METALLURGICAL CONTROL AND SOCIAL POWER. THE BRONZE AGE COMMUNITIES OF HIGH GUADALQUIVIR (SPAIN)

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ABSTRACT

This research project is centered on the archaeometallurgic process that was developed by Bronze Age communities in the High Guadalquivir (Spain). Copper, bronze and silver mining and metallurgic transformations constitute one of the bases of the historic development of these communities. Such activity implies the use of more complex technologies and the control of the distribution of these new products by the aristocratic groups.

The fieldwork carried out in the site of Peñalosa (Baños de la Encina, province of Jaen, Spain) has produced a great deal of archaeological remains showing the complexity of the metallurgical process in Recent Prehistory. Excavations at Peñalosa have allowed us to carry out archaeometallurgical research in relation to:

1. The sequence of metallurgical activity.
2. The ascription of this activity and its different phases to different village areas.
3. Use of different stone raw materials to create the necessary tools for the metallurgical process and different minerals (malachite, azurite, galena, etc.) to be fused.
4. General access to metallurgical processes (found in all the dwellings) and their products (present in a great number of tombs, especially in relation to daggers and swords).
5. Differences in the size of the weapons located in the different tombs.
6. Restricted access to non-copper minerals and, overall, to items made with precious metals.

KEY WORDS

Bronze Age, High Guadalquivir, Archaeometallurgical, Mining, Social Hierarchization

INTRODUCTION AND GOALS

This study is part of two Research Projects: *Archeometallurgical Project: Bronze Age Communities of the High Guadalquivir* (BHA2000-1512), funded by the Ministry of Science and Technology, and the *Peñalosa Project*, funded by the Ministry of Culture of the Autonomous Community of Andalusia. The data were obtained from the excavation of the last stratigraphical phases (1800-1500 cal BC) of the Peñalosa site (Baños de la Encina, Jaén) (Contreras & Cámara, 2002). The goals are:

1. To determine how the communities of the mining areas of the High Guadalquivir functioned and evolved during the second millennium B.C., by analyzing economic production and its dominant sector, metallurgical production.

2. To evaluate some proposed hypotheses on the evolution of prehistoric societies based upon three aspects: metallurgy as support and justification for social hierarchization, the role of contacts in social change and the ideological factor in the development of social inequality.

Fig. 1. Peñalosa site

In this study, we are concerned only with the metallurgical factor as a driving force behind social change.

METHODOLOGY

The first step was macroscopic description and determination, using a binocular magnifying glass, of all the elements related to metallurgical activity. Based upon this analysis, we selected samples for microscopic study.

The next step was the application of a series of analyses according to the different remains involved in each of the metallurgical phases, such as XRF, AAS, SEM and lead isotope testing.

PRELIMINARY ANALYTICAL RESULTS

Peñalosa, on the eastern edge of Sierra Morena (Andalusia), lies in the middle of a broad territory with numerous polymetallic sites. Its most common mineralizations are lead, argentiferous lead and copper, with the site's greatest concentration being of copper in the form of sulfides, especially easily exploitable pyrites and carbonates. Archaeological survey has shown a strong concentration of settlements with metallurgical activity across a wide belt running in a longitudinal direction along the Rumblar river (Contreras & Cámara, 2002).

The minerals exploited were mainly oxides (cuprite, tenorite) and copper sulfides (chalcopyrite) in complex paragenesis with other sulfides, in the case of pyrite, or with galena. As detailed below, in Peñalosa archaeometallurgical samples have been gathered that represent each of the phases of the metallurgical process, from extraction of the mineral to the final manufactured product, passing through roasting and reducing (depending on the material being treated) and smelting.

In the area of the settlement, cupriferous minerals generally appear in very small fragments, at times grouped together in relatively abundant quantities and having similar size. Minerals have also been found in the process of transformation, where a heat source was used to ready them for the fusion process.

It is difficult at this time to explain the abundant presence of lead (galena), both in and near the domestic areas, both because of the characteristics of the remains analyzed and because we have little evidence regarding their use and, further, they have not yet been sufficiently studied. This is the case with the crucible fragments with interior pieces of slag of a whitish color. However, it would be strange to have such a quantity of stored galena if it were not used for metallurgical tasks. There are remains of galena with the green coloring corresponding to their cupriferous content, although we do not know what was gained from these associations. We do know that there are plenty of lead seams with important quantities of copper in the region we are studying. In light of the existence of objects made of silver, it is conceivable to think that the galena was used to extract silver, but there are no clear indications that the Peñalosa metallurgists were familiar with the process of cupelation. It may be that the galena was used to smelt the copper (Moreno, 2000).

Fig. 2. Galena storage room

Four types of <u>slag</u> were recovered from the site:

1.- Slags of a globular shape, brilliant black or flat dark gray, with metallic copper inclusions. There are secondary products made of copper in their interior.
2.- Tree-shaped slags, not as compact as those above, black in color, with cavities ranging from elongated to elliptic and numerous gases, with a large number of impurities (grains of quartz and other minerals, small pieces of carbon, remains of sediment and some green remains, the product of the oxidization of the copper). They are lighter than those in the first group and there are residual remains of smelting inside. In some cases, they have dark brown inclusions possibly due to their iron content.
3.- Tree-shaped slags, whitish-yellowish, not very heavy and with few inclusions of other mineral compounds. Their shape tends to be fluid with a fair number of sponge-type cavities. This type has not yet been analyzed.
4.- Slags found on the interior wall of a few fragments of flat crucibles that are off-white, compact and globular. Their points of breakage have a bright dark gray color.

The analytical results of the study of the slags indicate that the majority belong to the smelting process. It is likely that the reduction was performed away from the domestic area of the settlement, which is why hardly any slags related to this first step in the process have appeared. Most of the slags analyzed are the result of the treatment of both sulfides (chalcopyrite, chalcosine) and copper carbonates (malachite) and oxides (cuprite and tenorite).

With the carbonates, a roasting temperature of 600-700 EC transforms malachite into copper oxide, releasing CO_2, while if copper oxides are used, the temperature must be higher, around 900 EC. Here, reduction to metallic copper is produced because of the presence of carbon monoxide (created in the combustion of the carbon added in a low oxygen environment).

The metallurgy of iron sulfides consists of roasting the ores in a highly oxygenated environment to eliminate the sulfur, which gives rise to the formation of copper oxide with an abundant release of sulfurous anhydrate. The temperature in the first stage must be relatively low, around 600 EC so that the copper oxide that is formed will later react with more copper sulfur to create metallic copper with the release of sulfurous anhydrate. During the reduction of the oxide, the temperature in the oven must be 900 EC or slightly higher. The entire process would produce a low yield, with part of the copper being lost in the matte, particularly in the case of using complex ores with arsenic and antimony, so that the copper standard in this *copper mattes* was usually rather high although it was not always recovered.

Finally, we must bear in mind that the arsenic detected in some of the mineral samples is consistent with the production of arsenical copper, although more data is needed to support this relationship scientifically. Production of this type during the Chalcolithic has been widely debated, rejecting or accepting it based on the differential presence of arsenic in the instruments produced, although this should imply more than the addition of arsenic in itself, the choice of copper minerals rich in arsenic, or perhaps, their being alloyed with other metals in the same smelting (Moreno, 1993).

The ceramic elements present in the metallurgical process at Peñalosa have been typologically divided into four morphometric groups: flat crucibles, deep crucibles (vessel ovens), moulds and circular pieces. To these we must add possible fragments of oven wall and some pieces that can be considered nozzles. The first three typological groups have been sampled and examined with a binocular magnifying glass to obtain a reliable characterization of them.

Fig. 3. Sherds of a vessel oven

The analysis of the slag from one of the flat crucibles indicates the presence of arsenic and copper, which implies their use in the smelting of arsenical copper just as we have documented with some of the metallic pieces analyzed. Generally, they are highly vitrified ceramics with wide pores that have borne high temperatures, above 1100 EC.

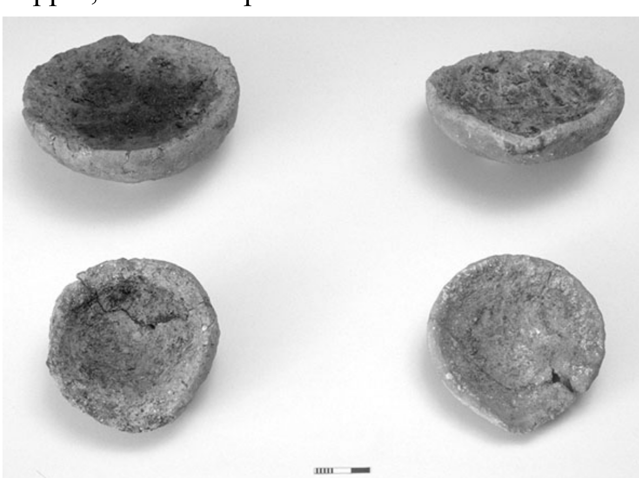

Fig. 4. Flat crucibles

Some flat crucibles have compact, off-white internal slags that sometimes contain some copper inclusion. Until we have the analytical series, it does not seem hasty to indicate that these are crucibles that contain lead as a principal component.

Inside the deep crucibles, there are residual remains of vitrification with an irregular whitish-yellowish-greenish color on the surface, and there is practically none conserving any real metallic slag. This suggests for now the possibility of the crucibles having been coated with a type of insulation to make it easier to loosen the resulting slag mass. They were fired from inside (vessel ovens). Another peculiarity with this type of fragment is that they show remains of the slag on the fracture even when the interior part has none. This suggests that they are broken immediately upon finishing the process.

The qualitative analysis carried out on a sample from the bottom of a deep crucible with a relatively abundant layer of slag reveals some ample copper and arsenic contents and a lesser quantity of tin and lead on the inner surface near the bottom of the crucible. The sample is overall very heterogeneous, but the data from the analysis may indicate that this crucible was used to smelt true bronze (with tin), although new analyses must be performed.

The archaeological register shows many ceramic moulds. They have a trapezoidal form, flat bottom and straight walls and trapezoidal ingots were obtained from them. They are dark brown in color and have remains of an off-white, grayish color on their inner surface, a type of smoking. This would be a substance applied to make it easier to extract the ingots.

Fig. 5. Ceramic ingot moulds

Fig. 6. Sandstone moulds

The stone chosen for the manufacture of the moulds in the Peñalosa register is generally sandstone. Found in the area around the settlement, it is easily worked and makes it possible to obtain smooth and homogenous surfaces. The surfaces are reddish in color. Although the majority of the moulds are univalve, it is likely that bivalve moulds existed. In one case, a two-hoop mould, it is possible to see that there were feeding canals or grooves to stabilize tapping and to release the gasses.

Regarding the implements, we have found punch tools and awls, chisels, daggers, arrowheads and ingots in domestic contexts, while weapons and adornments are almost exclusively found in funerary contexts. Two of the ingots were analyzed based upon with their composition in lead isotopes and they display what seems likely to be a different geographical origin. One of them had a lead isotope composition unique among the mineral ores and artifacts in the samples that have been analyzed in the Iberian Peninsula to this point. The other, on the other hand, had a lead isotope composition that is characteristic of the ores of southwestern Spain, included in the same orographic unit as Peñalosa (Sierra Morena) but very distant, although none shows the same combination (Moreno, 2000).

In Tomb 7 four silver bracelets have appeared along with a dagger with two rivets and a punch tool. The AAS analysis of one of the bracelets shows a high silver content and small indications of copper and lead, but no tin.

The only gold object is an earring from a funerary offering, associated with a child. It is very small and is made of a string of gold with a semicircular section, with overlapping ends.

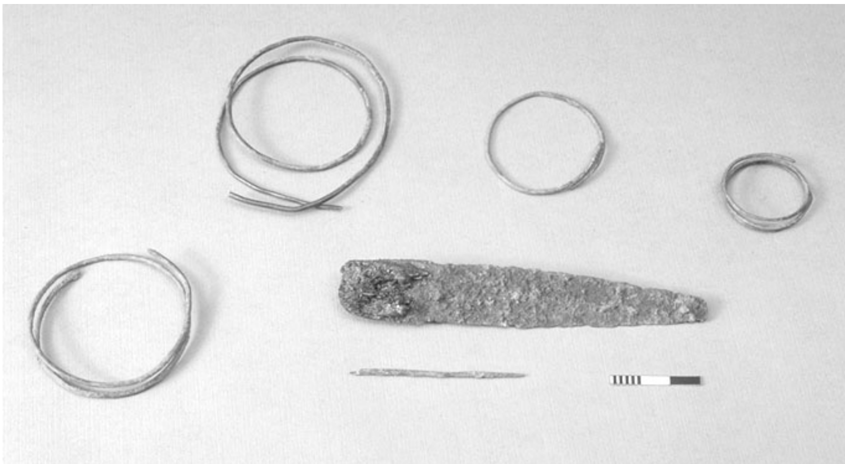

Fig. 7. Metallic grave goods from tomb 7

There is an important contradiction between the high number of axe moulds and the absence of axes in domestic and funerary contexts. In the first case, it can be argued that the inhabitants of the settlement took the axes with them when they abandoned the settlement. But this does not solve the problem of their absence in the tombs. Perhaps they were distributed among other settlements or swords were used as substitutes in the offerings of high prestige.

In any case, the preliminary results of the analysis of the pieces indicates that the majority of the artifacts analyzed were made of arsenical copper, typologically and technologically characteristic of the Full Bronze Age. The arsenic content of these alloys is generally between 3-4%, sufficient to produce a more durable alloy than pure copper if the metal was worked correctly. One of the dagger blades had a significantly higher quantity of arsenic than its associated rivet, which the analytical results of similar pieces has established as normal (Harrison & Craddock, 1981). This tends to show that the metallurgists knew how to recognize alloys of different degrees of hardness and used the harder metal to make the blade. However, and contrary to this, the rivet analyzed from another arsenical copper dagger showed higher quantities of arsenic than its corresponding blade.

Fig. 8. Swords and daggers

Generally speaking, the contents of trace elements of arsenical copper are low, which is also common in other metallurgical analyses of the Bronze Age in the Iberian Peninsula (Hook *et al*., 1990). This, combined with the low iron content, could indicate that at this site the process of reduction was not very complex and was carried out using relatively low temperatures and with little production of slag.

SPACIAL RESULTS

The distribution of archaeometallurgical materials in the Peñalosa settlement indicates that metallurgy is present in almost all of the spaces, although the proportion varies widely, with most of the items, except implements, concentrated in or near open spaces. These open spaces either form authentic workshops or are small open patios in the interiors of the dwellings.

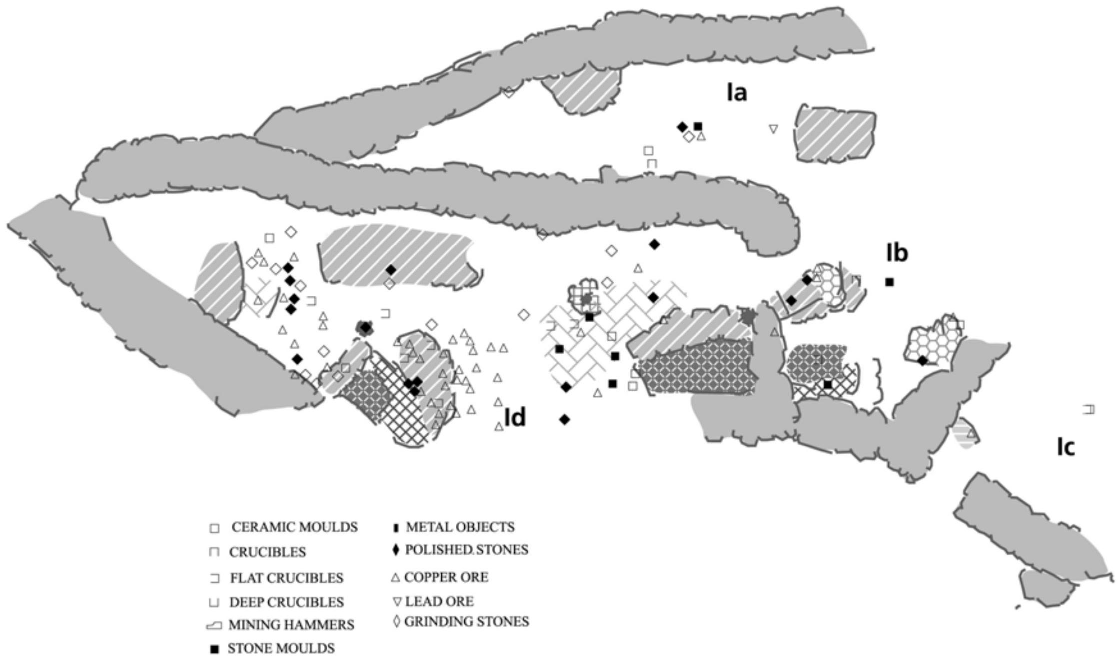

Fig. 9. Archaeometallurgical items from the Structural Group I

It is in these spaces that the activities of smelting/refinement took place, as documented especially by the remains of heated mineral, smelting drops, metallic remains and even fine layers of slag adhered to some of the clay platforms and/or the soil itself and the slags. Next to many of these spaces, in the areas giving access to them, we have identified fragments of oven vessels brought to the settlement from nearby places to be smelted in this area.

The pouring into the moulds also seems to have been spatially separated from the smelting activities, although the majority of the moulds – both ceramic and of sandstone – are located in spaces very close to the spaces described above.

The greatest concentrations of oven vessels appear in the oldest levels of the outside areas of the settlement. Numerous crucibles related to smelting have been documented in this old phase in the interior of the settlement.
With respect to the distribution of the artifacts found in living quarters, they are present in all the rooms, both those related to metallurgy and those where subsistence activities predominated.

CONCLUSIONS. DIFFERENT FORMS OF CONTROL AND APPROPRIATION OF METAL

During the Chalcolithic, both in the High Guadalquivir and in the Southeastern Iberian Peninsula, there was relative specialization of activities among the different settlements, with documentation of the following: mines intended solely for the extraction of raw material, whether metallic minerals (Alcaraz *et al*., 1994) or other types of rocks and minerals (Carrión *et al*., 1993), settlements near the mines where some or all phases of the metallurgical process were carried out, distribution settlements and central settlements, far from the seams of ore in most cases, where metallurgical activity has also been documented, like Los Millares (Santa Fe de Mondújar, Almería) (Arribas *et al*., 1987). This structuring of the population into settlements with some being intended for extraction of raw material and some for metallurgical transformation implies, first, the circulation of raw materials from mines to certain political centers or dependent transformation centers and, second, control from the large settlements of the transformation of the metal and its distribution.

During the Bronze Age, the process became more complicated in both areas. In the High Guadalquivir, the hierarchical centers controlled the movement of the finished products and established secondary centers, true colonies, that controlled the mineral coming from the mine and converted it into metal (ingot and objects) (Contreras & Cámara, 2002).

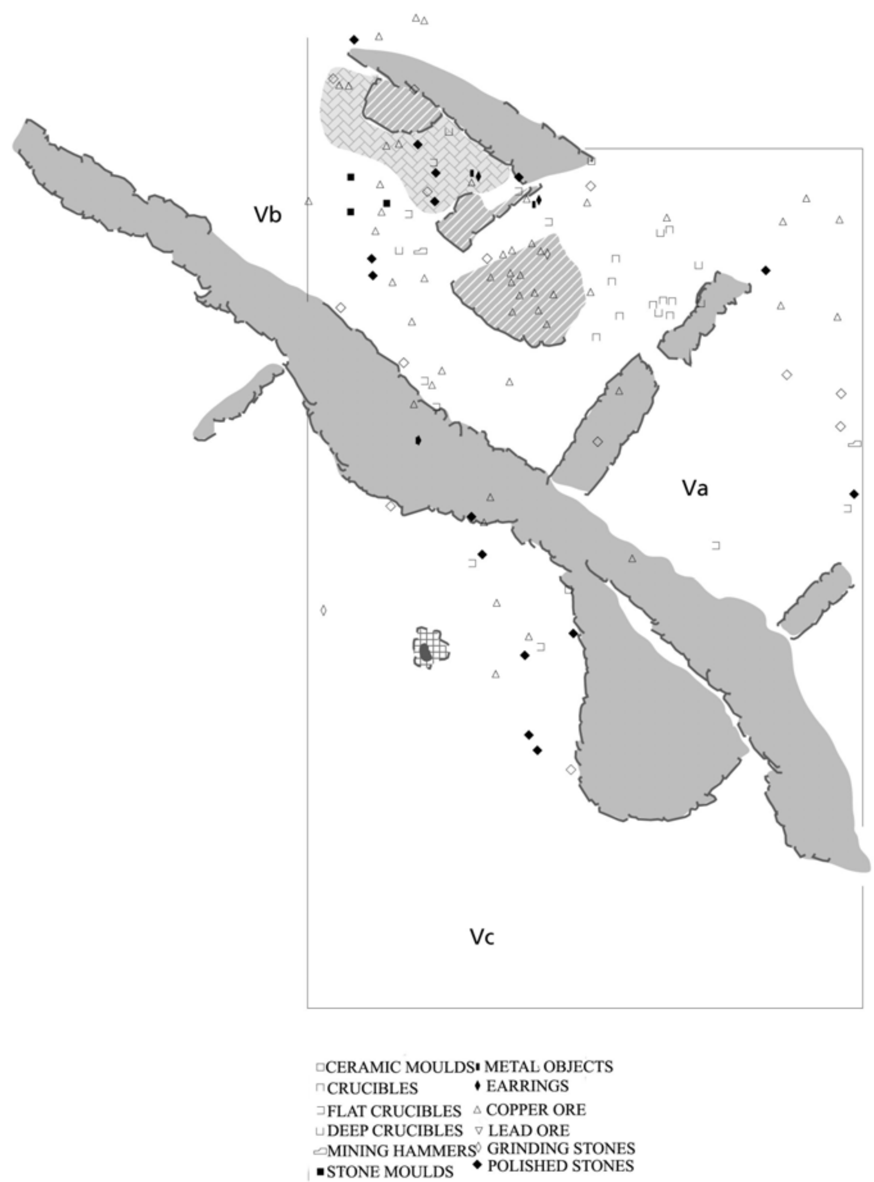

Fig. 10. Archaeometallurgical items from the Structural Group V

In the Southeast, it has been suggested that there was a more complex system where secondary settlements like Fuente Álamo (Cuevas de Almanzora, Almería) did not perform all of the phases of the metallurgical process. The analyses carried out on the metallic materials of the Gatas site (Turre, Almería) suggest that the source of the raw material, or of the finished product, was the Sierra Morena area (Castro *et al*., 2001), which implies interregional circulation. Different authors have suggested that the dependent organization in the settlement pattern of this area implies the circulation of subsistence products from the smaller settlements in the flat areas to secondary centers, perhaps with the centralizing and redistributing involvement of the large settlement of El Argar (Antas, Almería), which shows signs of the last phases of the metallurgical process (Schubart *et al*., 2000).

Generally speaking, the Culture of Argar verifies a non-generalized access to metal, even in the top-level metallurgical centers like Peñalosa where certain people did not have access to metallic elements at the time of their burial. The greater part of the masculine population, with exceptions, only had access to a dagger, which would become a symbol of social position and only a certain sector, a restricted minority, had access to precious metal adornments, which, in the case of men, usually appear with larger daggers or true swords (Cámara, 2001). These differences correspond strongly with those documented among the dwellings since, although metallurgical activity has been documented in all of them, only some show signs of mineral storage areas, consumption of large animals (bovine and equine) and an abundance of decorated ceramics (Contreras & Cámara, 2002).

In the social context of Peñalosa, where we can distinguish aristocratic elites, peasant-warriors and servants (Contreras & Cámara, 2002), metal became a symbol of *status*, either because weapons became the attribute of the community's true membership or because only certain people had access to certain metallic elements. However, we can also confirm the use of metal to create the instruments that facilitated productive activities, since, in addition to the punch tools, needles and awls documented in the dwellings, which must be related to textile activity because of their association with other elements (bone punch tools and needles, loom weights, etc.), the presence of cutting elements used in the quartering of animals has also been indirectly documented.

Weapons were not only symbols, but also a means of production because they were used in the acquisition of wealth through war and pillage (Cámara, 2001). Finally, the importance of metallurgical activity in Peñalosa in relation to the movement discussed above is shown in the documentation of real ingots intended for accumulation and circulation.

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