

# **ARCHAEOMETALURGICAL ANALYSIS AND ARCHAEOLOGICAL CONTEXTUALIZATION OF A BRONZE SPEARHEAD FROM GRALHEIRA (MURO MOUNTAIN RANGE, BALTAR, PAREDES, NORTH PORTUGAL)**

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## **RESUMO**

Este trabalho visa dar a conhecer o contexto de achado e a composição química de uma ponta de lança de alvado curto e de folha ligeiramente losângica com nervura central, inserível no Bronze Final e inédita.

Esta foi encontrada na serra do Muro, freguesia de Baltar, concelho de Paredes, distrito do Porto. A serra do Muro corresponde a um monte com uma implantação orográfica dominante na região sobre os vales dos rios Ferreira e Sousa, este afluente da margem norte da bacia do Douro, em área rica em recursos primários e secundários de estanho. No topo deste acidente geomorfológico foi edificado um povoado proto-histórico que figura na literatura arqueológica especialmente pelo grande perímetro e espessura das suas muralhas pétreas. Apesar da proximidade

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dade destes dois contextos arqueológicos não há qualquer indicação precisa de que estejam vinculados, podendo esta peça constituir um depósito.

Não sendo muito frequente o achado de pontas de lança no NO português, conhecem-se todavia alguns contextos, todos eles correspondentes a depósitos. É o caso da ponta de lança de Badim, de morfologia similar, que apareceu enterrada na base do monte cónico de Nossa Senhora da Graça, em Monção, e desvinculada do castro aí existente, localizado, aliás, em vertente oposta. Outros achados similares associados a montes são os do Outeiro do Rego, em Lama Chã, Montalegre, e o da Quinta do Telhado, no Monte da Penha, em Guimarães, ambos associados a afloramentos.

Apesar das diversas pontas de lança conhecidas no NW português, apenas as duas de Vale Travesso, em Montalegre, foram alvo de análise de composição química (BOTTAINI 2012: 49-52), pelo que os resultados das análises arqueometalúrgicas obtidas por espectrometria de fluorescência de raios X da ponta de lança do Muro, contribuirão, certamente, para o conhecimento da metalurgia do Bronze Final do NO.

**Palavras-chave:** NO. de Portugal; Bronze Final; Ponta de lança; Contexto; Composição química.

## 1. THE FIND AND ITS CONTEXT

The artifact was found at the bottom of the eastern slope of the Muro mountain range, in a fallow field known as Loto or Veloto, in Gralheira, Baltar parish, Paredes municipality, Porto district. The approximate geographical coordinates in degrees, minutes and seconds, in the WGS84 system are: 41° 11'59.65"N; 8° 22'49.65"O. WGS84, at an altitude of c. 350 m (see Figs. 1 and 2).

The location of the find constitutes an open platform, of easy access, overlooking the Baltar stream, which flows into the River Sousa, a tributary on the right bank of the Douro. It also corres-

ponds to the “entrance” of the single natural passage between the valleys of the rivers Sousa and Ferreira, both located north and south of the Muro mountain range, respectively (Figs. 1 and 2). According to the Geological Map of Portugal, scale 1:50.000, 9-D (Penafiel), the area is dominated by porphyroid coarse-grained granites with two-micas, but essentially biotites, commonly found at the surface. They occur in veins of aplite-pegmatites (MEDEIROS *et al.*, 1980). The municipality of Paredes is rich in primary and secondary mineral resources, including tin, gold and silver, although these are not known in the vicinity of the find spot. These are found only at

2 km northwest of the Muro mountain range, in the tin mines of Rebordosa, and at 5 km to the south, in the gold and silver mines of “Covas de Castromil” (DGE; COUTO 1993: fig. 3).

There is no evidence about other archaeological sites ascribed to the Bronze Age in the limit of this parish. The only settlement that has been identified to date is the Muro de Vandoma hillfort, at the top of the Muro mountain range, whose specific occupations are poorly known (AZEVEDO 1898: 194, SILVA 1986: 85, SILVA 2000: 100). It has been classified as a Monument of Public Interest<sup>6</sup>. The settlement was acknowledged in the archaeological literature due to the large perimeter and thickness of its stone walls (SILVA 1963, 1966), together with some other particular features. Despite the proximity of the two archaeological contexts, the settlement and the find spot of the spearhead (which occurred at about 250 m to the east of the hillfort walls), there is no clear indication that both are connected, therefore, the spearhead possibly constitutes a deliberate deposition. The artefact was found in a property owned by José Vicente da Silva, during the opening of an access road to his thickets, in the late 1950s, however the circumstances of discovery are unknown.

## 2. DESCRIPTION OF THE OBJECT

The artifact under study constitutes a short socketed spearhead with a central midrib, present on both sides. With an almost conical section, it is solid between 11.9 cm and 13.7 cm, from which seems to be again hollow. The base has two circular holes, both symmetrical and aligned with the edges, designed to secure the spearhead, and the leaf is of slightly losangic shape. It has been partially broken at the tip and in the socket, therefore it's not possible to know its exact length. It currently measures, 14.5 cm in height, 3.6 cm of maximum width of the leaf and 2.5 cm of maximum width of the socket. The maximum thickness in the socket is 0.3 cm, and at the tip (broken) is 0.6 cm. Weights 82.5687 gr (Figs. 3 and 4).

It presents a greenish patina resulting of the actual state of corrosion, however it has been recently undergoing chemical stabilization, including a volumetric and chromatic reintegration process with a pigmented epoxy resin. It is curated by the family of the heirs of Mr. José Vicente da Silva<sup>7</sup>, in Gralheira, Baltar, Paredes.

<sup>6</sup> Dec. nº 45/93. *Diário da República*. I Série. 280 (30-11-1993): 6698-6701.

<sup>7</sup> Presently it is in the possession of Mr. Engineer Manuel Cunha.



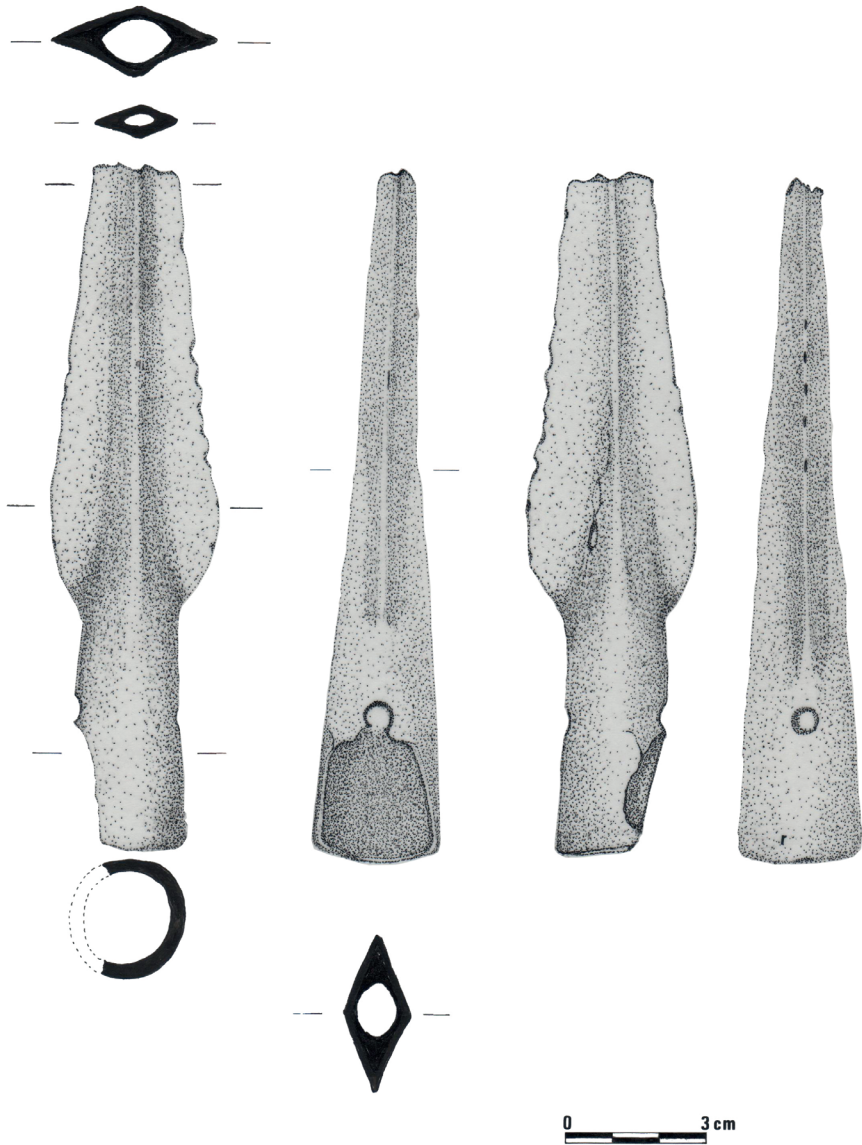
**Fig. 1:** Approximate location of the find in the Military Map of Portugal, esc. 1:25.000, pgs. 111 and 123 (IGE-1998-99).



**Fig. 2:** Approximate area of the find spot in an orthophotomap (ETRS89-EN-TM06. CM Paredes).



**Fig. 3:** Galheira spearhead. Front and side views (Photos by M. A. Silva).



**Fig. 4:** Gralheira spearhead. (Drawing by Maria Antonia Silva).

### 3. CHEMICAL COMPOSITION AND MICROSTRUCTURE

The determination of the chemical composition was made through quantitative archaeometalurgical analysis obtained by X-ray fluorescence spectrometry, in the Chemical Analysis Laboratory of TecMinho (Department of Mechanical Engineering, Minho University, Guimaraes) and through metallographic examination in a scanning electron microscope, in the CEMUP, Materials Center at Porto University.

The sample, about 1x1 mm, was removed with a mechanical saw, at the distal end of the spear. The chemical analysis focused on the cutting surface, using a suitable analytical program for copper alloys, and calibrated by a set of certified reference materials. For the purpose of observation by scanning electron microscopy, the cutting section was mounted in epoxy resin, followed by polishing of the silicon carbide with sandpaper, and finally in diamond suspension grain of 1 mm.

As can be seen in Table 1, the results showed that the artefact was made in a binary copper alloy with 88.71% copper and 8.6% tin, being this a typical composition of the alloys used for the manufacture of metal objects (SCOTT 1991). The analysis of the metallographic

structure of the alloy through a scanning electron microscope focused on the inner zone of the fragment, in order to avoid the surface corrosion layer, allowing for the identification of the following elements, as illustrated in Figures 5 and 6:

Z1 - *Cu* with 6.9% *Sn*;

Z2 -  $Cu_2O$ ;

Z3 - *Cu* "pure";

Z4 - *Cu* with 30% *Sn* and

Z5 -  $Cu_2S$

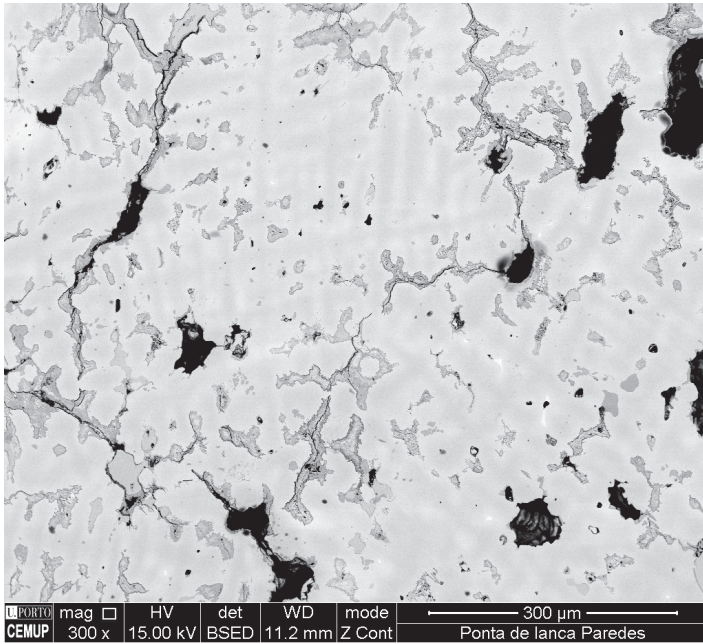
The results of this analysis allowed to consider that the spearhead corresponds to a bronze of biphasic type ( $\alpha + \delta$ ), with a predominance of  $\alpha$  phase. Given the tin content at this stage, it seems to us that the cooling after solidification was processed at high speed, derived, for example, of air cooling.

There have been recognized the division in zones of the internal phase, which is normal in these materials (SCOTT 1991). It is also evident the presence of internal oxidized zones, and of a smaller amount of sulphides. The presence of almost pure copper (Z3 zone), even if occurring in a rare form, it seems abnormal to us, although possibly motivated by an incomplete dissolution between the two metals *Cu* and *Sn*.

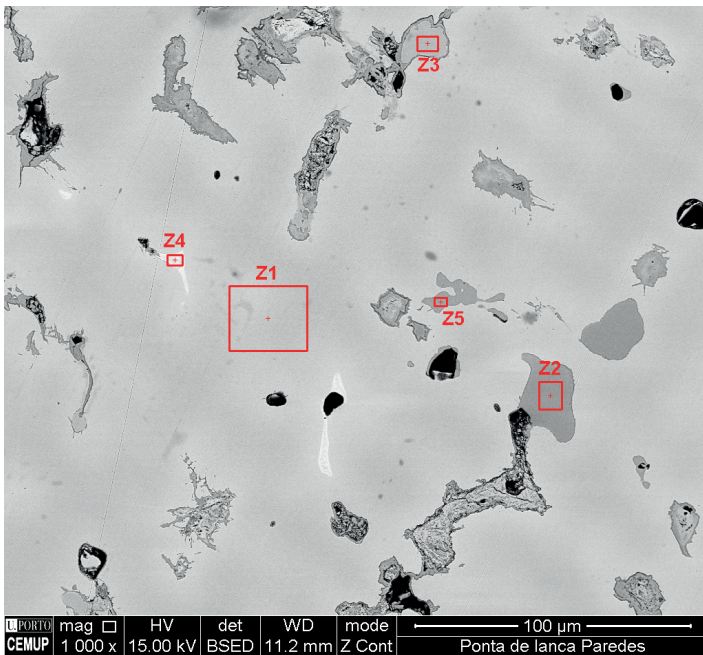
**Table 1 - Composition of the alloy**

Sample N.º	<i>Cu</i>	<i>Sn</i>	<i>Pb</i>	<i>Al</i>	<i>Fe</i>	<i>P</i>	<i>S</i>	<i>SI</i>
LAQ 2015/80	88,7	8,6	-	1,31	0,13	0,10	0,35	0,80

values in % weight



**Fig. 5:** Examination in a scanning electron microscope.  
General appearance of the sample.



**Fig. 6:** Detail of the metallographic structure of the alloy.



#### 4. FINAL CONSIDERATIONS

The spearheads attributed to the Later Bronze Age, similar to the one subject of study, are not very frequent in the Northwest of Portugal. However a few contexts are known, corresponding to hoards or isolated finds, interestingly, all of them associated with mountains.

In the first case we have the spearhead of Badim, of similar morphology, which was buried at the base of the conical hill of Nossa Senhora da Graça in Monção (MARQUES 1984) and disconnected with the proto-historic settlement existing there, located, in fact, at the opposite side of the hill (Marques 1987). Similar finds associated with hills and mountains are Outeiro do Rego, in Lama Chã, Montalegre<sup>8</sup>, Quinta do Telhado, in Monte da Penha, Guimarães (SAMPAIO 2014), both associated with rocky outcrops, and Chão de Meses, in Barcelos, on the northwest slope of the Arefe Mountain<sup>9</sup>.

Even though we know several spearheads in the Portuguese NW, only the two found at Vale Travesso, in Montalegre, were the subject of analysis of their chemical composition (BOTTAINI 2012: 49-52). These correspond to binary copper alloys, with *Cu* percentages between  $84.2 \pm 0.9$  and  $90 \pm 1$ ,

which are closer to the results obtained by the Muro's artefact.

If we take into account the results of the archaeometalurgical analysis of the spearhead of Gralheira, this once again proves that the metallurgy of the Later Bronze Age of the Northwest of Portugal is essentially binary, and well made, which is in line with what is known for the metallurgy of this period in the North of the country (VILAÇA 1997; BETTENCOURT 1998; BOTTAINI 2012).

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<sup>8</sup> Information resulting from the fieldwork carried out during ongoing doctoral research of one of us (A.M.B.), entitled *Bronze Age Hoards of the Western Atlantic facade of Iberia between the Vouga and Ulla Rivers: Contexts and Interpretations*.

<sup>9</sup> *Idem*.

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