Pottery production technology throughout the third millennium BC on a local settlement network in Fornos de Algodres, central Portugal

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ABSTRACT Chemical and mineralogical characterization of ceramics from archaeological sites from a settlement network in Fornos de Algodres (Central Portugal), occupied during the third millennium BC, were studied. Potential local/regional raw materials (residual clays of granites, schists and veins of aplite-pegmatites and dolerites) were also analysed. Important stylistic differences occur in ceramic tradition through the third millennium BC in Fornos de Algodres region, but no substantial differences in ceramic composition were noted, reflecting similar raw materials resource exploitation strategies and technology. Exception was found for bell beakers of Fraga da Pena, which present a more careful production technology and clay selection. In general raw materials preferably used were the derived by weathering of granites, and in some cases derived by weathering of dolerites. In both cases the addition of temper of granite origin in different proportions occurred.

1. Introduction

The study of provenance and production technology of ceramics presented in this work comprise a settlement network occupied during the third millennium BC in central Portugal, including four archaeological sites: Castro de Santiago dated from the first quarter of the third millennium BC (Chalcolithic), the Malhada from the Chalcolithic/Early Bronze Age, the Qta. Assentada from the Final Chalcolithic and the Fraga da Pena from the transition to the Early Bronze Age.

This archaeometric study has as main purpose to emphasis on continuities or innovations in the production technologies and on raw materials resources through the third millennium BC in these local settlements, near Fornos de Algodres. The foremost objectives lead us to contribute to the characterisation of material culture, technologies and organisation of pottery production, as well as resources exploitation strategies and regional and interregional interaction patterns, throughout the millennium.

2. Materials: ceramics and clays

2.1 Ceramics

Castro de Santiago (CS) – The CS is a fortified domestic context (Valera, 1997). Fifty-three samples were selected for analyses including the most representative shapes

(hemispherical and hemi-ellipsoid bowls and spherical and globular some decorated with incised and impressed motives). The loom-weights, also analysed, have parallelepiped morphology with four grip holes.

Malhada (MAL) – From Malhada (Valera, 1995), also a domestic (open) context, ceramic was sampled taking into consideration the most representative typologies, the exceptions, their possible uses, as well as the stratigraphic units of provenance. So, 83 sherds and loom-weights were selected, representative of Chalcolithic and Bronze Age contexts.

Quinta da Assentada (QA) – Is also an open settlement where domestic activities seem to be predominant (Valera, 2004). Fifteen samples were selected from the most representative typologies of the Final Chalcolithic.

Fraga da Pena (FP) – The archaeological remains of FP revealed a significant quantity of rare goods, mainly high proportion of bell beakers, and a relative absence of objects related to daily life (Valera, 1997). There are morphologies and decorations that clearly reveal the permanence of local Chalcolithic patterns, but also new types of recipients appears, marking the transition to the Early Bronze Age in the region. Beakers appear with the common decorations ("International" and "Geometrical" styles), but also with a "local" pattern (nail printed). This ensemble of material culture and edifications indicate an occupation where symbolic activities could overcome the domestic ones. Four main typological groups were selected for archaeometric study: beakers (nail printed; "international"; pointed decoration, impress decoration, without decoration, with "omphalo" base), decorated vessels with combed incisions and vessels with morphological and decoration patterns of Chalcolithic tradition and Bronze Age new morphologies. Sixty-nine representative samples of these groups were studied.

2.2. Raw materials

Twenty-eight clay samples were collected of the different geological contexts of the settlements. The raw materials available in the area are residual clays corresponding to different stages of weathering of granites (7 samples) cut by veins of quartz, aplite-pegmatite (4 samples) and dolerite (14 samples); and schists (3 samples).

3. Methods

The chemical and mineralogical analyses of sherds and clay materials were done by means of (NAA) neutron activation analysis (Cabral et al.. 1983; Prudêncio et al., 1989) and X-ray diffraction (XRD). Sediment GSD-9 and soil GSS-1 (IGGE) were used as standards. Samples and standards were irradiated in the grid core of the Portuguese Research Reactor (Sacavém), obtaining the concentration of: Na, K, Fe, Sc, Cr, Mn, Co, Zn, Ga, As, Br, Rb, Zr, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Dy, Yb, Lu, Hf, Ta, Th, U. Details of our INAA procedures were published elsewhere (Prudêncio et al., 1986; Dai Kin et al., 1999).

Data were treated using Statistica software (StatSoft, Inc., 2003) by uni-, bi- and multivariate statistical methods.

Ceramics and clays were examined by XRD using the whole material prepared as unoriented aggregates, and the < 2μm fraction for selected samples, as oriented aggregates under ambient conditions, after solvating with ethylene-glycol and after heating to 500°C.

Thin section optical microscopy was done for selected ceramics.

4. Archaeometric results and discussion

4.1. Mineralogical composition

Among the raw materials studied, dolerites are the most clayey samples. XRD revealed that the minerals present in dolerites are phyllosilicates associated with feldspars, quartz and as minor pyroxenes and iron oxides. Aplite-pegmative veins present higher amounts of alkali-fedlspars associated with phyllosilicates, quartz and plagioclases. Granites are mainly composed of quartz, alkali feldspars, plagioclases and phyllosilicates. Schists present an association of quartz, alkali-feldpars, phyllosilicates, plagioclases, gibbsite and iron oxides. Clay minerals associations clearly differentiate basic veins from the other materials, mainly due to higher amounts of smectite relatively to kaolinite.

Phyllosilicate minerals of ceramics are mainly composed of mica, illite, chlorite and smectite with small amounts of kaolinite in a few samples. In some ceramics, especially of F. Pena, the clay fraction presents considerable amounts of smectite and interstratifieds. In the other sites the dominant clay mineral is kaolinite. In the first case a more correlation with dolerite sample is obvious and in the second case with granites. Feldspars, plagioclase and quartz appear to be the main temper minerals, and hematite is also present in the most studied ceramics, as well as, traces of pyroxene in several ceramics.

The results obtained point to low temperature firing processes, not higher than 500°C-600°C.

At a macroscopic view, in general the non-plastic grains occur in great amounts, with various sizes, showing the paste a high irregularity of grain size distribution, and in the Castro de Santiago ceramics, it's very evident the presence of feldspars, more than in the F. Pena ones, specially in the bell-beakers of F. Pena, that have a finer paste.For the generality of the ceramics from the studied sites, the clay-temper grain mixture used as paste shows that it wasn't certainly grounded sieved and well mixed. Thin sections of CS and FP sherds enhances these characteristics, presenting the paste high irregularity of grain size distribution with lumps of clays joined to the paste, giving a very irregular texture with very nebulous and irregular aspect of the orientation of the clays. Non-plastic grains occur in great amounts added by the potter, also pointing to a not very careful working on the process of assembling the paste, with a very heterogeneous clay-temper grain mixture material. However it is important to enhance the particularities presented by some pastes, especially in the case of Fraga da Pena bell beakers ceramics, mainly the nail-printed ones. These ceramics present textural and mineralogical singularities, as they are fine-grained ceramics, which even distribution and grain size gives a more regular texture, pointing to a careful mixing and working of clays and temper mixture, thus leading to a different/careful production technology in the case of those F. Pena bell beakers (Dias et al., 2002).

The firing practices were probably on open firing for most of the studied cases. The paste is sometimes dense, but generally the particles are not compacted and voids and pores are common, pointing to a quick heating phase. Another aspect is that ceramics were

most likely fired for a period which has not transformed the paste to an oxidized state, considering the outer edges of most of them, which are red to brown and the centre grey or even black.

4.2. Chemical composition

In chemical point of view clays derived by weathering of granite and dolerite can be respectively distinguished by their Na and K contents (alkali feldspar and plagioclase) and other elements with geochemical affinity to ferromagnesian minerals, such as Cr, Co, Sc and Fe (Fig. 1). Although it is possible to clear differentiate between these different geological materials, in some cases also important chemical differences occur within each type (namely in the Rare Earth Elements - REE contents), as they result of different grades of weathering. Chemical characterisation showed that in general dolerite veins present a more heterogeneous composition than the other materials (Dias et al., 2000a).

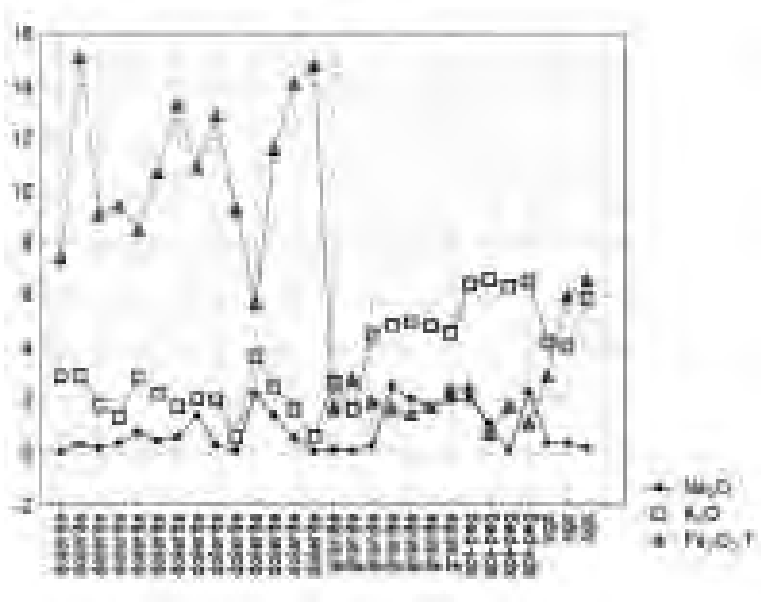

FIG. 1 – Line plot of Na_2O, K_2O and Fe_2O_3 T for geological materials.

This kind of detailed chemical and mineralogical characterisation of the clay materials allowed the distinction between the different types of availability of potential raw materials for ceramic manufacture in the region.

Considering the context of this research, regarding the provenance study of ancient ceramics, it is important to enhance that in the studied area the most clay materials are the dolerite veins. So, potters could have mainly used them to make their pots, especially as the plastic component of the paste, as in previous work done for F. Pena site was already noticed (Dias et al., 2000b, 2002). The relation with schist samples it is not very clear, more additional samples are need.

Potters from C. Santiago should have used preferably raw materials derived by weathering of granites (cluster 3), and in some cases derived by weathering of dolerites (cluster 2), but with the addition of temper of granite origin in different proportions (Fig. 2). Two ceramic samples outliers were defined. There is no correspondence of the groups defined

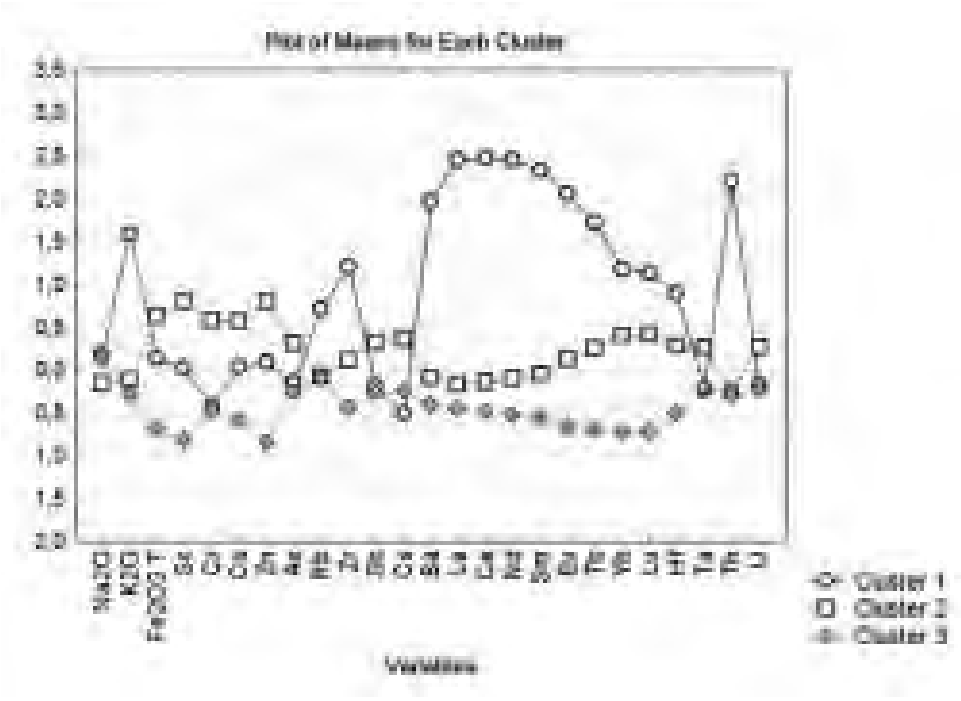

FIG. 2 – K-means clustering of chemical results for C. Santiago ceramics.

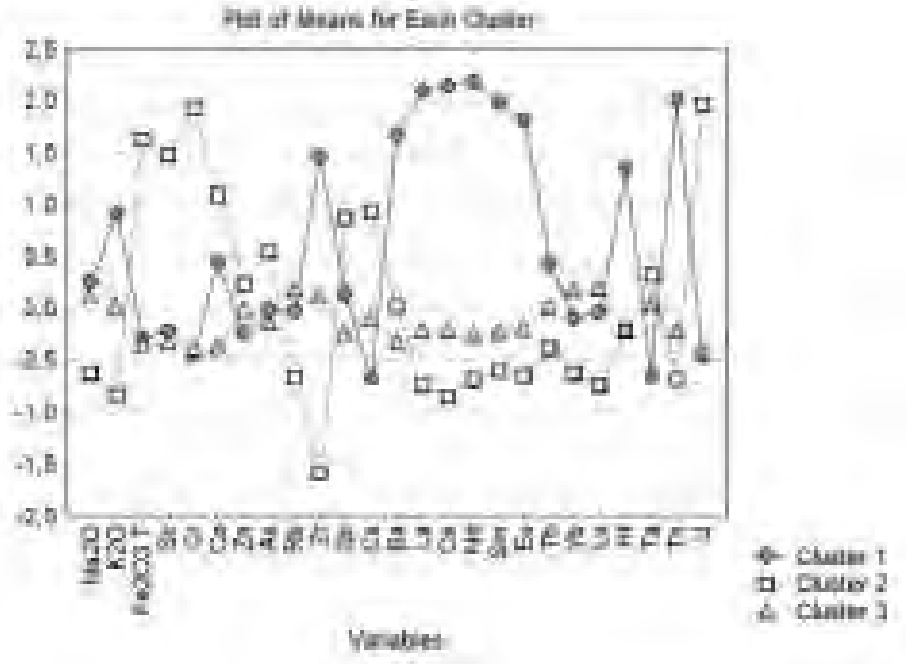

FIG. 3 – K-means clustering of chemical results for Malhada ceramics.

according with chemical composition and a specific typology. Regarding the five loomweights analysed, three are more related with granites and the other two with dolerites, using temper of granite origin.

Ceramics from the archaeological site of Malhada present more chemical heterogeneity. Three main groups may be defined (Fig. 3). Cluster 3 comprises the majority of the ceramic samples, presenting a geochemical affinity with materials of granite origin. Cluster 2 presents a reverse geochemical behaviour, entailing the use of some clay samples

derived by weathering of dolerites. Considering the chronological/typological approach, no particularly difference was noted; besides the tendency of Bronze Age ceramics present only correlation with samples of granite origin and, in the case of Chalcolithic ceramics, a more diversified resources exploitation, with the use mainly of raw materials derived by weathering of granites, but also using raw materials of dolerite origin and also mixing supplies with dolerites as clay matrix and temper of granite origin. The three analysed loom-weights don't point to the most commonly used raw material, which is granite. Two outliers were defined.

Chemical composition of analyzed ceramics from QAS points in general to the use of one type of raw materials associated to more acid rocks, with a positive correlation with local granites, like the ones from Bronze Age of Malhada site. The only exception is two samples (QAS-4 and QAS-8) related with clay samples derived by weathering of dolerites.

Previous works for FP ceramics enhance the occurrence of geochemical differences between typologies (Dias et al., 2000b, 2002). Bell beakers present a more homogeneous chemical composition, and within this typology the nail printed bell beakers present a different behavior. The main geochemical features heighten three main groups related with regional geological materials and a few outliers (Fig. 4). Group 1 (G1) comprises mostly bell beakers, group 2 (G2) is essentially composed by Chalcolithic and Bronze Age typologies, as well as combed incisions ceramics, and only a few bell beakers, group 3 (G3) includes, like the first group, essentially bell beakers, and also Chalcolithic and Bronze Age typologies. The chemical composition of the groups including mostly bell beakers (G1 and G3) are more related with basic rocks, with considerable amounts of ferromagnesian minerals, like local/regional dolerites. The differences found are due to differences among dolerite veins, namely in REE fractionating. The chemical composition of G2 points to the use of more acid rocks, like local/regional granites. In some cases chemical variations found in ceramics may be explained by different mixing proportions of dolerites and granites in their production. When in presence of fine pottery, a more positive correlation exists with dolerites, and in coarser pastes with granites, even in both cases non-plastic grains of granite origin are pre-

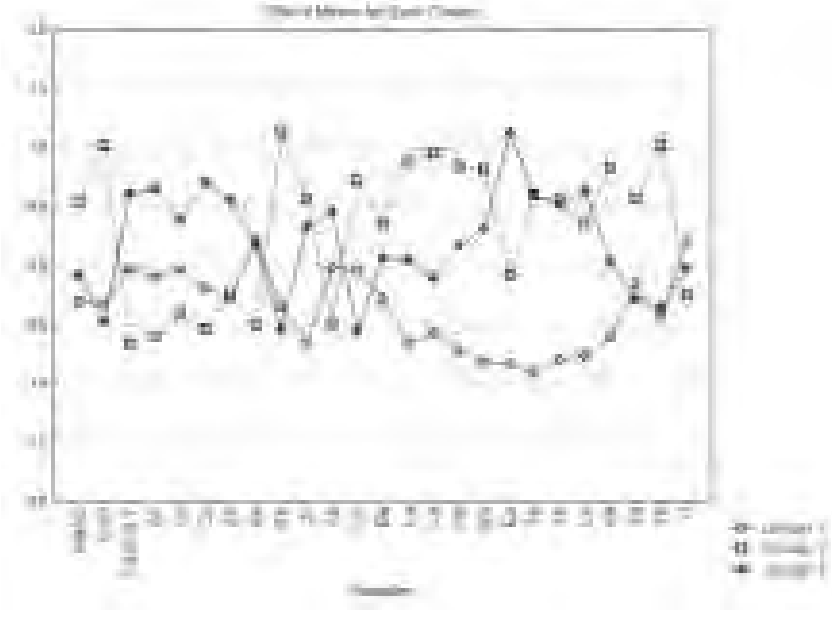

FIG. 4 – K-means clustering of chemical results for F. Pena ceramics.

sent. In the case of bell beakers, specially the "nail printed" ones, which are in general more fine and have less temper, it is more obvious the correlation with dolerites as raw materials. In this later case, which includes mainly bell beakers with a local decoration pattern, a careful production technology occurred, with the use of well selected materials of dolerite origin. There are also ceramics with no specific typology presenting fine textures, but with material of granite origin, also well selected. Besides these cases, most of the ceramics, present in general a more composition variability, explained by a different technological practice in the preparation of pastes, with less care, as they are coarser with less selected temper and with various grain sizes distributions.

Seven outliers were defined corresponding typologically to: one bell beaker imitation of the "international complex" (FP5); two "international complex" bell beakers (FP20, FP38); one undecorated beaker (FP53); one combed incision decorated vessel (FP14), one vessel of chalcolithic tradition (FP21); one Bronze Age morphology recipient (FP57). Chemical composition of these outliers, including different typologies, differs significantly from the local productions, probably corresponding to importations.

Comparing ceramics from the four sites it is important to enhance that, geochemistry and mineralogy allowed the definition of two main groups of local production: 1) related with granites, including most of the samples of CAS, Bronze Age MAL and also Chalcolithic MAL, G2 from FP and QAS; 2) the second group, with lower number of samples, is related with dolerites, comprising mainly FP bell beakers, and a few ceramics from the other sites, with special attention to Chalcolithic from MAL.

5. Final remarks

The results obtained for Fornos de Algodres region during the third millennium BC point to the preferential use of clay materials deriving by weathering of granites for ceramic production, which are the most available raw materials in the region. Clays of weathered dolerites were also used, commonly with the addition of temper of granite origin.

In the Chalcolithic occupation of Malhada and in Fraga da Pena site, besides the use of granites, a more diversified procurement of raw materials occurred, being the case where the exploitation of clays of dolerite origin is more evident, especially for the production of ceramics with thinner pastes, and careful production technologies. This diversification of raw materials is in accordance with geology close to those two sites, where a more concentration of dolerite veins occur.

Even a correlation was found with the two above referred geological materials, a certain chemical heterogeneity is found in ceramics, as well as intermediate composition between them. This can be explained by the nature of regional available raw materials: residual clays derived of different stages of weathering of diverse rock types, and by their mixture in different proportions.

The presence of outliers was registered in all sites; even they were more frequent in Fraga da Pena, where a correspondence with bell beakers is evident, particularly to "international complex" types or its imitation.

Important stylistic differences occur in ceramic tradition through the third millennium BC in Fornos de Algodres region, but no substantial differences were noted in raw materials resource exploitation strategies and technology. Exception must be pointed out to some bell beakers of Fraga da Pena, where a more careful production technology took place.

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