation. Additionally, some technological aspects related to the raw material treatments and paste preparations have been recognized.

In order to specify the mineral composition and firing temperature, X-ray diffraction analyses (XRD) were performed using the randomly oriented powder method. Monochromatic Cu–K$_{\alpha_1}$ X-radiation was used, at 40 kV and 20 mA, from a Philips PW1710 diffractometer belonging to the X-Ray Research Service of the University of the Basque Country (SGIker, UPV/EHU). Prior to this, samples were conditioned through manual milling in an agate mortar until a grain-size $< 0.053$ mm was achieved.

The elemental concentration was determined by the ICP–AES method using an ARL 3410 Minitorch™ instrument from the Analytical Chemistry Department of the University of the Basque Country (UPV/EHU). The major element contents were quantified using standard operating conditions (Ortega and Menéndez 1998; Ortega and Zuluaga 2005).

Figure 3  Representative examples of Mendandia pottery, showing the decorative techniques according to the cultural levels.
RESULTS

Petrographic study

Mendandia potsherds exhibit a dark brown, almost black-coloured, inner surface and a little more reddish outer surface, indicating reducing firing conditions. According to Picon (1973), these sandwich structures were produced by firing under reducing conditions with an oxidizing cooling stage. Only two samples display reddish colouring along the wall, suggesting oxidizing firing conditions. However, due to the antiquity of these potteries and their conservation, the possibility of colour change owing to burial oxidation should not be neglected.

Although most of the potsherds exhibit a solid aspect, elongated voids can be observed. The development of open porosity appears to be related partly to the raw material processing, which was obviously performed without intense mixing and compressing. Other cavities within the matrix are drying shrinkage caused during drying and firing processes (Fig. 4 (A)).

Petrographic study allows the identification of two different pottery-making technologies, naturally tempered and intentionally tempered. Based on the nature, amount, grain-size, degree of sorting, and roundness and sharpness of the inclusions, two types of ceramic paste can be distinguished.

Intentionally tempered pottery (ITP) Technologically, the majority of the Mendandia pottery corresponds to tempered pottery. Carbonates were the most common tempering agent, although occasionally grog, or crushed pottery, was used. Limestone fragments and calcite are recognized, but this use of a different temper has not been considered as an additional criterion to define subtypes. The proportion of carbonate temper established by visual estimation is variable, ranging from approximately 7 to 30 vol% in MD-3.3. Usually, limestone fragments and calcite occur in the same pottery (Fig. 4 (B)).

Calcite is by far the most used temper, and two types of calcite crystals were found in the pottery. Rhombohedral calcite and coarse crystalline calcite were probably collected from veins and druses (Fig. 4 (B)) available from Cretaceous limestone outcrops in the Mendandia area. Several coarse limestone fragment types have been distinguished, mainly ‘dirty’ microcrystalline micrite (Fig. 4 (B)), and occasionally micritic foraminifer-rich limestones. In some cases, sparitic limestones occur and exhibit remarkable deformation signs (Fig. 4 (C)).

Grog is the other tempering agent used in the Mendandia potsherds. MD-3.2 and MD-3.1 samples corresponding to level III are grog-tempered. Grog is the only tempering agent in sample MD-3.2, whereas in MD-3.1 potsherd grog and carbonates are used. In both cases, the grog corresponds to carbonate-tempered paste (Fig. 4 (A)).

The matrix content constitutes approximately 65–75 vol%. On the basis of matrix features, two types have been established within tempered pottery (referred to as ITP hereafter). Samples MD-2.1, MD-2.2, MD-2.3, MD-2-4, MD-2.8, MD-2.9 and MD-3.3 (type A) show a microcrystalline clay matrix with scarce angular to sub-angular quartz and feldspar grains of a small size (<0.1 mm) (Fig. 4 (B)). However, MD-2.1 and MD-2.9 show a slightly sandy matrix, characterized by larger amounts of tiny non-plastic inclusions; whereas in samples MD-2.6, MD-2-7, MD-3.4 and MD-3.5 (type B), larger sub-rounded to rounded quartz grains (0.2–0.5 mm) constitute nearly 5–7 vol% of the total matrix (Fig. 4 (C)). To summarize, type A corresponds to a clayey matrix, whereas type B corresponds to a more sandy paste.

Another distinctive feature of the ITP potsherds is their significant porosity, constituting approximately 6 vol%, represented by voids, channels and planar voids. An incomplete mixing
and compression of the clay paste generate part of this porosity (see Figs 4 (A), 4 (B) and 4 (D)). The preferred parallel orientation to the potsherd walls results in a rather layered ceramic. The elongated voids apparently originate from the non-plastic inclusions, causing cracks during drying and firing. Finally, within the studied potsherds, only one has been observed to show intense breaking.

Figure 4 Photomicrograph images. (A) Grog-tempered pottery (ITP) sample MD-3.2, showing carbonate tempers within the grog and two types of microcracks, one surrounding the grog due to thermal shock and elongated voids. (B) Carbonate-tempered pottery (ITP) sample MD-3.3, showing well-shaped calcite crystals and a ‘dirty’ micrite limestone rock fragment in a very fine matrix (Type A). (C) Sample MD-2.6, showing deformation signs in a sparite limestone fragment within a quartz-feldspar sandy matrix (Type B). (D) Sample MD-2.8, showing a drusy growth calcite crystal—compare with (A). (E) Non-tempered pottery (NTP) sample MD-2.10, showing a quartzite rock fragment in a fine matrix. (F) Sample MD-2.5, showing rounded quartz grains in a sandy matrix. Photo width 3.6 mm. (A, D) Plane-polarized light; (B, C, E, F) cross-polarized light.
Non-intentionally tempered pottery (NTP) Only two of the studied samples (MD-2.5 and M-2.10) compose this group and both correspond to level II. The matrix comprises clays constituting more than 75 vol% by visual estimation, and minerals and rock fragments with natural non-plastic inclusions. However, these two samples display different petrographic features with respect to the nature of their non-plastic inclusions. In MD-2.5, rounded quartz grains, constituting nearly 30 vol% and with a size up to 2.2 mm (Fig. 4 (E)), chert grains and partially silicified micritic carbonates are identified; whereas large sub-angular to rounded quartzite rock fragments (Fig. 4 (F)) and polycrystalline quartz grains (≤2 mm) constituting approximately 10 vol% characterize sample MD-2.10.

The nature of these non-plastic inclusions is perfectly compatible with natural tempers and thus is not added to the finer clay (referred to as NTP hereafter). Most of the porosity corresponds to elongated voids that are mainly related to breaking during burial.

Mineralogical study

Mineralogical analysis of the potsherds was performed by XRD and is closely related to the nature of the raw materials mineralogy, the carbonate tempers and the minerals formed during firing. The mineral assemblages identified and their relative abundances are listed in Table 1. Semi-quantitative analysis of the bulk mineral assemblage was undertaken, measuring the peak areas with intensity corrections, using the reflection powers of Schultz (1964) and Biscaye (1965). Calcite is generally the most abundant phase, except for naturally tempered pottery. Quartz and phyllosilicates are less abundant, and feldspars (both plagioclase and potassium feldspar), brookite/anatase and gehlenite are generally present in minor amounts (Fig. 5).

The presence or absence of specific mineral phases provides constraints on the maximum firing temperature. The mineral assemblages are compared with data from firing experiments (Shoval et al. 1993, 2006; Cultrone et al. 2001; Maritan et al. 2005, 2006; Jordán et al. 2009; Trindade

<table>
<thead>
<tr>
<th>Sample</th>
<th>Type</th>
<th>Phyl (%)</th>
<th>Qtz (%)</th>
<th>Pl (%)</th>
<th>Kfs (%)</th>
<th>Cal (%)</th>
<th>Other minerals</th>
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<td>2</td>
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<td>Brk/Ant</td>
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<td>2</td>
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<td></td>
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<td>Gehlenite Brk/Ant</td>
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</table>

Mineral abbreviations after Kretz (1983): Phyl, phyllosilicates; Qtz, quartz; Pl, plagioclase; Kfs, potassium feldspar; Cal, calcite; Brk/Ant, brookite/anatase.
The most significant mineralogical change during firing is the disappearance of clay minerals. Up to 500°C, clays decompose by removal of the hydroxyl groups of the silicate lattice. The diffraction maximum at 10 Å corresponds to dehydroxylation of the phyllosilicate phase. The peak intensity of these phases reduces drastically with an increase in the firing temperature from 700°C to 800°C. Brookite/anatase appears as a residual compound up to 500°C in fired natural clays. In the XRD pattern, it is often difficult to distinguish anatase from brookite when both phases appear as trace minerals. However, anatase was characterized in archaeological pottery by micro-Raman spectroscopy (Olivares et al. in press). According to these data, anatase is the titanium oxide present.

Calcite decomposes yielding CaO (lime), with the release of CO$_2$, at temperatures ranging from 750°C to 850°C, dependent on the firing conditions. The occurrence of calcite suggests firing temperatures below 850°C. Above 800°C, the free CaO reacts with free silica and alumina derived from the breakdown of clay minerals to form gehlenite. The determined gehlenite corresponds to trace amounts, and the coexistence of calcite and gehlenite is indicative of the commencement of the reaction, which suggests firing temperatures ranging from 800°C to 850°C.

**Chemical features**

The major element geochemical data are reported in Table 2. On the basis of the P$_2$O$_5$ content, the burial contamination problem of the potsherds was assessed (Freestone 2001; Maritan 2004; Maritan and Mazzoli 2004). In the present work, no evidence of burial contamination was observed petrographically, with open pores and the lack of any secondary crystallized mineral phase. In addition, the P$_2$O$_5$ concentration is relatively low, less than 0.16 wt%, which indicates the absence of chemical contamination.

The analytical data clearly indicate that the chemical groupings are more related to petrographic features than to cultural levels. Potsherds of both cultural levels are grouped according to the nature of the paste. Thus, the chemical variation reflects the differences between NTP/ITP
pottery, temper abundance and raw material composition. Calcium is indeed the main factor in the chemical distribution. The distribution of the CaO concentration reflects the carbonate abundance related to tempering, displaying differences between the ITP and NTP groups. The alumina (Al$_2$O$_3$) versus lime (CaO) concentrations (Fig. 6 (A)) clearly show the separation of the natural and grog-tempered potsherds. The increased calcium concentration of grog-tempered sample MD-3.1 corresponds to carbonate tempering in the grog (Fig. 4 (A)). Likewise, potsherds with a sandy matrix (ITP type B) are closely grouped, whereas ITP type A (with a clayey matrix) display larger dispersion as a result of large differences in carbonate temper content.

In order to evaluate whether the differences between types A and B correspond to different raw materials or to sorting effects, other major elements were compared. Two chemically separated groups of potsherds become visible, reflecting different clay and feldspar contents, and therefore different raw materials. The Al$_2$O$_3$ versus TiO$_2$ biplot (Fig. 6 (B)) shows two chemical trends, one involving NTP, grog-tempered potsherds and the second corresponding to the clayey matrix ITP.

Table 2  The chemical data (in wt%) for the major elements of the studied potsherds

<table>
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<tr>
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<th>SiO$_2$</th>
<th>TiO$_2$</th>
<th>Al$_2$O$_3$</th>
<th>Fe$_2$O$_3$</th>
<th>MgO</th>
<th>MnO</th>
<th>CaO</th>
<th>Na$_2$O</th>
<th>K$_2$O</th>
<th>P$_2$O$_5$</th>
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Figure 6  Scatter plots. (A) Al$_2$O$_3$ versus CaO, showing the separation of natural and grog-tempered potsherds and their distancing from the clayed ITP type A paste trend. (B) Al$_2$O$_3$ versus TiO$_2$, showing two subparallel compositional trends.
group. Before using elemental data for carrying out such comparisons, it is important to evaluate whether the variability relates to differences in the abundance of temper or to raw material chemical differences. It is a known fact that as the amount of temper increases, the concentrations of elements associated with the raw materials are diluted. Moreover, as raw materials are available mainly from alluvial clays from river floodplains and terraces, it is widely accepted that hydraulic sorting and quartz dilution can significantly influence the chemical composition of terrigenous sediments (Condie 1993; Cullers 1994).

The ratioing of major elements removes the occurrence of dilution/concentration effects by natural sorting and/or by carbonate tempering (Ragland 1989). Because different minerals plot at different locations on the diagrams, the chemical variations provide evidence of raw material sources with distinctive mineral assemblages (Le Maitre 1982). To verify whether the composition reflects raw materials from different sources, SiO2/Al2O3, Fe2O3/MgO and Fe2O3/MgO, Al2O3/Na2O ratios were considered (Fig. 7). The bivariate plots of the elemental ratios separate the two compositional groups, as does the Al2O3 versus TiO2 biplot. These clouds reflect different raw materials, characterized by plastic (clays) and non-plastic (mainly feldspars) minerals with different chemical compositions.

**DISCUSSION**

At the Mendandia site, the crumbly nature and small size of the potsherds conditioned the sample selection. To obtain explicable results, only adequate-size potsherds with recognizable forms were considered. As a result of the limited number of samples, discussion of the data must be regarded with some caution.

The petrographic features and chemical compositional data of the Mendandia potsherds allow an assessment of the production technology, including raw materials handling, firing temperatures and the provenance of raw materials. Most of the Mendandia pottery was intentionally tempered and carbonates were the primary tempering agent—grogs were also occasionally used, but they only occur in the oldest level. Unintentionally tempered potsherds appear in level II.

The use of carbonate tempering has long been established (Arnold 1985; Porat 1989; Basso et al. 2006). Many authors suggest that potters preferred calcite tempering to support a higher mechanical strength for storage and transport purposes (e.g., Papachristodoulou et al. 2006), and others to ensure higher thermal shock resistance for cooking pots, as calcite provides a long life.
over repeated heating and cooling cycles (Maggetti 1982; Echallier 1984; Shoval et al. 1993, 2006; Tite et al. 2001; Martineau et al. 2007). At Mendandia, it is impossible to define the functionality of the carbonate tempers, because the artefacts are too fragmented to reconstruct the vessel shapes and their usage. In the regional context of Mendandia, the carbonate tempering practice is spread over a long period of time, becoming commonplace in the Neolithic (Olaetxea 2000; Ortega and Zuluaga 2005) to medieval cooking pottery (Alonso et al. 2005), including the Bronze Age (Olaetxea 2000; Ortega et al. 2001), the Iron Age (Larrea et al. 2001) and the Roman period (Urteaga et al. 2003). This suggests that carbonate-tempered Mendandia pottery had a cooking purpose, due to the fact that the thermal expansion rate of calcite ensures a higher heat capacity than quartz and most other geological materials (Lide 2005). The scarce non-tempered pottery, occurring only at the most recent level II, probably had a purpose other than cooking.

Estimation of the firing conditions is an additional technological issue that is considered. It is interesting to note that the estimated firing temperatures of the Mendandia potsherds spread uniformly over a temperature range from 750°C to 850°C, indicating non-standardized firing conditions and showing little evolution over time.

With regard to the provenance of the raw materials, when specific non-plastic inclusions (mineral or rock fragments) that can conclusively identify the raw material source area are absent, the chemical data can provide constraints on the provenance problem. Most of the identified non-plastic inclusions are common in sediments from the hydrographic basins of the Mendandia region. Only the silificied limestone fragments of MD-2.5 allow unequivocal definition of the provenance area, consistent with a Loza-flint-type supply source (Fig. 1; Tarriño 2006a,b), suggesting other occasional supplies of raw materials. However, the petrographic composition of the inclusions indicates two main different source areas for both the raw materials and the tempering carbonates. Both the argillaceous and the sandy raw materials (ITP type A and ITP type B) appear to be distributed through pottery from different cultural levels. Regarding carbonate tempers, grogs of potsherd MD-3.5 (level III, c. 6000 cal BC) show similar carbonate tempers to those of sample MD-2.8 (level II, c. 5500 cal BC) (compare Figs 4 (A) and 4 (D)).

According to the chemical data, two well-distinguished populations can be identified. The first one is represented by the sandy matrix (ITP type B, NTP and grog-tempered pottery groups), while the second contains all the samples belonging to the petrographic ITP type A (Figs 7 (A) and 7 (B)). Samples of different cultural levels (levels II and III) are broadly distributed in both compositional populations, indicating a continuous supply of raw materials from two sources.

The petrographic features and the chemical data reveal two main sources of raw materials that are consistent with the alluvial deposits. Because of quite similar features throughout the Mendandia area, it is not possible to point out which one of the rivers furnished the raw materials. Moreover, Mendandia corresponds to a hunter–gatherer community and, as indicated by the flint remains, there was movement over relatively large distances. For these reasons, it is problematic to assign compositional groups to geographical areas. However, these two main raw material supply areas spread during the period of occupation of the shelter.

CONCLUSIONS

The Mendandia site was a regularly recurring seasonal hunting rock shelter from the blade-rich Mesolithic (7488–7546 cal BC) to the Early Neolithic (5283–5437 cal BC). The first occurrence of pottery is dated at 5967–6119 cal BC, predating the Iberian Cardial wares, and therefore becoming the oldest pottery occurrence in the Iberian Peninsula.
Petrographic study of potsherds yields evidence for the longevity of the supply of both the raw materials and the carbonate temper. Clays from alluvial deposits were used as the raw material for pottery production, and the sedimentary components are consistent with those outcropping along the drainage basins of the regional streams. The chemical composition supports the use of at least two clay sources and discounts sedimentary sorting effects between the two paste types, clayey (ITP type A) and sandy (ITP type B). Since the Mendandia pottery was made and used by a mobile community, it is difficult to assign a definitive source to the supply of the raw materials.

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