L. Longo y N. Skakun (eds), "Prehistoric Technology" 40 years later: Functional Studies and the Russian Legacy. Proceedings of the International Congress, Verona (20th-23rd April 2005), B.A.R., IS 1783, Archeopress, Oxford (2008), pp. 235-252.

Lithic perspectives on metallurgy: an example from Copper and Bronze Age South-East Iberia

Selina Delgado Raack and Roberto Risch
Departament de Prehistòria, Universitat Autònoma de Barcelona, Spain

To the memory of Volker Pingel

Summary. *One of the centres of early development of metallurgy is the South-East of the Iberian Peninsula, where it played a key role in the formation of the so called Los Millares and El Argar "cultures" during the 3rd and first half of the 2nd millennium BC. Yet, most arguments about the importance of metalworking are derived from the funerary evidence, i.e. from the finished objects used as grave goods, while direct evidence of the production processes is still scant.*
During the last years systematic analyses have been carried out in South-East Iberia concerning the (macro-) lithic artefacts coming from a series of Copper and Bronze Age settlements and necropolis. The observation of features and traces related to metalworking on some of these labour instruments has allowed to identify the final stages of metallurgical production, as well as to the maintenance of metal artefacts.
The functional analysis of these tools and their spatial distribution at a regional as well as local scale reveals important aspects of the social organisation of the process of metal production. Finally, the different technical situations are evaluated in order to understand the changing relationship between metallurgy and the emergence of new forms of domination and exploitation.

Résumé. *Un des centres les plus anciens de développement de la métallurgie est le sudest de la péninsule ibérique, où cette technologie a joué un rôle crucial pour la formation des « cultures » de Los Millares et El Argar, pendant le III millénaire et la première moitié du II millénaire BC. Jusqu'aujourd'hui la plupart des arguments au sujet de l'importance de la métallurgie se sont fondés sur les évidences provenant du mobilier funeraire (objects de parure, armes, outils), tandis que les évidences directes concernant le procés de production sont peu connues.*
Pendant les dernières années, des études systématiques ont eté réalisés au sudest péninsulaire sur les outils (macro)lithiques découverts en plusieurs habitats et nécropoles chalcolithiques et de l'Âge du Bronze. L'observation sur quelques de ces matériaux lithiques de traces produïtes pour le travail métallurgique a permis d'identifier les dernières étapes de cette production, de même que le maintien des outils métalliques.
L'analyse fonctionnelle au sujet des outils lithiques mentionnés et sa distribution spatiale à niveau régional et local montre des importants aspects de l'organisation social du procés de production métallurgique. On s'évalue finalement les situations techniques envisagées pour mieux comprendre les relations changeantes entre la métallurgie et le développement de nouvelles formes de domination et d'exploitation.

Key words: Metallurgy, Los Millares, El Argar.

Introduction

Metallurgical production has been considered as one of the most outstanding technological achievements in prehistory (Childe 1930). The uneven distribution of mineral outcrops and the complexity of the chain of labour processes implied in the manufacture of metal tools and ornaments supposed, in the long term, a radical change in the economic and social organisation of the Neolithic societies of Asia and Europe. One of these centres of early development of metallurgy was the South-East of the Iberian Peninsula, where it played a key role in the formation of the so called Los Millares and El Argar "cultures" during the third and first half of the second millennium BC. While copper in general was used at least from 3100/3000 cal BCE onwards, arsenical copper became more and more important through time, until tin bronze was introduced around 1800-1700 BC. Gold and silver was worked at least since the middle and the end of the third millennium respectively. Yet, no evidence of mining activities has been found so far, and only few of the known metallurgical workshops have been studied in detail. While hoarding was not a common practice in southern Iberia until the late Bronze Age either, metal objects are seldom encountered in domestic contexts, due to the high value of this raw material and the ability to recycle it. Consequently, most of our understanding on the exploitation, distribution and manufacture of copper or bronze artefacts is based either on typological or on characterisation analyses of the abundant funerary objects. The available evidence and analytical results are often inconclusive, and have led to contradictory views on the scale of metal production (e.g., Lull 1983; Chapman 1984, 2003) or on the origin of the exploited resources (Montero 1994; Stos-Gale *et al.* 1999).

Given the difficulties in moving further in the present debate without increasing significantly the already existing collection of metal artefacts and analytical data, it seems convenient to consider alternative approaches to ancient metallurgy. During recent years systematic analyses of macro-lithic assemblages from different third and second millennia settlements and cemeteries have been carried out (Delgado 2003; Risch 1995, 2002). On a small number of artefacts use traces and residues related to metalworking have been identified. Semenov (1969) already noticed and described some of these tools, and other authors have drawn attention to their presence in some Copper and Early Bronze Age tombs throughout Europe (Butler and van der Waals 1967-68). Yet, their unexciting aspect and the general lack of habit in later prehistoric research to describe and analyse macro-lithic artefacts, implies that these tools and, most importantly, the activities related to them have remained largely unnoticed in the archaeological record. The aim of this study is to develop the identification of the labour instruments used in metallurgy, in order to gain a better understanding of the social organisation of this production process.

The technical and social conditions of metal-working.

Usually, the metallurgical production process is considered to be organised into a *smelting,* a *shaping* or *melting* and a *post-casting* or *finishing process.* Forging, sheeting, polishing, decorating, assembling and sharpening of artefacts represent the main activities involved in this last working phase (Mohen 1992; Pernot 1998). Maintenance activities and repairing are further aspects of metallurgy, if efficient tools and weapons or showy ornaments are required. All of these operations are carried out by means of specialised tools, many of which had to be made out of stone, in order to fulfil the necessary technical requirements in terms of hardness and thermal resistance. A second implication is that the whole production sequence, from the smelting of the metal to the finishing and maintenance of the metal artefacts, can be divided into spatially and chronologically different operations. In fact, the separation of a *primary* production, concerned with the procurement of workable metal, from a *secondary* processes, devoted to the finishing of the objects, is a common observation in ethnographic cases. While archaeology has mainly been concerned with the mining, procurement and smelting of minerals, much less effort, in terms of field work, experimental replications or analytical studies, has been dedicated to the final stages of metal production.

The importance of this secondary phase of early metallurgy becomes evident in view of the existing casting technology. During the Iberian Copper Age (3000-2250 cal BC), the melting process was probably carried out with moulds formed with sand or unburned clay of which no traces have preserved in the archaeological record. The first stone moulds represent, as in many other parts of Europe, one of the technological innovations of the early Bronze Age, and their appearance seems to be linked with the intensification of production and the working of harder metal alloys. Sandstone moulds are part of the standard metal working tool kit from El Argar onwards. But even in this period (2250-1550 cal BC), a comparison between the melting shapes of the moulds and metal types shows, that only 65% of the objects, mainly axes, awls and rings, seem to have been cast in these tools at some stage of their production process. Especially surprising is the lack of moulds for knifes and daggers, one of the most common grave goods in El Argar tombs. In other cases, it is the casting matrix which does not seem to have an equivalent among the known metal types. Consequently, it has to be concluded that in Los Millares, but also in El Argar contexts, the finishing activities had a crucial importance in the transformation of ingots, bars and casts into usable artefacts.

Metallographic analysis carried out on objects from different third and second millennia sites have confirmed that forging through hammering formed part of the technical skills of ancient metal working (Nocete *et al.* 2004; Rovira and Delibes 2005). Annealing was only used occasionally and with limited technical control during the Copper Age, but became a standard procedure combined with cold hammering during El Argar (Montero 1994). The result was a more homogenous metal, which increased the resistance and hardness of tools, weapons and ornaments.

Sheet gold was produced in South-East Iberia at least from the later Copper Age. Although this tradition continues during the Bronze Age, a characteristic of El Argar metallurgy is the working of silver. Such sheeting processes must have implied, as in the case of forging, the use of stone hammers and anvils with hard and polished working surfaces. Other copper and silver objects, such as spirals, rings and bracelets were produced through the hammering, bending and twisting of cast bars. Grinding and polishing can be necessary at all production stages, especially after the object is taken out of the mould and after each hammering session. The aim of this operation is to remove the so called *casting skin* or any irregularities left on the surface. Artefacts with a cutting edge also need to be sharpened regularly in order to prevent dullness. All these activities require a good technical control, adequate instruments, and ultimately they determine the efficiency of tools and weapons, and the quality of the ornaments.

An interesting aspect of early metallurgy is the presence of stone instruments related to the secondary metallurgical process in a restricted group of tombs of the third and first half of the second millennium BC throughout Europe. Moulds, anvils, hammers and polishing stones appear for the first time in some of the Kurgans of the northpontic area. Their position close to the skeleton has led to define these tombs as "metal worker's graves". An outstanding example is the recently discovered tomb 32 of the Great Ipatovskij Kurgan, near Stavropol, dated around 2200 cal BC (Belinskij and Kalmykov 2004). Inside this large wooden chamber a 35-45 years old man was buried together with a set of stone instruments, as well as a series of metal ornaments, tools, weapons and a complete wagon, a grave good which distinguishes the most important tombs, also called "Adelsgräber".

In central and north-western Europe metal working tools seem to enter the funerary record during the Bell Beaker period, in the second half of the third millennium (Butler and van der Waals 1967-68). A recent find of special importance is the male beaker burial discovered in Amesbury, Wessex (Fitzpatrick 2002). It contained more than 100 objects of flint, pottery, bone, copper and gold, as well as an anvil and two so called "archers wristguards", which could have been used as sharpening stones. The Early Bronze Age burial mound of Leubingen (Thüringen), dated around 1900 cal BC, is another well known funerary context including metal working tools. Apart from an anvil and a perforated stone axe-hammer, its central wooden chamber contained several golden ornaments and an important number of bronze weapons and tools, some of which seem to be damaged and were meant to be recycled. Such an exceptional assemblage places this tomb among a small group of very rich funerary structures or "Fürstengräber" of the Unetice complex.

The deposition of metallurgical instruments in a restricted group of funerary assemblages is also documented in the Early Bronze Age of the eastern Mediterranean. One interesting case is the tomb 21 of Pyrgos in north-western Cyprus. Again, we are dealing with a male burial with an extraordinary funerary outfit, including about 110 ceramic and bronze objects of great quality. Further grave goods were two stone slabs, four polishing stones and three more tools for bending and hammering metal sheet (Belgiorno 2002). Around the same time, the social importance of the transformation of metals was also emphasised in some Egyptian tombs belonging to state functionaries of the 5th Dynasty. In this case, the melting, forging and polishing processes are represented as complete scenes on stone reliefs (Müller and Thiem 2001, Figs. 147-154).

At the other extreme of the Mediterranean, metal working tools have been found in at least three of the c. 1800 known tombs of the El Argar complex. The best known example is the large cist nr.3 of Los Cipreses (Lorca) dated around 1800 cal BC (Martínez *et al.* 1996). It contained a man more than 50 years old, which, according to his funerary outfit, belonged to the dominant class of El Argar. Next to his skull lay two anvils, a perforated polishing stone or so called "archer's wrist guard" and a piece of scrap metal, forming a close set of objects. In the shaft a large polishing/sharpening stone had been carefully placed. Two urn burials (T 580 and 597), excavated at the end of the 19th century at the site of El Argar, contained a further set formed by a possible anvil and a stone slab. Unfortunately, these artefacts are only known to us through drawings (Siret and Siret 1890, lám. 23; Risch 2002, pp.103-104).

The common trait in this trans-European group of burials is the combination of male adult individuals, with metal weapons and an often exceptional outfit in terms of the quality or quantity of the grave goods. Independently if the association with metal working tools pretended to express a direct involvement of the buried person in a particular craft, or, rather, to signal a political control over a given production, it cannot be overlooked that in all cases the economic emphasis is placed on the secondary phase of the metallurgical process, and not on the mining or smelting activities. Not only the type of tools, but also the distance of some of the funerary structures in relation to metal sources, manifests the social relevance of the finishing processes in these communities of the third and first half of the second millennia. The economic principle underlying such social organisation of the forces of production seems to have been the control of one of the productions with the largest added value at that time, and, consequently, from which most surplus value could be extracted. In modern economic terms, this means that the exchange value of a product increases exponentially as more and more raw materials, labour force and technology are invested in its manufacturing process. Consequently, in a context of social inequality, much more surplus value, i.e. value above labour costs, can be obtained from its exchange for other products or services. The close connection repeated in the funerary record between these specialised activities and the accumulation of wealth by some individuals, turns the study of the metal worker's instruments into a priority for our understanding of the social and economic structure of early Bronze Age societies.

Metal working tools of the third and second millennium BC in South-East Iberia

The identification of tools implied in the metal production process depends primarily on the functional analysis of the rich assemblages of macro-lithic artefacts. Although the development of this methodology in relation to non flaked industries is still at an initial stage, during recent years important progress has been made in determining the basic principles underlying the formation of wear patterns on different rock types. Further information has been gained through residue analysis, experimental work and the study of ethnographic materials (e.g., Hayden 1987; Adams 1989; Risch 1995, 2002; Fullagar 1998; Dubreuil 2002; Hamon 2004; Procopiou 2004). In the context of the South-East of the Iberian Peninsula, several thousand macro-lithic tools coming from a series of recently excavated Copper and Bronze Age settlements have been analysed according to a standardised recording procedure (Fig. 1).

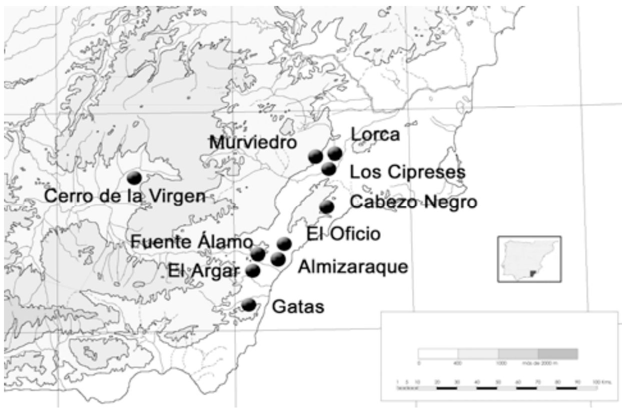


Fig. 1: Copper and Bronze Age settlements of southeast Iberia, for which systematic analysis of macro-lithic artefacts are available (map S. Gili).

Macroscopic production traces	Microscopic production traces	Morpholgy of the microtopography	Bibliography
-	Edge-rounding of grain	Sinuous	Hayden 1979, 18-19 Adams 1989 Risch 1995
-	Grain extraction	Irregular	Hayden 1987, 86 Adams 1993
-	Crushing or shattering of grain	Irregular	Hayden 1979, 19; 1987, 89-91
Levelling	Levelling	Flat	Adams 1989 Risch 1995 Dubreuil 2002 ("plage") Hamon 2004
Polish	Polish	Flat / sinuous	Semenov 1981 Plisson & van Gijn 1989
Plaque	Plaque	Sinuous	Hayden 1987, 87-88
Linear traces	Striations (width < 0.5 mm)	Irregular	Semenov 1981
	Scratches (width >0.5 mm)	Irregular	Semenov 1981
	Polish striations	-	Grace 1989
	Pigment striations	-	Delgado Raack (in press)
Pitting	Pitting	Irregular	Hayden 1987, 86-87 Adams 1989; 1993
Checks	Checks	Irregular	Hayden 1987, 85-86
Frosted appearance	Frosted appearance	Irregular	Hayden 1979 Adams 1989
Stepped fractures	Stepped fractures	Irregular	Hayden 1979, 19; 1987, 91
Concoidal fractures	Concoidal fractures	Irregular	Hayden 1979, 19; 1987, 91
Residues	Residues	-	Delgado Raack (in press)
Thermal alteration	Thermal alteration	Irregular	Delgado Raack (in press)

Fig. 2: Wear traces which can be observed on macro-lithic artefacts.

Its starting point is a standard orientation of the artefact and its division into six separate faces, each of which can be described in terms of shape, size and the presence of natural or anthropogenic wear traces and residues (Risch 2002, pp.35-54). The identification of wear patterns and artefact categories is achieved through a combination of different variables:

a) Petrographic characteristics of the rock (texture, hardness), which determine the behaviour of the rock in contact with other materials.
b) Morphology and size of the artefacts and, particularly, of the active surfaces generated through work processes.
c) Production traces, understood as all the modifications caused by the working and use of artefact (Risch, this volume). A number of traits are identified through macro- and meso-scopic observation (10-80X) and recorded according to their weft, depth, shape, placement and orientation (Fig. 2). Of special importance is the description of the topography of the surfaces and the degree of invasiveness of the use-wear (high and low topography). Experimental tests, ethnographic observation and contextual information allow us to establish causal relations between wear patterns and particular activities (Fig. 3).
d) Residues can provide further information on the use of a particular artefact. Unfortunately, it has been observed that mineral particles disappear rapidly even on modern metal working stone tools.

Casting tools

Moulds (Fig. 5,1)
Artefact morphology: The characteristic feature of this artefact category is the presence of one or more casting matrices worked into a surface which has been ground flat. Usually, the other faces are only roughly prepared through percussion or abrasion.
Geology: Slabs of fine grained sandstone (0,13-0,25 mm) or, rarely, calcareous sandstone (0,06-0,13 mm). Grains are embedded in a carbonate matrix.
Morphology of the active surface: Most of the known early and middle Bronze Age casting matrices of South-East Iberia conform to axes and awls or ingot-bars. Other shapes are indefinable in terms of finished metal artefacts.
Production traces: Thermal alteration of the rock grains is a characteristic feature visible in the melting shape and its margins (Figs. 8; 9). The casting surface often presents an irregular micro-topography due to grain extraction, which is probably caused by the loosening of mineral particles from the rock matrix during the casting and subsequent separation of the metal blank from the mould. This wear is not comparable with abrasive traces, where grains show micro-fractures and angular shapes. Rather, complete grains with a rounded or blunt surface are visible (Fig. 8).

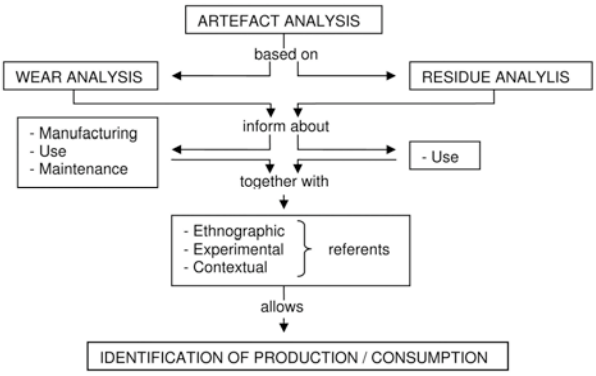


Fig. 3: The study and interpretation of lithic artefacts.

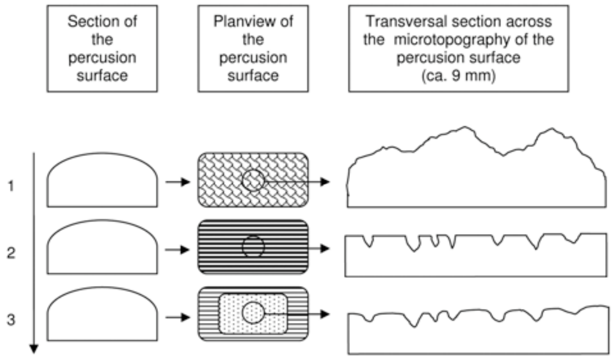


Fig. 4: Development of wear along the production and use of forging artefacts. Moment 1: natural surface of a water worn cobble; Moment 2: dense and fine striations parallel to the longitudinal axis of the active surfaces, caused by grinding processes on hard material (manufacture traces); Moment 3: striation becomes more and more superficial as the surface flatens during hammering (use wear).

Validating information: None of the artefacts analysed so far preserved metal adherences either on the grain surfaces or in the interstices. Nevertheless, abundant contextual data identifies this artefact category as a metal working tool.

Forging tools

Hammers (Figs. 5,3-5,6)
Artefact morphology: While axe-shaped hammers have been identified in several Los Millares sites (Fig. 5,3), so called "mining hammers" with hafting grooves or notches are a characteristic tool type of the El Argar and Post-Argaric periods (Figs. 5,5; 5,6). Small cylindrical artefacts form a third type of hammers (Fig. 5, 4).
Geology: Axe shaped hammers are always made out of micro-gabbro or similar hard and dense rocks with an ofitic texture; the same material and, occasionally, quartzite are used as grooved hammers; quartzite is also the rock employed for the few known cylindrical tools.
Morphology of the active surface: The distinctive feature of all these artefacts is a smooth and slightly convex working surface. This obliges us to consider "mining hammers" with signs of heavy battering (fractures, checks, etc.) as a different artefact category.
Production traces: All active surfaces show an intense levelling of the mineral particles, together with a shiny polish, which mainly appears on the highest spots of the topography. These spots are high plateaus located between series of very fine, dense and superficial striations, which cover the hammering front in a longitudinal sense. These striations tend to blur, without completely disappearing, towards the centre of the active surface (Fig. 11). Additional traces are small pits, scattered over the percussion surface. Quartzite artefacts have slightly more irregular surfaces than gabbros, and do not present striations, due to the different petrological characteristics of these rocks (Fig. 12.
Validating information: According to experimental tests, intensive levelling and fine regular striation on this type of hard rocks are the result of grinding on more or less abrasive rocks, and consequently represent fabrication traces. Instead, the blurring of these patterns and the development of a shiny surface can be related to the hammering of metal. The order and location of the observed patterns allows us to propose a general model of wear development (Fig. 4).
No metal residues could be identified, but examples of these stone tools have been found associated with other metal working equipment in burials (Lebedi, Kuban; Soesterberg, central Netherlands), hoards (La Petite Laugère, Saône-et-Loire; Wageningen, central Netherlands) and workshops (Campos, Almería; Cerro de la Virgen, Granada; Kültepe-Karum, Kayseri).

Anvils (Fig. 5,2)
Artefact morphology: According to their more or less square shape, slightly rounded edges and intensely polished surfaces, these artefacts have also been named "cushion stones" (Butler and van der Waals 1967-68).
Geology: Micro-gabbro. It should be taken into account that the grinding of such rocks into small ashlars is more labour intensive, than the production of any other known metal working artefact, apart from the axe shaped hammers (Risch 2002, Fig. 4,11).
Morphology of the active surface: Obverse and reverse sides tend to be flat, while the lateral ones usually are plano-convex.
Production traces: All sides present a shiny polish, resulting from the intense levelling of the mineral particles. As in the case of the hammer stones, this polish impregnates fine and dense striations. Under the microscope, these linear traces are especially visible on the rounded edges of the artefacts, while their presence, rather than frequency, is much more subtle in the central area of the active surfaces. Here, longer striations appear randomly spread, without a recurrent orientation above the first weft of striations. Small pits can also be observed on the flat faces (Figs. 11a, b).

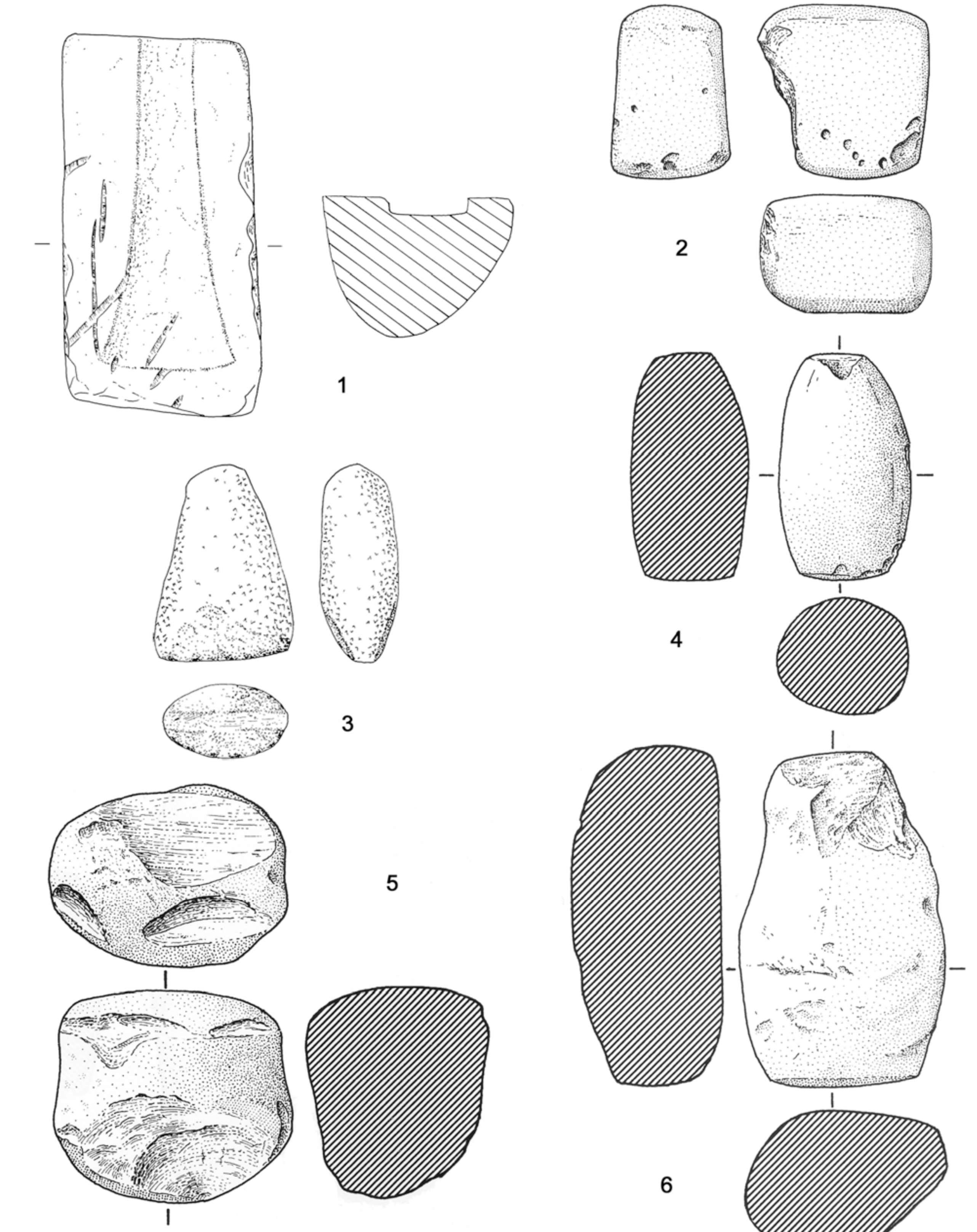


Fig. 5: Artefacts related to the final stages of metal production during the third and second millennium cal BC in southeast Spain: 1. Mould (Murviedro); 2. Anvil (Fuente Álamo); 3. Axe shaped hammer (Cerro de la Virgen); 4. Cylindrical hammer (Fuente Álamo); 5-6. Grooved hammers (Fuente Álamo) (scale 1:2).

Validating information: Again, we seem to be dealing with a combination of manufacture and use traces, according to which these artefacts could have been used scars and flakes during hammering and, consequently, to maintain the full area of the working surface.

In the case of an anvil coming from the post-argaric site of Murviedro, Lorca (ca. 1550-1300 cal BC), tiny dark brown metallic spots were detected on the surface coinciding with pits (Fig. 10c). The particles were analysed in the laboratories of the Universitat Autònoma of Barcelona through SEM-EDAX, and turned out to be pure iron, as well as iron oxides.[1] This suggests that we are dealing with post-depositional formation of goethite in an iron rich sediment, rather than with residues resulting from the forging activity. Metal traces resulting from work processes could be observed on the experimental replicas, but only seem to be preserved in exceptional cases on archaeological artefacts (Fig. 11d). This is the case of an anvil found in Dalverzin in central Asia, on which Semenov (1969) detected the presence of iron particles. Another example comes from the late Bronze Age workshop found in Choisy-au-Bac (Oise, Francia). In this case, traces of gold remained trapped in linear pits on the active surface (Èluere 1985). The presence of anvils in metallurgical workshops (Arslantepe, Malatya; Newgrange, Ireland), deposits of scrap metal (Wageningen, Netherlands), as well as in so called "smith's graves" (Zutovo, Volgograd) further supports their interpretation as metal working tools.

Polishing, cutting and sharpening tools

Polishing and sharpening slabs (Fig. 6,1)
Artefact morphology: Rectangular stone slabs.
Geology: Siliceous or carbonated sandstone with middle sized quartz grains (0,25-0,5 mm). The geology clearly distinguishes them from cereal processing or other grinding tools.
Morphology of the active surface: A large (ca. 15-30 x 7-17 cm), oval and slightly concave surface appears in the central part of the obverse side of the slab. The lateral margins can be worn down in a similar way too.
Production traces: The complete obverse surface appears more or less levelled and covered by pits (Fig. 15a). In the central and lateral facets these pits are worn away by intense levelling (Figs. 14a; 15b). Quartz grains present flat surfaces and micro-fractures. Longitudinal and transversal parallel striations represent a further trait of these areas.
Validating information: According to experimental replications such intense levelling, crushing and scratching of siliceous material corresponds to an abrasive wear produced by hard materials (stone or metal). Prior to this use wear the stone slab surface had been prepared through a rough abrasion and regular pecking, probably with stone tools. This sequence and as hard supports, and as hammers. Experimental tests have proved the importance of the flat polished surfaces on the forging tools, in order to prevent the extraction of arrangement of the production traces follows an inverse order in comparison to cereal grinding tools, where periodic pecking roughens primarily the central part of the work surface, while the margins remain smooth.

On the upper margin of a stone slab found in an El Argar context at Fuente Álamo (Almería) a significant amount of metal residues was preserved (Fig. 14b). The ICP-OES analysis at the Deutsches Bergbau Museum (Bochum) revealed that they contained 30,9% of copper and 4,85% of tin, apart from other trace elements.[2] Yet, it remains unclear if the worked material was mineral or metal. The fragility of the carbonated sandstone and the abrasive traces rule out that the stone slab was used to crush mineral. Rather, use wear traces conform to what has been observed on ethnographic examples of sharpening tools (Fig. 15c).

Polishing tools (Figs. 6,2-6,3)
Artefact morphology: Two types of small sized sharpening stones have been identified. The first is a semi-oval artefact with a longitudinal groove. These artefacts can easily be taken for so called "arrowshaft straighteners" (Fig. 6,2). A small cylindrical object found in Fuente Álamo (Almería) seems to represent another type of metal polisher (Fig. 6,3).
Geology: The grooved polishers are made out of fine to middle grained sandstone (0,13-0,25 mm), which can be more or less cohesive, depending on the nature of the matrix (carbonate or siliceous). Instead, the cylindrical artefact is worked out of a very fine grained (< 0,0039 mm) slate clast.
Morphology of the active surface: The straight grooves present a V or, occasionally, a U shaped profile. This incision cuts through a surface, which is straight in the longitudinal and slightly convex in the transversal axis. The active facet of the slate polisher is limited to a flat surface placed diagonally at its upper end.
Production traces: The surface of the grooves shows an uneven aspect and is covered by short and irregular striations, which run in a longitudinal direction (Fig. 16c). Frequently, the complete artefact has acquired a dark colouring due to its exposure to fire and in one case we recognized some residues adhered to the ground of the groove (Fig. 16b). The slate, which is a much softer material, has been levelled completely, while dense, parallel striations cross the active surface mainly in a vertical direction (Figs. 17a, b).
Validating information: The formation of striations suggests, in principle, the working of hard material, such as metal. The polishing also seems to have implied some form of heating of the tool. The described functional particularities allow to distinguish these artefacts from

[1] The analysis was carried out and interpreted by Francesc Bohils and David Gómez-Grass from the Department of Geology of the U.A.B.

[2] We wish to thank Andreas Hauptmann and Karsten Hess for having carried out these analyses.

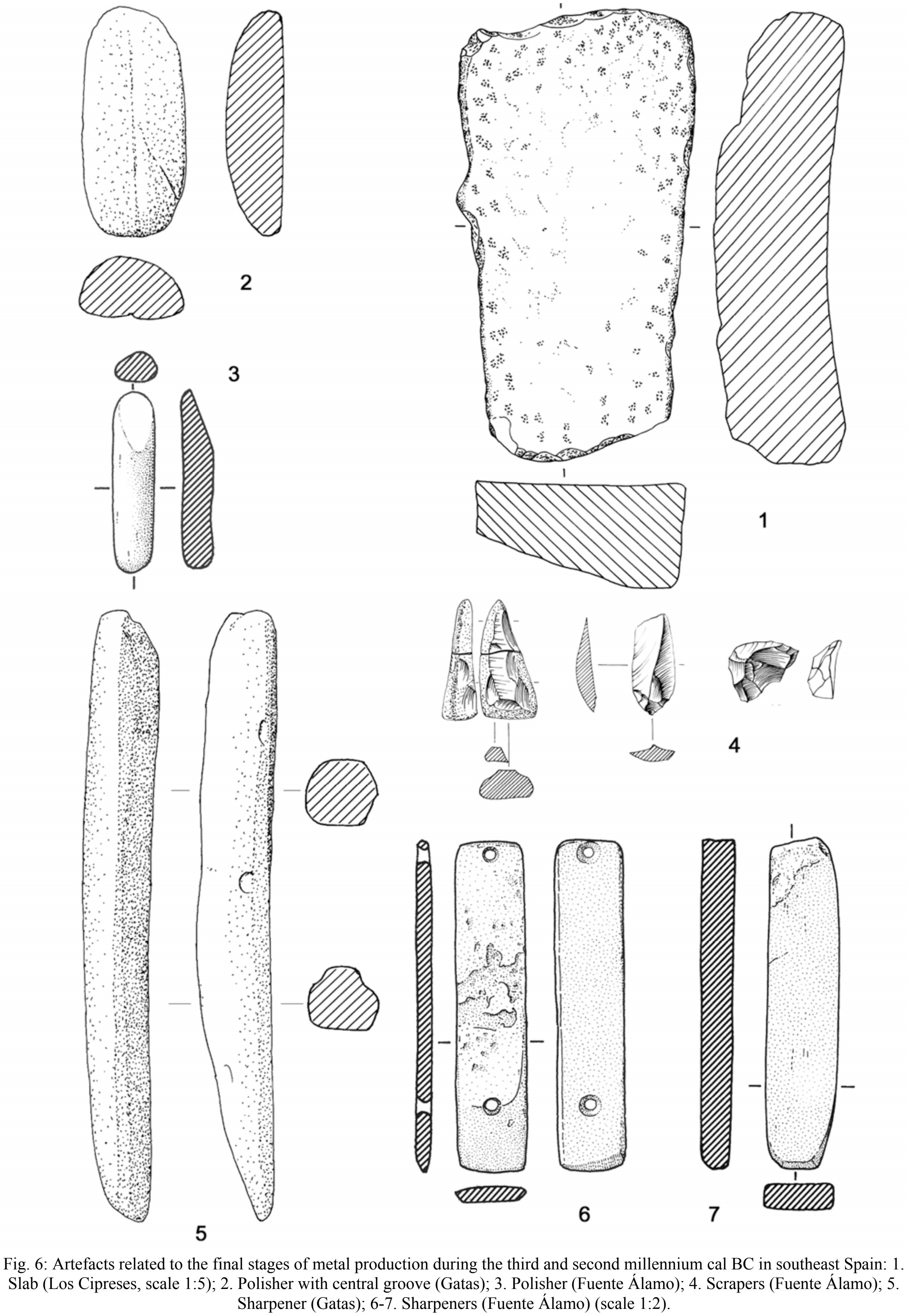


Fig. 6: Artefacts related to the final stages of metal production during the third and second millennium cal BC in southeast Spain: 1. Slab (Los Cipreses, scale 1:5); 2. Polisher with central groove (Gatas); 3. Polisher (Fuente Álamo); 4. Scrapers (Fuente Álamo); 5. Sharpener (Gatas); 6-7. Sharpeners (Fuente Álamo) (scale 1:2).

similar ones used for the working of wood and bone. Wear patterns similar to those observed on the slate polisher could be reproduced working copper sheet for one hour (Fig. 17c).

Sharpening plaques (Figs. 6,5-6,7)

Artefact morphology: Small rectangular slabs, either perforated or unperforated at one or both ends, are a characteristic late third and second millennia artefact of South-East Iberia. Archaeology tends to pay attention only to the perforated examples, known as "archers wristguards" (Fig. 6,6). The site of Gatas has provided a so far unique type of sharpener, which is longer and thicker than the plaques, but similar in terms of geology and production traces. Originally, it must have been a rectangular plaque with a deep groove crossing the obverse and reverse sides. After it broke in two, the preserved half continued to be used (Figs. 6,5; 19b).

Geology: Fine grained psamitic or micaceous slate and schist, which are relatively hard and still highly abrasive rocks.

Morphology of the active surface: Generally flat, although the transversal profile often presents a slightly convex shape.

Production traces: All sides of the plaques have been shaped by abrasion, but the obverse face presents a distinct wear pattern. The dominant feature is an intense levelling of the grain surfaces (Fig. 18d). Scratches and striations, which follow a transversal and occasionally also diagonal direction, can be visible even by eye, especially towards the margins of the surface (Fig. 18a). While scratches are loosely scattered, the striations form an irregular pattern of juxtaposed, dense and more or less parallel traces. Occasionally, the active surface presents a slightly undulating micro-topography, with grooves following the same direction as the linear traces. In the case of the oblong plaque from Gatas, analogous wear traces on the obverse and reverse faces are covered furthermore by long and dense striations (Fig. 19a). Their aspect on the surfaces of the original grooves is more dense and superficial (Fig. 19b).

Validating information: All these traces have been observed on traditional sharpening stones used to whet knifes and sickles (Figs. 18b, c). Striking similarities with the modern sharpening stones also exist in terms of the selection of raw materials. Surprisingly, neither on the modern nor on the prehistoric artefacts could metal residues be identified. The only example, known to us, where this is the case is a perforated plaque found in Mallorca (Waldren 1982, Fig. 41,2).

Further support for their identification as sharpening tools is provided by contextual information. In the South-East, but also in other parts of the Mediterranean, such as Crete, perforated plaques are found in burials together with metal tools and weapons, but not arrowheads. A direct association with a bronze knife has been observed in two Argaric tombs (Zapata nr.15 and El Oficio 205), and in the north Italian lake dwelling of Fiavé. Only for artefacts with less developed wear can an ornamental function not be ruled out.

Cutting and scraping tools (Fig. 6,4)

Artefact morphology: Flakes of 20-45 cm.

Geology: Fine grained flint.

Morphology of the active surface: Abrupt edges.

Production traces: Strong rounding, numerous wide, long and deep striations, combined with a flat, dense and very brilliant micropolish with a metallic aspect (Gibaja 2002).

Validating information: According to experimental tests, these wear patterns suggest a scraping action on very abrasive and hard materials such as stone or metal.

Results

Petrographic, morphological and functional analysis have allowed us to distinguish a group of tools which served to hammer, abrade, scrape or cut very hard materials, such as metal and stone. Given that the production of polished stone became marginal from El Argar onwards, the working of metal seems to be the most probable explanation for the identified use traces. In most cases, contextual information and residue analysis confirm the participation of these instruments in the post-casting or secondary metallurgical activities (Figs. 5; 6).

Most of the traces identified by functional analysis, such as the intense levelling of the mineral particles, striations and the additional presence of pits, have a mechanical origin. In general terms, where the direct contact with metal was intense and/or lengthy, roughness is low and totally flattened surfaces are dominant in comparison to depressions or fractures, which are practically absent. Chemical alterations, such as shiny polish and thermal modifications are more exceptional.[3] The first appears related to the intense levelling and compression of the mineral particles on forging tools such as hammers and anvils made out of gabbro, and, to a certain extend, on polishing slabs of siliceous sandstone. On other rock types, surfaces seem to be too unstable, due to grain extraction, to allow the development of shiny polish. A further variable, which significantly conditions the intensity of polish is the grain size of the rock. Thermal alterations have only been detected on moulds and some grooved polishers.

While the different wear patterns allow us to distinguish between abrasive and percussive activities, it is more difficult to imagine the specific task carried out with these tools, and the position of these tasks in the metallurgical production sequence. More experimental tests and better contextual data are needed in order to shed light on this issue. However, the variety of specific working instruments identified is indicative of the degree of technical specialisation and the complexity of the finishing processes, in terms of knowledge, means and

[3] We use Plisson's and van Gijn's definition of glossy polish as "a structure of the flat surface, which results out of the modification of the original microrelief, which itself comes from the extraction and adding of material, caused by a natural or artificial chemical process" (Plisson and van Gijn 1989).

MATERIAL	Flint	quarzite	gabro		schist/slate		sandstone		
hardness cohesion abrasiveness	+++ ++ -	+++ ++ -	++ +++ +		+ + +++		++ ++ ++	+ + +++	
ACTIVITY	Scraping	Percusion			Abrasion		Abrasion		
CATEGORY	Flake	Hammer	Anvil	Hammer	Polisher	Sharpener	Slab	Polisher	Mould
Morphology of the active surfaces	Ed (≥45º)	Cx	Fl/Cx	Cx	Fl	Str/Cx	Cv	“U” “V”	Cv
TRACES									
Levelling	x	x	x	x	x	x	x	(x)	
Striations	x		x	x	x	(x)	x	(x)	
Scratches						(x)	x	x	
Polish	x		x	x			(x)		
Pitting		x	(x)	(x)			(x)		(x)
Stepped fractures		x							
Grain extraction						(x)	x	x	x
Grain crushing		x					x	x	
Grain rounding	x	x							(x)
Residues			(x)				(x)	(x)	
Thermal alteration								(x)	x

Fig. 7: Overview of the manufacture and use traces identified on the different artefact categories. Ed = edge; Cx = convex; Cv = concave; Fl = flat; “U” or “V” = groove with “U” or “V” shaped section; X = dominant trace; (X) = occasional trace.

skills. This increasing specialisation might explain why at a certain moment, a politically and economically dominant position of certain men became linked to the control of precisely the secondary stages of metal production where these skills and artefacts became relevant. Again, the social implications of the introduction of most of these artefacts, such as moulds, grooved hammers, grooved polishers, or sharpening plaques, in the second half of the third millennium, that is at the transition from the Los Millares to the El Argar period, need to be considered.

The changing social relations of metal production in South-East Iberia

The working of copper became a widespread technology in South-East Iberia around 3000 cal BC, at the beginning of Los Millares. Most of the systematically excavated settlements of this period have provided some evidence of metal working, such as crucibles or reduction vessels, kilns, ores or copper droplets (Keesmann *et al.* 1991-92; Montero 1994). At least in the settlements of South-East Iberia, the complete production sequence, from the reduction of the mineral until the finishing of the metal objects, seems to have been carried out inside settlements, independent of their size, geographical location or architectural complexity. The analysis of the macro-lithic assemblage of the classic site of Cerro de la Virgen (Granada) has revealed that the majority of the metal working tools (hammers, slabs, sharpening plaques), as well as other evidence related to a metallurgical production cluster in one area of the ca. 50m^2 excavated in this 0,7 ha settlement (Delgado 2003). The workshop was placed in the open air and surrounded by round dwellings, which did not stand out in terms of wealth, size or other features which could hint towards an unequal access to metallurgy. The distribution of sharpening plaques inside and outside many buildings further suggest that the produced metal tools were used and maintained by all members of the community. The widespread distribution of metal objects, as well as other materials with a high social value (e.g. high quality pottery, ivory, non-local flint and other raw materials) also supports the idea that metal production and craft specialisation in general played an important role during Los Millares, but did not lead towards the emergence of a class society (Castro *et al*. 1998; Chapman 2002).

As we have mentioned above, the end of the third millennium is a period of drastic changes. Apart from the introduction of new technological devices, many of which are linked to metallurgy, most of the previous settlements are abandoned and a completely new settlement pattern and territorial organisation emerged. Contrary to the situation observed before, evidence of metal workshops becomes extremely scant during El Argar. The only exception is Peñalosa (Jaen) and probably other sites located at the southern slopes of Sierra Morena, where most buildings participated in the reduction of metal (Contreras 2000). The exceptional number of crucibles (43) and moulds (50), most of which served to cast ingots, shows that this production exceeded the domestic sphere and must have been linked to an over-regional distribution network. None of the settlements of the “central” area of El Argar (north-eastern Almeria and southern Murcia) have produced any evidence of such large scale smelting and casting activities. Specialised workshops, with clear evidence at least of the melting process, have been identified in one building of El Argar (Almeria) and another one in La

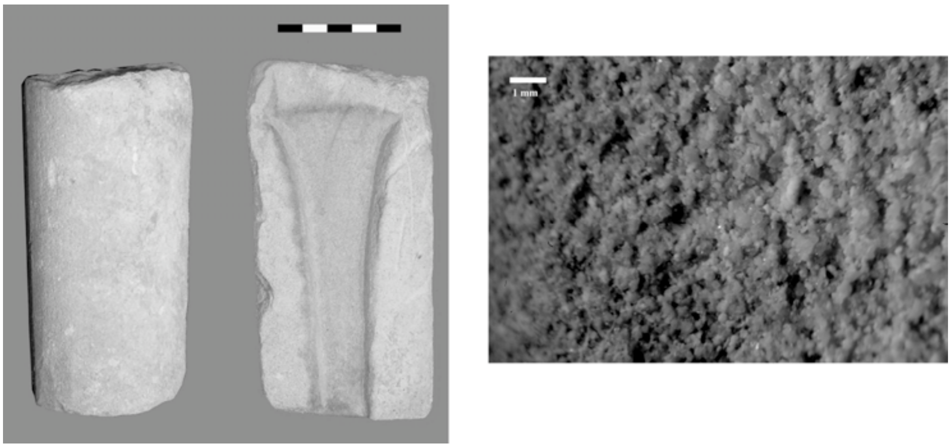


Fig. 8: Mould from Murviedro (Lorca).

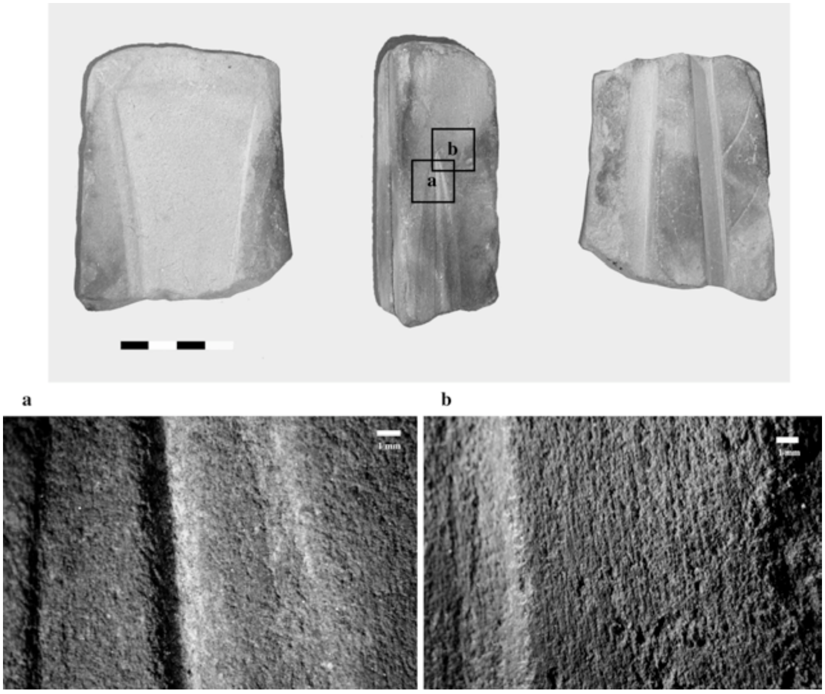


Fig. 9: Mould from the city of Lorca.

Bastida (Murcia), two of the most important centres at that time. Yet, the functional analysis of lithic tools discussed above reveals that metal objects were worked and maintained on other sites too.

In Fuente Álamo (Almería), a hill settlement, which has been extensively excavated by the German Archaeological Institute between 1977 and 1998 (Schubart *et al.* 2001), the spatial distribution of the lithic artefacts shows that most of the forging, polishing, scraping, as well as sharpening tools come from the summit of the hill, and more specifically, the northern sector of the so called "Eastern Slope". This was a prominent area, often named "acropolis", where monumental buildings (square towers, possible granaries, industrial buildings, etc.) and the 'richest' burials were placed. Around 90% of all the metal weight recovered from over 100 intramural funerary contexts of Fuente Álamo, was deposited in this sector. Such a concurrence of production, maintenance and consumption spaces reveal 1., that the social access to metal tools, weapons and ornaments was asymmetric, and 2., that this nequality was warranted by the direct control of the secondary phases of metal production by a dominant group. In other terms, the funerary practices only seem to sanction ritually the fact that metal had now become the private property of an emerging dominant class. Thus, the socio-economic organisation of Fuente Álamo confirms the meaning given to the presence of anvils, polishing tools, etc. in some of the most outstanding male tombs of the third and early second millennia in Europe.

According to the presently known distribution of metal working tools in the Argaric territory, metallurgy appears as a strongly divided production process, both in technical as well as in social terms. Although much more information from systematically excavated and studied settlements is necessary, a model seems to emerge in which 1., the reduction of the mineral and production of ingots was taking place at a large scale in some marginal

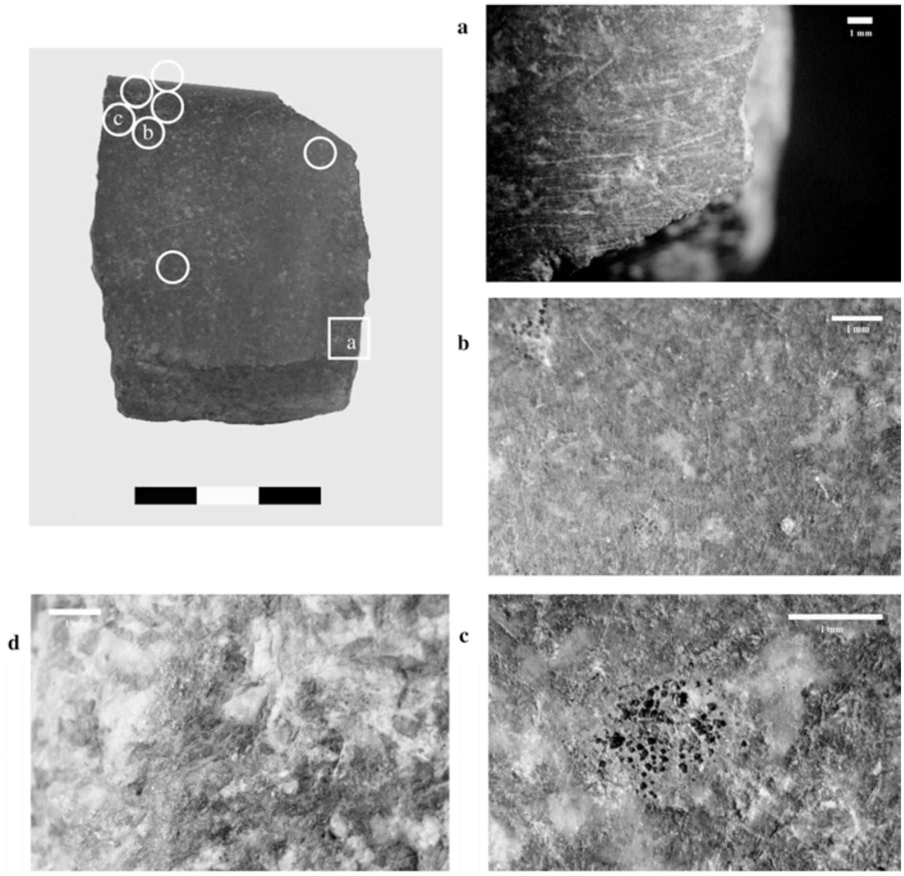


Fig. 10: a-c) Anvil from Murviedro (Lorca), circles indicate the position of the residues; d) residues of copper on an experimental forging artefact.

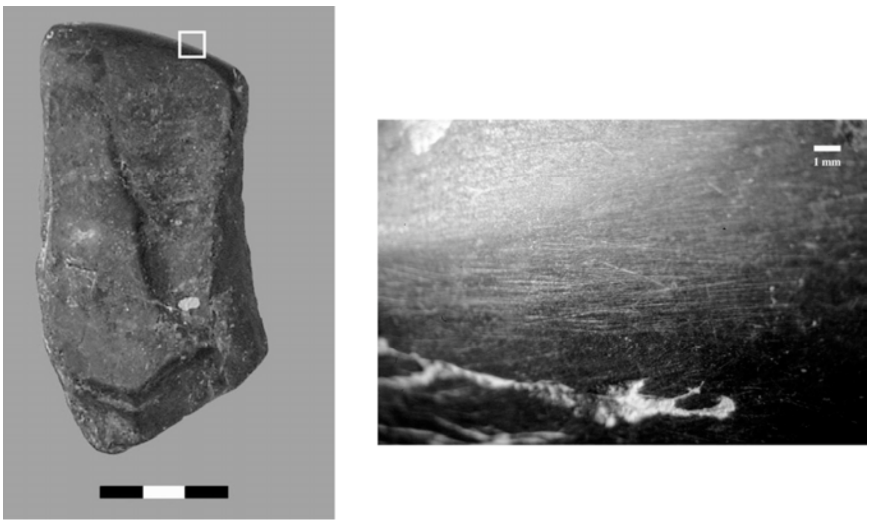


Fig. 11: Hammer from the city of Lorca.

regions, 2., central places could include workshops specialised in the casting and forging of metal tools, weapons and ornaments, 3., specialised workshops in second order settlements were primarily carrying out forging, repairing and maintenance activities, and 4. small scale sites depended on the previous two centres in relation to metal artefacts.

The sudden collapse of El Argar around 1550 cal BC supposed again a new situation, as the analysis of the metal working tools begins to show. Until the 1970s it was practically impossible to distinguish the Post-Argaric from previous occupation phases, and all the materials coming from multiperiod settlements were classified as Argaric. The absence of hardly any funerary evidence after 1550 supposed a further difficulty in the identification of metal artefacts. Yet, as more stratified information becomes available, metallurgy appears as an important aspect in post-Agaric economic organisation. At a technological level, the same means of production continued to be used as during the previous phase. Yet, their distribution at a territorial as well as at a settlement level changed notably. At Gatas, another important Bronze Age hill settlement excavated since 1986 by the

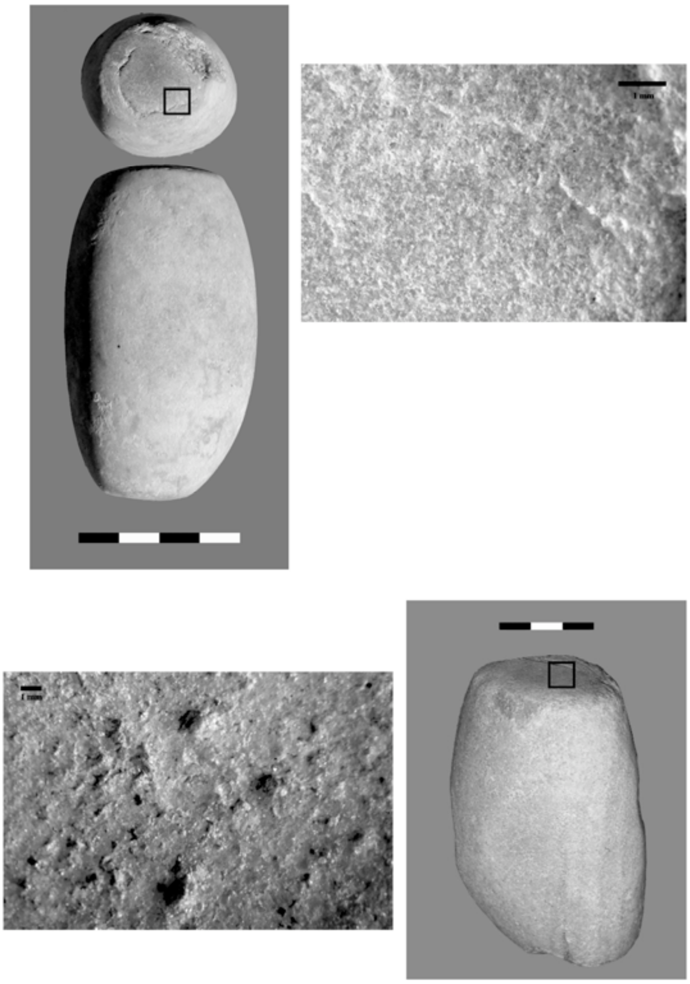


Fig. 12: Hammers from Fuente Álamo and Murviedro (Lorca).

	LOS MILLARES	EL ARGAR	POST-ARGAR
Raw Materials	Copper/Arsenical copper (Gold, after 2500 BC)	Arsenical copper / Silver / Gold (Bronze, after 1800 BC)	Bronze / Arsenical Copper/ Gold / Silver (Iron)
Specialisation of the labour instruments (simplification of tasks)	*Low* (axe shaped hammers), until late Beaker Phase (axe shaped hammers, anvils, sharpening plaques)	*High* (moulds, anvils, , axe shaped hammers, grooved hammers, grooved polishers, polishing slabs, sharpening plaques, etc.)	*High* (apparently the same tool kit as during El Argar)
Specialisation of production spaces (spatial exclusiveness 1)	*Moderate to High*, inside settlements *Low*, at a territorial level	*High*, inside settlements, as well as at a territorial level	*Moderate to Low*, inside settlements *Low*, at a territorial level
Division of the production process (spatial exclusiveness 2)	*Low* All tasks can be carried out at the same place	*High* Smelting / Melting / Finishing	*Moderate* Smelting / Melting & Finishing (?)
Relative volume of production (according to metal working tools)	**+**	**+++**	**++++**
Social access to metal (consumption)	*High*: Communal	*Low*: Class based	*High*: Domestic-Segmented

Fig. 13: Technical conditions and economic organisation of metallurgy in southeast Iberia (analytical criteria according to Risch, this volume).

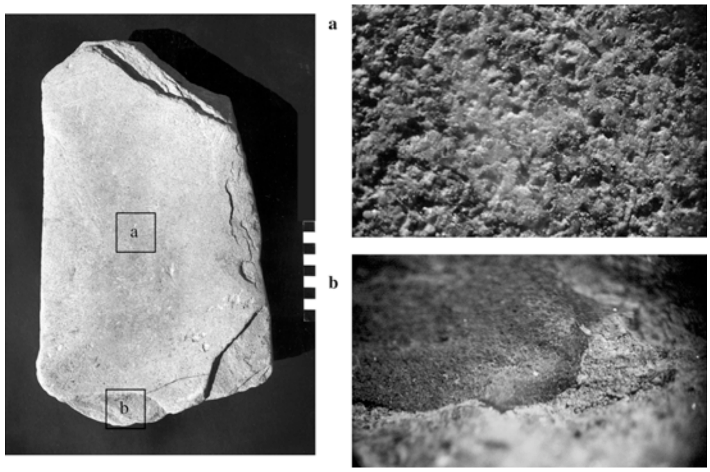


Fig. 14: Stone-slab with metal residues from Fuente Álamo.

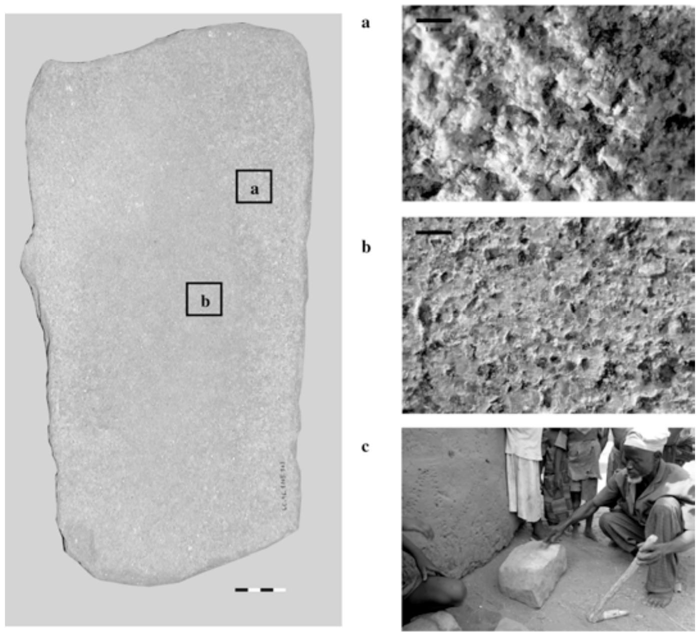
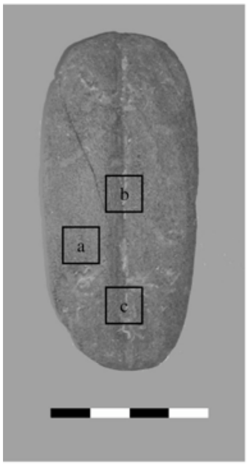


Fig. 15: a-b) Stone-slab from tomb number 3 of Los Cipreses (Lorca); c) sharpening of an iron axe on a stone-slab in the village of Bende, Ghana (Photography J. A. Soldevilla).

Universitat Autònoma of Barcelona (Castro *et al.* 1999), metal working tools, such as moulds, grooved hammers, sharpening plaques and a crucible, have been found in four different contexts located at two opposed sides of the hill. Also in Fuente Álamo a considerable number of such means of labour has been identified. They are distributed over five of the seven habitational spaces which could be explored on the summit of the site (Risch 2002, pp.200-208). In a similar way, the recent excavations at Murviedro (Murcia) have provided evidence of metalworking in several larger and smaller buildings. Yet, neither in these nor in other sites is it possible to talk about specialised workshops. Usually, metal working instruments appear associated with a variety of other tools, as well as common domestic remains. In general, the qualitative differences between structural units in terms of available means of production and, consequently, the spatial division of labour during Post-Argaric period seem to have been rather limited. It can be suggested that metallurgy or, at least, the casting and finishing processes became a more widespread technology, no longer controlled directly by a dominant class.

This brief discussion of the forces and relations of production related to the metallurgy of South-East Iberia during the third and second millennia BC, reveals some of the social and economic issues which begin to be raised once the instruments of labour participating in this activity are identified (Fig. 13). Future research will probably determine new artefact categories and production wear patterns, and provide more validating information in terms of contextual data, experimental work, residue analysis, etc.. However, the picture which starts to emerge is much more complex than expected, and has clear implications for the way we understand how differently societies can organise and dispose of means of production which have become crucial in their further development. None of the technical variables (tools types, raw materials, specialisation, etc.) nor the volume of production determine by itself the organisation of and access to metallurgy. Rather, it is the social control over



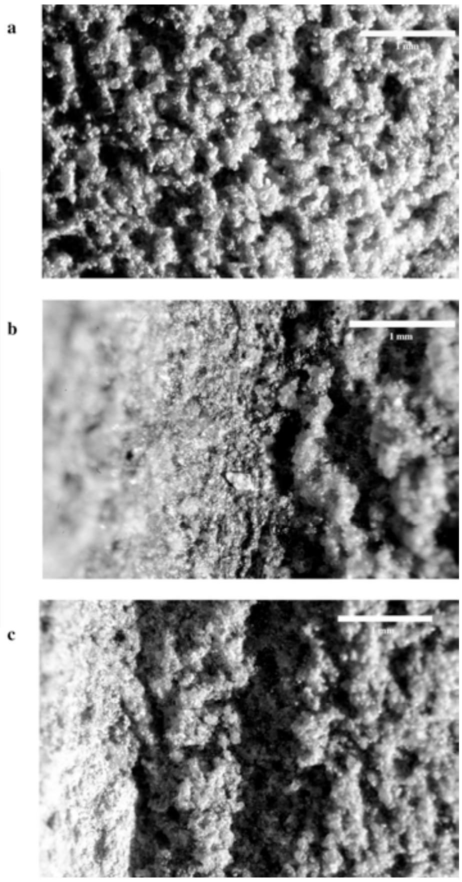


Fig. 16: Polisher with central groove from Fuente Álamo.

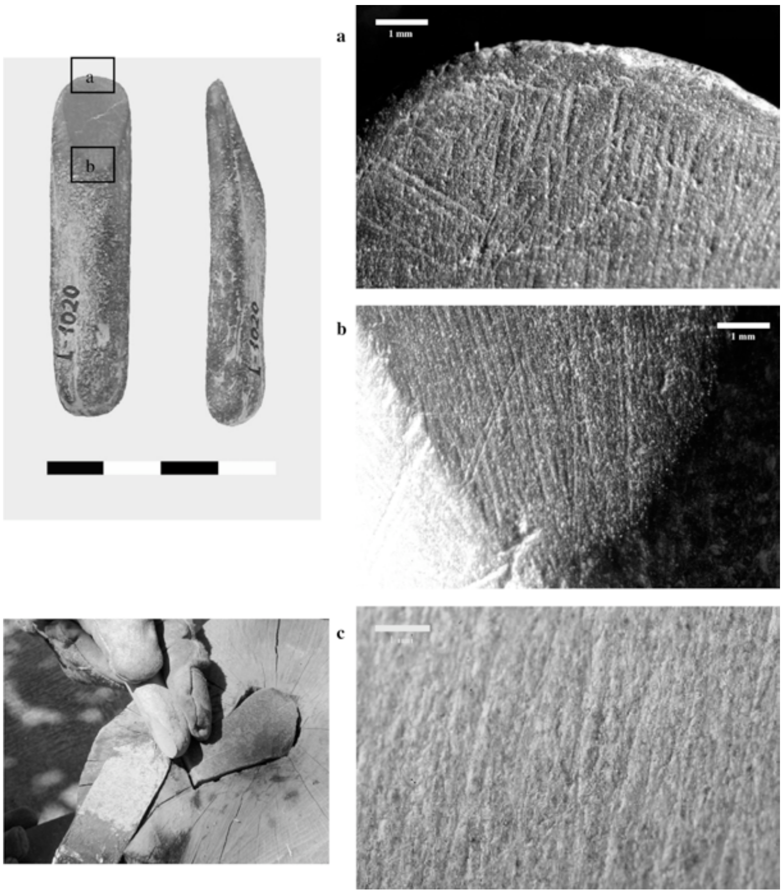


Fig. 17: a-b) Polisher from Fuente Álamo; c) experimental polisher during the forging of a copper sheet (Photography M. Rosas).

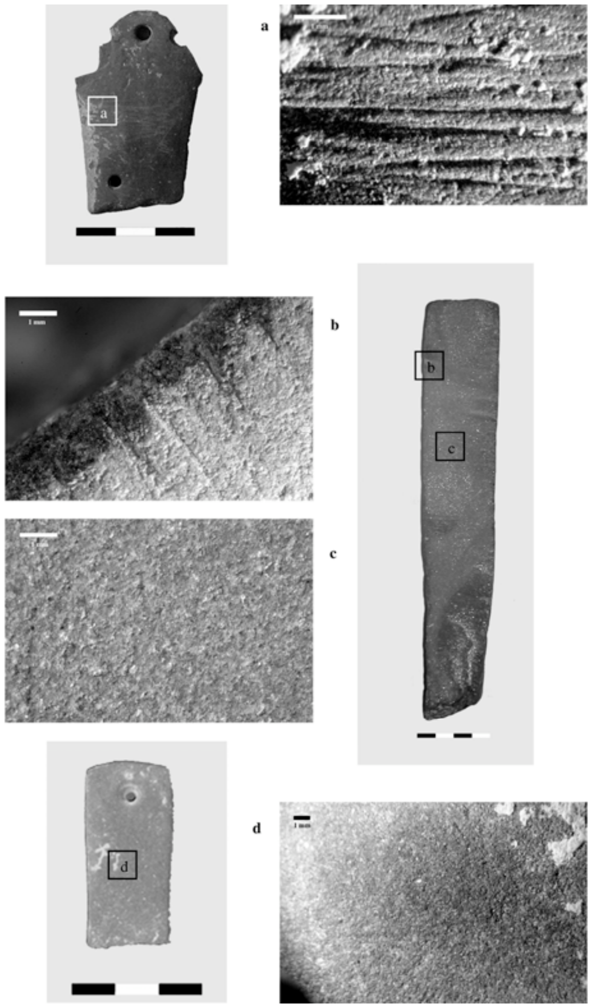


Fig. 18: a) Sharpeners from Murviedro; b-c) ethnographic knife sharpener; d: sharpener from Los Cipreses.

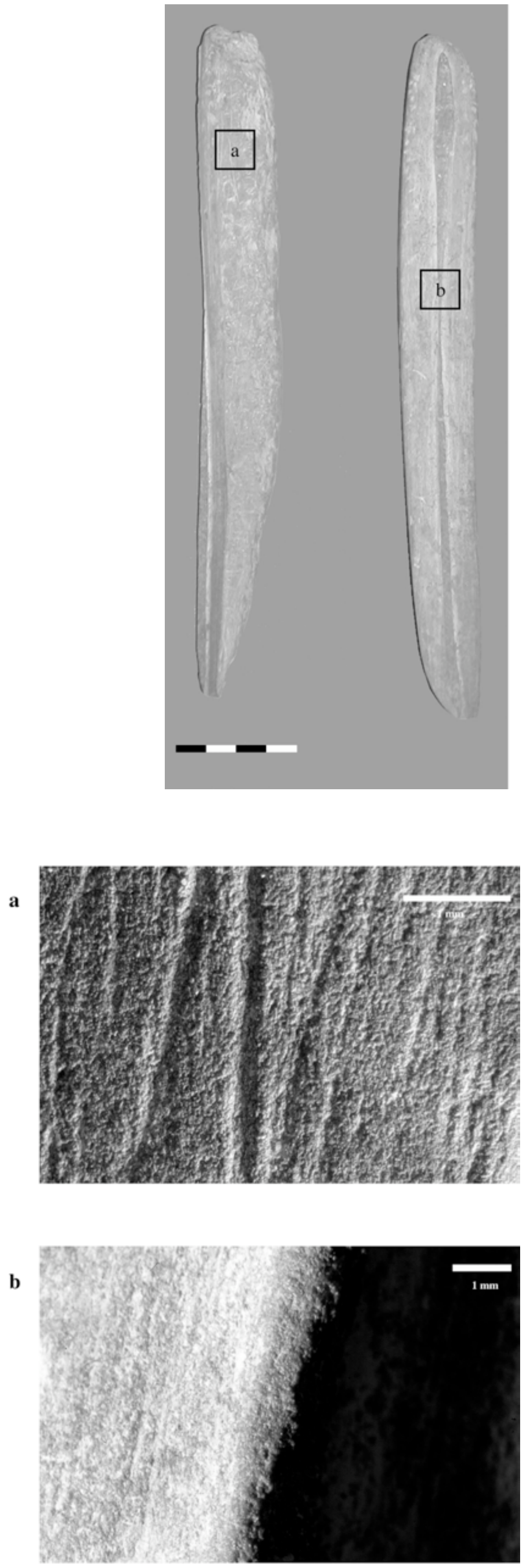


Fig. 19: Sharpener found in Gatas; a) striations; b) edge rounding.

production or, in other words, the introduction of certain property relations, which leads to an unequal distribution of metal products. The new forms of domination and social exploitation emerging in different parts of Europe during the third and early second millennia were apparently linked to the concentration of certain means and skills in the hands of a group of men, which gave them the effective command of the production and circulation of a growing range of weapons, tools and ornaments.

Acknowledgments

We wish to express our gratitude to Robert Chapman, Vicente Lull and Rafael Micó for their useful comments and editing of the text. The investigation of the prehistory of South-East Iberia is supported by the Spanish Ministry of Science and Technology (BHA2003-045546) and by the *Direcció General de Recerca de la Generalitat de Catalunya* (2001SGR000156).

Bibliography

ADAMS, J.L., 1989. Methods for improving ground stone artefacts analysis: experiments in mano wear patterns. *In:* D.A. AMICK AND R.P. MAULDIN, eds. *Experiments in lithic technology*. Oxford: BAR International Series, 528, 259-276.

ADAMS, J.L., 1993. Mechanisms of Wear on Ground Stone Surfaces. *Pacific Coast Archaeological Society Quarterly*, 29(4), 60-73.

BELGIORNO, M.-R., 2002. Does tomb nº 21 at Pyrgos (Cyprus) belong to a blacksmith? *In:* H. PROCOPIU AND R. TREUIL, eds. *Mouldre et Broyer II – Archéologie et Histoire*. Paris: Publicacions du C.R.N.S., 73-80.

BELINSKIJ, A.B. AND KALMYKOV, A.A. 2004. Neue Wagenfunde aus Gräbern der Katakombengrab-Kultur im Steppengebiet des zentralen Vorkaukasus". *In*: M. FAMSA AND S. BURMEISTER, eds. *Rad und Wagen: Der Ursprung einer Innovation – Wagen im Vorderen Orient und Europa*. Mainz: P. von Zabern, 201-220.

BUTLER, J.J. AND VAN DER WAALS, J.D., 1967-68. Bell Beakers and early Metal-Working in the Netherlands. *Palaehistoria*, 12, 41-139.

CASTRO, P., GILI, S., LULL, V., MICÓ, R., RIHUETE, C., RISCH, R. AND SANAHUJA YLL, Mª E., 1998. Teoría de la producción de la vida social. Mecanismos de explotación en el Sudeste ibérico. *Boletín de Antropología Americana*, 33, 25-77.

CASTRO, P., CHAPMAN, R., GILI, S., LULL, V., MICÓ, R., RIHUETE, C., RISCH, R. AND SANAHUJA YLL, Mª E., 1999. *Proyecto Gatas 2. La dinámica arqueoecológica de la ocupación prehistórica*. Sevilla: Junta de Andalucía, Consejería de Cultura.

CHAPMAN, R., 1984. Early Metallurgy in Iberia and the West Mediterranean: innovation. *In:* W. WALDREN, R. CHAPMAN, J. LEWTHWAITE AND R.-C. KENNARD, eds., *The Deya Conference of Prehistory*. Oxford: BAR International Series, 229, 1109-1138.

CHAPMAN, R.W., 2002. *Archaeologies of complexity*. London: Routledge.

CHILDE, V.G., 1930. *The Bronze Age*. Cambridge: Cambridge University Press.

CONTRERAS, F., ed., 2000. *Proyecto Peñalosa: análisis histórico de las comunidades de la Edad del Bronce del piedemonte meridional de Sierra Morena*. Sevilla: Junta de Andalucía.

DELGADO RAACK, S., 2003. *Tecnotipología y distribución espacial del material "macrolítico" del Cerro de la Virgen de Orce (Granada), campañas 1963-1970: una aproximación paleoeconómica.* DEA. Universitat Autónoma de Barcelona.

DUBRUEIL, L., 2002. *Etude fonctionelle des outils de broyage natoufiens: nouvelle perspectives sur l'émergence de l'agriculture au Proche-Orient*, Thesis (PhD). Bordeaux I University.

ÉLEURE, C., 1985. Attention aux pierres de touche. *Bulletin de la Socété Préhistorique Française*, 85, 203-205.

FITZPATRICK, A.P., 2002. 'The Amesbury Archer': a well-furnished Bronze Age burial in southern England. *Antiquity*, 76, 629-30.

FULLAGAR, R., ed., 1998. *A closer look: Recent Australian studies of stone tools*. Sydney: Sydney University Archaeological Methods, Series 6.

GIBAJA, J.A., 2002. Análisis del material lítico tallado de Fuente Álamo. *In*: R. RISCH, ed. *Recursos naturales, medios de producción y explotación social. Un análisis económico de la inudustria lítica de Fuente Álamo (Almería), 2250-1400 antes de nuestra era.* Iberia Archaeologica 3. Mainz: P. von Zabern, 163-177.

GRACE, R., 1989. *Interpreting the function of stone tools*. Oxford: BAR International Series, 474.

HAYDEN, B. 1979. *Palaelithic reflections: lithic technology and ethnographic excavations among Australian Aborigines*. New Jersey: Australian Institute of Aboriginal Studies.

HAYDEN, B. 1987. *Lithic artefacts among the contemporary Highland Mayas*, Tucson.

HAMON, C., 2004. *Broyage et abrasion au Néolithique ancien. Caractérisation technique et fonctionelle de l'outillage en grès du Bassin parisien*, Thesis (PhD). Paris I University.

KEESMANN, I., MORENO ONORATO, A. AND KRONZ, A., 1991-92. Investigaciones científicas de la metalurgia de El Malagón y Los Millares, en el Sureste de España. Cu*adernos de Prehistoria de la Universidad de Granada,* 16-17, 247-302.

LULL, V., 1983. *La cultura de El Argar. Un modelo para el estudio de las formaciones económico-sociales prehistóricas.* Madrid: Akal.

MARTÍNEZ, A., PONCE, J. AND AYALA, Mª M., 1996. *Las prácticas funerarias de la cultura argárica en Lorca, Murcia*. Lorca: Caja de Ahorros de Murcia, Ayuntamiento de Lorca.

MOHEN, J.-P., 1992. *Metalurgia prehistórica. Introducción a la paleometalurgia*. Barcelona: Masson.

MONTERO RUIZ, I., 1994. *El origen de la metalurgia en el sureste de la Península Ibérica*. Almería: Instituto de Estudios Almerienses.

MÜLLER, H.W. AND THIEM, E., 2001. *El oro de los faraones*. Madrid: Libsa.

NOCETE, F., ed., 2004. *Odiel – Proyecto de investigación arqueológica para el análisis del origen de la desigualdad social en el Suroeste de la Peninsula Ibérica*, Sevilla: Junta de Andalucía, Consejería de Cultura.

PERNOT, M., 1998. L'organisation de l'atelier du Bronzier. *In*: C. MORDANT, M. PERNOT AND V. RYCHNER, eds. *L'atelier du bronzier en Europe du XXe au VIIIe siècle avant notre ère*. Paris: CTHS, 107-116.

PLISSON H. AND VAN GIJN, A., 1989. La tracéologie: mode d'emploi. *L'Anthropologie*, 93(3), 631-642.

PROCOPIOU, H., 2004. Le broyage des matières minérals – L'apport de la tribologie à l'identification de la transformation des matières minérales. *Dossiers d'Archeologie,* 290, 58-61.

RISCH, R., 1995. *Recursos naturales y sistemas de producción en el Sudeste de la Península Ibérica entre 3000 y 1000 ANE*. Thesis (PhD). Universidad Autónoma de Barcelona.

RISCH, R. 2002. *Recursos naturales, medios de producción y explotación socail. Un análisis económico de la inudustria lítica de Fuente Álamo (Almería), 2250-1400 antes de nuestra era*. Iberia Archaeologica 3. Mainz: P. von Zabern.

ROVIRA, S. AND DELIBES, G., 2005. Tecnología metalúrgica Campaniforme en la Península Ibérica: coladas, moldeado y tratamiento postfundición. *In:* M. ROJO-GUERRA, R. GARRIDO-PENA AND I. GARCÍA-MARTÍNEZ, eds. *El Campaniforme en la Península Ibérica y su contexto Europeo*. Valladolid: Universidad de Valladolid, 495-521.

SCHUBART, H., PINGEL, V. AND ARTEAGA, O., 2001.*Fuente Álamo, Teil 1: Die Grabungen von 1977 bis 1991 in einer bronzezeitlichen Höhensiedlung Andalusiens*, Madrider Beiträger, 25. Mainz: P. von Zabern.

SEMENOV, S.A., 1981. *Tecnología prehistórica. Estudio de las herramientas y objetos antiguos a través de las huellas de uso*. Madrid: Akal.

SEMENOV, S.A., 1969. Kamenniye orudiya Epokhi rannikh Metallov. *Sovetskaya Arkheologiya*, 2, 3-14. *In*: L. LONGO AND N. SKAKUN, eds., 2005. *The roots of use-wear analysis: selected papers of S. A. Semenov*. Memorie del Museo Civico di Storia Naturale (II serie), Sezione Scienze dell'Uomo, 7. Verona: Cortella Poligrafica, 94-101.

SIRET, L. AND SIRET H., 1890. *Las primeras Edades del Metal en el Sudeste de España*. Barcelona.

STOS-GALE, S., HUNT-ORTIZ, M. AND GALE, N., 1999. Análisis elemental y de isótopos de plomo de objetos metálicos de los sondeos de Gatas. *In:* P. CASTRO, R. CHAPMAN, S. GILI, V. LULL, R. MICÓ, C. RIHUETE, R. RISCH AND Mª E. SANAHUJA YLL, eds. *Proyecto Gatas 2. La dinámica arqueoecológica de la ocupación prehistórica*. Sevilla: Junta de Andalucía, 347-361.

WALDREN, W.H., 1982. *Balearic prehistoric ecology and culture: the excavation and study of certain caves, rock shelters and settlements*. Oxford: BAR International Series, 149.