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Research paper

Provenance and circulation of Bell Beakers from Western European societies of the 3rd millennium BC: The contribution of clays and pottery analyses

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ABSTRACT

This work intends to contribute for the discussion of beaker's social role in Western Europe, by studying Central - South Portugal evidences, establishing provenance and therefore pottery transactions between sites and/or regions, emphasizing the circulation /diffusion of this kind of pottery, and their impact on the European societies of the 3rd millennium BC. Ceramics from four relevant Chalcolithic - early Bronze Age archaeological sites of Central and Southern Portugal are studied, based on compositional paste analysis, confronting the bell beakers with other typologies, complemented with local/regional clays characterization. A broader spatial relationship is established, especially with other Iberian sites, and in the European context. Compositional studies were done by instrumental neutron activation analysis (INAA) and X-ray diffraction (XRD). Results for the four sites emphasize that some bell beakers have chemical composition similar to the other typologies, associated with local raw materials close to the archaeological site, pointing to local productions. On the other hand, the outliers identified are mainly comprised of bell beakers, assuming an exogenous nature. Thus, bell beakers are a complex material expression, where local productions are in relation with interregional systems of circulation of ideas and materials.

1. Introduction

Bell Beakers occur all over Europe and North Africa, and depending on the location, they belong to the Final Copper Age, or the Early Bronze Age (Fokkens and Nicolis, 2012; Kristiansen, 2011; Linden, 2004; Salanova, 2004; Turek, 2013). Classical archaeological studies regarding the Bell Beaker phenomenon together with laboratory research has been providing considerable important results (Dias et al., 2002; Hejcman et al., 2013; Lantes-Suárez et al., 2015; Prieto-Martínez et al., 2015) concerning some of the usual foremost questions posed by archaeologists studying this kind of pottery. These questions are related with production technology, raw materials exploitation strategies, provenance and distribution networks, therefore accomplishing a clue to mechanisms of circulation. These mechanisms of circulation are of significant importance, as bell beakers present considerable regional differences in style and context, which combined with the existence of an interregional system of shared ideas and social needs, contributes to a wider reading of the phenomenon.

The problem of the circulation versus provenance is mainly focused in the establishment of local production and importation of pottery. The potter was more tied to the local resources for his production than nowadays, which influenced pottery production and distribution, as it is more likely that the potter would have adapted local resources to answer specific needs, technical, functional, communicational and aesthetic. Being clays the major constituents of a pot, it is fundamental to know clays composition, the leftovers in the clay-making process and the chemical traces of both pots and potential raw materials, which can give a clue to the geographic origin of clay materials. Therefore, to understand the origin of the components or the materials, which make up pottery, chemistry/mineralogy and geology are of great help, achieving in this way the chemical identity and geological-mineralogical identities of the different components of a pot.

The first archaeometric study of Portuguese bell beakers was done in the eighties, with a chemical and mineralogical characterization of sherds from the “pre-beaker” and “beaker” levels of Porto Torrão Chalcolithic settlement located at Ferreira do Alentejo (Beja, South Portugal). Clay materials from the area were also analyzed (Cabral et al., 1988). Later, more southern and also central Portuguese bell beakers, from Fraga da Pena (Fornos de Algodres) (Dias et al., 2005a, 2002, 2000a) and from Monte do Tosco (Mourão) (Dias et al., 2013),

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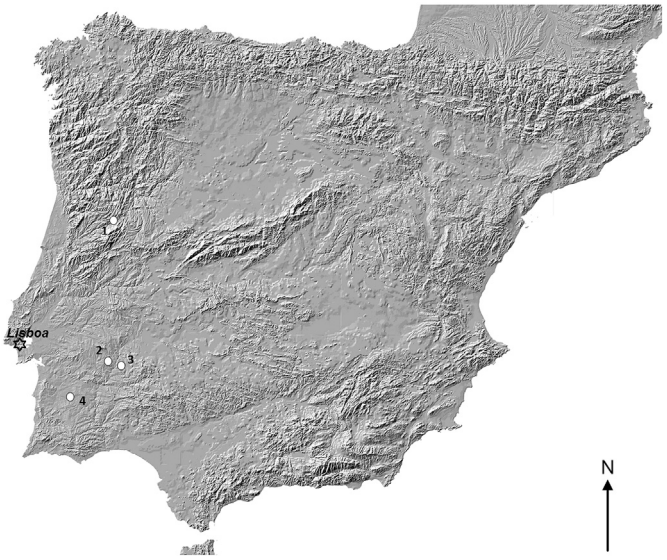

Fig. 1. Location of the "bell beakers archaeological sites" in the Iberian Peninsula. 1. Fraga da Pena; 2. Perdigões; 3. Monte do Tosco; 4. Porto Torrão.

were studied, as well as clay materials from the corresponding areas (Dias, 2013; Dias et al., 2003, 2000b; Marques et al., 2010).

In the last years, the interdisciplinary Portuguese team (C^2TN and Era Arqueologia SA) and the Spanish team from Seville University worked together to better define the Middle Guadiana River Basin Copper Age pottery consumption and distribution patterns (Odriozola et al., 2009a, 2009b, 2008a, 2008b, 2007). In these works, the flow patterns of bell beakers are thought to mirror social dynamics and boundaries throughout the bell beaker production and consumption patterns across landscape. Supported in other evidences as settlement spatial patterning, and spatial distribution of ideological and symbolic related goods.

In this work, we aim to study the ceramic record from four archaeological sites (Fig. 1) of Central (Fraga da Pena) and Southern Portugal (Porto Torrão, Monte do Tosco and Perdigões), adding new evidences based on compositional paste analysis, stressing the bell beakers in relation to the other typologies, thus inferring provenance and circulation issues. In addition, local/regional clays for all those sites will be studied. This approach will allows working with large data sets in order to better define pottery production and consumption patterns in the transition Chalcolithic - early Bronze Age in southwest Iberia and its impact on the societies of the 3rd millennium BC. The methodological approach will include chemical composition by instrumental neutron activation analysis (INAA) and mineralogical composition by X-ray diffraction (XRD) applied to both ceramics and local/regional clays. Petrographic analyses are only applied in some cases that together with XRD will contribute to better define production technology, like firing temperature and admixing raw materials recipe. The combined use of this variety of techniques constitutes a key approach in our understanding of the technology and provenance of the materials examined here. This approach will generate reference pottery compositional groups that can discriminate between locally and non-locally produced groups, in order to establish pottery provenance and therefore pottery transactions between sites and/or regions, with special emphasis in the bell beakers phenomenon, thus contributing to the discussion of the circulation/diffusion of this kind of pottery.

2. Experimental

Two separate pieces ~2 cm^2 in area were removed from the shards (~2 g potsherd) for mineralogical and chemical analyses of the ceramic paste (whole sample) by XRD and INAA. To obtain powder samples of ceramics for XRD and INAA the inner and outer surfaces of the shard were scraped using a drill burr made of tungsten carbide. More details are given in Prudêncio et al., 2006. Clay raw materials and ceramics were grinded in a planetary agate mortar into a fine powder (< 53 mm). Sub-samples were taken for XRD and INAA.

To obtain the chemical data used in the compositional characterization of clay materials and ceramics, chemical analysis was done by means of INAA. Irradiations were done in the core grid of the Portuguese Research Reactor (Sacavém), as neutron source. GSD-9 (sediment) and GSS-1 (soil) of the "Institute of Geophysical and Geochemical Prospecting" (IGGE) were used as reference materials. The reference values were taken from data tabulated by Govindaraju (1994).

All powdered samples were prepared for irradiation by weighing 200–300 mg of powder into cleaned high-density polyethylene vials. Long irradiations (7 h) on specimens were performed on batches of 20 unknowns along with four standards in the core grid of the Portuguese Research Reactor at a thermal flux of 3.96×10^{12} n cm^{-2} s^{-1}; ϕth/ϕepi = 96.8; ϕth/ϕfast = 29.8, obtaining the concentration of the elements: Na, K, Fe, Ca, Sc, Cr, Co, Zn, Ga, As, Br, Rb, Zr, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Hf, Ta, Th and U. Also short irradiations were performed, during 2 min, at a flux of 4.4×10^{12} n cm^{-2} s^{-1} obtaining the concentration of Mn and Dy. Nuclear radiation from activated products was measured by a high-resolution γ -ray spectrometry, which includes detectors made from high purity germanium associated with preamplifiers, amplifiers and multichannel analyzers. More details in Dias and Prudêncio, 2007; Dias et al., 2010; Prudêncio et al., 2009. Relative precision and accuracy are, in general, to within 5%, and occasionally within 10%.

The corrections for the spectral interference from uranium fission products in the determination of barium, rare earths and zirconium were also taken into consideration (Gouveia et al., 1987; Martinho et al., 1991).

The concentrations of trace and major elements were used as variables for a multivariate statistical study and for a detailed analysis of the element distributions, including elements not very susceptible to mobilizing processes (Trindade et al., 2011). This problem must have special attention, as it can occur not only during the ceramics manufacture processes, but also during its use and burial (post-depositional processes) (Golitko et al., 2012). Multivariate statistical methods were employed by using the Statistica program (Dell Inc., 2016), like the joining tree-clustering method, by using the absolute concentration of the chemical elements as variables, with diverse amalgamation methods and similarity/correlation coefficients. The abundance of data obtained by the chemical characterization and thus the high amount of variables and cases studied in the current work needs the use of combined data analysis and statistical methods. It is commonly a challenge to examine and interpret the significance of many elements, in terms of processes, and even more difficult to observe or understand the relationships between a large group of elements. The application of multivariate data analysis and statistical techniques combined with elemental ratios, provide support for data interpretation and subsequent archaeological interpretations. Exploratory multi-variate methods include: plots of all relevant pairs of data, assessment of the individual distributions, adjusting for missing data, detecting atypical observations, computing robust means, correlations, principal components analysis, cluster analyses, etc., specially aiming to identify geological processes, and so geochemical signatures for clays and ceramics.

The mineralogical composition of both whole samples and clay-sized fractions (< 2 μm) was obtained by XRD using a Philips diffractometer, Pro Analytical, with Cu Kα radiation at 45 kV and 40 mA. Spectra were gathered in the case of the whole sample at a step size of 1° 2θ/min from 3° to 70° 2θ and in the case of the < 2 μm fraction at a step size of 1° 2θ/min from 3° to 35° 2θ. For the whole rock sample preparation, samples were powdered in an agate mortar; the powder was then side loaded into a glass sample holder to obtain randomly