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Smelting and recycling evidences from the Late Bronze Age habitat site of Baiões (Viseu, Portugal)

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ABSTRACT

Many aspects of bronze production during Late Bronze Age in Western Europe are so far unknown. In the present study selected artefact fragments and metallurgical debris, which include a slag fragment, from the emblematic Late Bronze Age habitat site of Castro da Senhora da Guia de Baiões (Viseu, Portugal) have been studied by optical microscopy, micro-EDXRF, SEM–EDS and XRD. Evidences were found for bronze production involving smelting and recycling. Compositional analysis showed that the artefacts are made of a bronze with 13 ± 3 wt.% Sn (average and one standard deviation) and a low impurity pattern, namely <0.1 wt.% Pb, being comparable with the composition of other bronzes from the same region (the Central Portuguese Beiras). This alloy is generally different from elsewhere Atlantic and Mediterranean bronzes, which show frequently slightly lower Sn contents and higher impurity patterns, namely Pb which is often present as an alloying element. The present study gives further support to early proposals suggesting the exploration of the Western Iberian tin resources during Late Bronze Age, and besides that, it indicates that metalworking and smelting could have been a commonplace activity requiring no specific facilities, being bronze produced at a domestic scale in this Western extreme of Europe.

1. Introduction

During Late Bronze Age (LBA) the circulation and consumption of bronze increased, as evidenced by the numerous metal artefacts and deposits found all over Europe (Huth, 2000). This period is also characterized by the full adoption of bronze in many regions, namely in the Iberian Peninsula, as well as a significant diversification in artefacts typologies (Melo, 2000).

Although the high number of metal artefacts dating to LBA all over Europe, many aspects of prehistoric technologies for Cu–Sn production are so far unknown. Three hypotheses for bronze production have been proposed in literature (Coghan, 1975; Rovira, 2007): (1) smelting ores of tin and copper together, in a co-smelting operation; (2) adding one of the metals to the other still as ore, in a partial smelting operation; (3) smelting the ores separately and then alloying the metals in a melting operation.

Slags are a crucial evidence for the study of the technology involved in bronze production. Nevertheless, these are very scarce in Western European contexts, namely in the so called Atlantic areas (Craddock, 2007; Faoláin, 2004; Pendleton, 1999). Most of the latest works on the topic are based on some copper–tin slags that have been found in a number of settlements in the Iberian Peninsula, particularly in the Spanish territory, having the earliest ones been found in north-eastern regions, and later ones (dating to LBA and Early Iron Age) all over the Spanish territory (Gómez Ramos, 1999; Rovira, 2007). Studies on these slags and associated metallurgical debris (e.g. reduction vessels) has conducted to the proposal that bronze was initially obtained by co-smelting (option 1), a technique that was still in use during LBA and Early Iron Age in many settlements. They also showed some possible evidences of smelting cassiterite (tin oxide, as it appears in nature) with metallic copper (option 2) during the transition from LBA to EIA, being the earliest evidences of copper and tin alloying (option 3) dated to

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VIII–VII century B.C., probably as a result of Mediterranean contacts (Rovira, 2002).

In the Iberian Peninsula, the adoption of bronze did not seem to change the extractive technology; bronze was obtained in a similar way as was previously done in Chalcolithic times for copper, with a direct smelting of ores in reducing vessels (Gómez Ramos, 1999). Such primitive smelting process involved a very simple infrastructure, as those composed by a small pit excavated in the soil where a vessel containing the ores was placed, with charcoal, being heated from above. The resulting smelt was completely fragmented to recover the metallic lumps and prills (also called smelting droplets) (Hauptmann, 2007) leaving scarce evidences (e.g. slags) in the archaeological record.

Significant changes in extractive metallurgy in the Iberian Peninsula just happened at the beginning of Iron Age in those regions better connected with the Eastern Mediterranean (frequently called the Orientalising period) as has been indicated by the content of iron in copper-based metals which increased to values >0.05 wt.% (iron is most dependent on the smelting process and primitive relatively mild reducing conditions prevented iron minerals to be reduced to metal) (Craddock and Meeks, 1987).

The employ of a primitive and simple method for smelting for such a long period of time in the Iberian Peninsula (about 3 millennia) has been related to its adequacy to the kind of minerals being worked – rich minerals, such as copper carbonates, achieving acceptable efficient rates of metal recovery – and to the social adequacy – serving the metal requirements of the immediate local community (Rovira, 2002).

A different reality existed in most Eastern regions, as in Central and Alpine regions of Europe, Eastern Mediterranean and Middle East, that experienced important developments in technological knowledge and skills between Chalcolithic and LBA, i.e. a transition from simple primitive, crucible based, small scale domestic production to mass production involving slag heaps and complex furnaces, the existence of large smelting sites distributing ingots, sites specialized in producing copper and sites specialized in producing tin (Adriaens et al., 1999; Burger et al., 2007; Rothenberg, 1985).

These differences may rely mostly in the Iberian Peninsula (and generally Western Europe) social landscape, which was very different from the one in the Eastern Mediterranean, which saw the development of early states which controlled large territories and populations (Whittaker, 2008).

In the Iberian Peninsula almost all the recently excavated habitat sites, including some of very small size, from Chalcolithic in most southern regions to LBA sites in Northwest regions record metallurgical activities (Bettencourt, 2000; Rovira, 2002; Senna-Martinez and Pedro, 2000a; Vilaça, 2004). This reality indicates disseminated metallurgical knowledge since early times, and substantiates absence of any monopoly controlling production. It also suggests regular supply of ores and metals for a long period of time, probably a reflection of the exploration of the Iberian minerals.

The Iberian Peninsula is very rich in both copper and tin ores, having one of the major tin deposits of the European Old World. The geographical distribution of the copper and tin deposits is different, with a general dispersion of the former ones and a concentration of the latter ones mainly in the northwestern region. During the last quarter of the second millennium B.C., with the advent of full adoption of bronze and the increase in metallic artefacts production, the Central Portuguese Beiras witnessed an emergence of many sites, most of them with vestiges of metallurgical activities. This emergence has been suggested to be related to the control and exploitation of gold and cassiterite (Senna-Martinez and Pedro, 2000a), the latest an essential ore for bronze fabrication. The collapse of most of those sites in the middle of the 1st millennium B.C. (Vilaça, 1995a) has been explained as a possible result of the rupture on metal circulation, which happened with the crisis of the Phoenician settlements in Iberian coastal areas (Senna-Martinez, 1998).

The development of local elites during the LBA has been linked to the role of metallurgy in producing status enhancing artefacts (archaeologically expressed by the higher number of metallic artefact productions, their more complex shapes as well as and new techniques of production). So an easy access to the minerals must have been seen as an advantage, and can also be taken into account in the positioning of some emerging sites (Senna-Martinez, 1996; Vilaça, 1995b).

While the exploitation of Iberian copper resources seems to be widely accepted, the exploitation of the local tin resources is more discussed, and rather difficult to prove due to the scarcity of evidence. Old mines can be difficult to find due to posterior mining works and due to the possibility that most of the tin explorations would occur in alluvial placers. Nevertheless, in the Central Portuguese Beiras – a region with abundant tin and gold resources (Garcia, 1963) – during the reopening of the ancient gallery of the S. Martinho mine (Orgens, Viseu), during the World War Two, a bronze dagger of "Porto de Mós" type was found at the bottom of the rubble which filled its shaft, proving its original opening and posterior infilling during the Late Bronze Age, probably for cassiterite exploration (Correia et al., 1979). Other Iberian evidences of tin exploration come from the Spanish area of Cáceres, from the LBA settlement of Cerro de Logrosan (Caceres, Spain) (Merideth, 1998; Rovira, 2002).

An LBA Iberian production of bronze, based on the exploitation of the local ores and independent of the most Atlantic and Mediterranean areas has been previously suggested based on the composition of many Iberian bronzes. While comparing the composition of bronzes from the Ria de Huelva LBA hoard with contemporaneous bronzes from external peninsular regions, Rovira and Gómez-Ramos (1998) have stressed the low impurity pattern (namely of Pb) and the slightly higher Sn content that seem to differentiate the Huelva bronzes from other bronzes in Atlantic and Eastern Mediterranean areas (Fig. 1). Analysis of bronzes from various emerging sites in the Central Portuguese Beiras has also showed compositions similar to the Ria de Huelva hoard, mostly ~8–15 wt.% Sn and <1 wt.% Pb (Figueiredo et al., in press; Valério et al., 2007; Vilaça, 1997). If these bronzes were made just by recycling imported bronzes, lower contents in tin were to be expected since tin is lost preferentially to copper after remelting (Rovira and Montero, 2003).

In the present work we will discuss the analytical results of a study made on selected items – that include a slag fragment – recovered at the Castro de Nossa Senhora da Guia de Baiões LBA archaeological site, situated in the Central Portuguese Beiras.

2. Baiões site and its artefact collection

The Castro de Nossa Senhora da Guia de Baiões (CSG) site is placed on a granitic hilltop in the county of S. Pedro do Sul, Viseu, in central Portugal, part of a series of residual reliefs which dominate the Vouga river valley (Fig. 2A and B). In modern times, a sanctuary (Senhora da Guia Sanctuary) has been constructed which provoked the destruction of most of the archaeological site (Fig. 2C).

The site has a great domain over the involving landscape and controls the old road going west through the passes of the Gralheira massif, alongside the northern margin of the Vouga river that was navigable just some 20 km ahead (until middle of XIX century), allowing a good access to the Atlantic waters (Fig. 2B). Its