Rovira, Salvador

Early metallurgy on the Iberian Peninsula

in: Kunst, Michael – Steiniger, Daniel (Hrsg.), Settlement Structures and Metallurgy. The Relations between Italy and the Iberian Peninsula in the Early Chalcolithic. Papers of an International Conference Held in Rome, Museo Nazionale Romano – Palazzo Massimo, 6–7 October 2011, Palilia 33 (Wiesbaden 2021) 169-180.

DOI: https://doi.org/10.34780/qdv3-d4d7

Herausgebende Institution / Publisher:
Deutsches Archäologisches Institut

PALILIA 33

Michael Kunst | Daniel Steiniger (eds.)

SETTLEMENT STRUCTURES AND METALLURGY

The Relations between Italy and the Iberian Peninsula in the Early Chalcolithic

Papers of an International Conference Held in Rome, Museo Nazionale Romano – Palazzo Massimo, 6–7 October 2011

For some considerable time right up to the present, almost all specialists have been dealing at various different regional levels with the topics of the conference published here. The expansion of the source material in the last decades has led to a comprehensive understanding of early metallurgy and its role in social, economic and settlement-structure terms. Despite this far-reaching progress, concrete questions are emerging more and more clearly that can only be answered at international and interdisciplinary levels. It is precisely this international communication that the conference on which the present volume is based has attempted to set in motion so as to address these complex questions. This publication pulls together and sets out the state of research on the topic at the beginning of the 21st century for the entire Central and Western Mediterranean regions.

ISBN 978-3-447-11579-7

9 783447 115797

www.harrassowitz-verlag.de

Michael Kunst | Daniel Steiniger (eds.)

SETTLEMENT STRUCTURES
AND METALLURGY

Palilia 33

DEUTSCHES ARCHÄOLOGISCHES INSTITUT

PALILIA 33

Herausgegeben im Auftrag des Instituts von
Ortwin Dally und Norbert Zimmermann

DEUTSCHES ARCHÄOLOGISCHES INSTITUT

Michael Kunst | Daniel Steiniger (eds.)

SETTLEMENT STRUCTURES AND METALLURGY

The Relations between Italy and the Iberian Peninsula in the Early Chalcolithic

Papers of an International Conference Held in Rome,
Museo Nazionale Romano – Palazzo Massimo, 6–7 October 2011

HARRASSOWITZ VERLAG · WIESBADEN

X, 320 Seiten mit 122 Abbildungen

Library of Congress Cataloging-in-Publication Data
A CIP catalog record for this book has been applied for at the Library of Congress.

Bibliografische Information der Deutschen Nationalbibliothek
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie;
detaillierte bibliografische Daten sind im Internet über https://dnb.de abrufbar.

Verantwortliche Redaktion: Redaktion des Deutschen Archäologischen Instituts, Rom
Redaktionelle Bearbeitung: Luisa Bierstedt und Julia Böttcher

Umschlagfoto: Zambujal, Portugal; Credit: Michael Kunst; Libiola Mine, Italien; Credit: Mark Pearce

Buchgestaltung und Coverkonzeption: hawemannundmosch, Berlin
Prepress: le-tex publishing services GmbH, Leipzig

Otto Harrassowitz GmbH & Co. KG, Wiesbaden · https://www.harrassowitz-verlag.de

ISBN 978-3-447-11579-7

Gedruckt auf säurefreiem und alterungsbeständigem Papier
Printed in Germany

Inhaltsverzeichnis

Vorwort

von *Henner von Hesberg* und *Dirce Marzoli*

Ein offener Dialog, eine einsichtige Darstellung der jeweiligen Arbeitsweisen und die Bereitschaft, den anderen Forschern in die Archive Zugang und in die Ergebnisse eigener Arbeiten Einblick zu gewähren, sind Voraussetzungen eines fruchtbaren Austauschs. Sie führen zu einer vertieften Kenntnis der jeweiligen Erforschung einer archäologischen Epoche, ihrer lokalen Besonderheiten und überregionalen Verbindungen. Ausdruck einer solchen Art von Austausch, der selbst in Zeiten problemloser Kommunikation nicht immer selbstverständlich ist, bilden diese Tagung sowie deren jetzt vorliegende Publikation. Sie erfolgt bedauerlicherweise mit großer Verspätung, aber ihre grundlegende Botschaft ist nicht überholt: nur gemeinsam und länderübergreifend lässt sich das Thema angehen.

Der hier behandelten Kupferzeit Südwesteuropas widmen sich methodisch innovative und interdisziplinär angelegte Projekte, zu denen Ausgrabungen von Siedlungen, Nekropolen, Bergbauarealen ebenso zählen wie Material- und Umweltstudien. Immer komplexer werden dabei auch Einblicke in Gesellschaftsstrukturen, Wirtschaftsweisen, Handelswege und Technologien, zunehmend deutlicher lassen sich zudem die Wege der Übertragung von Fertigkeiten und Produktionsformen nachzeichnen. Einige Ergebnisse liegen schon in internationalen Referenzwerken vor, gleichwohl werden sie im Kontext der Tagung ergänzt und vertieft und um die Forschungsergebnisse aus nicht immer leicht zugänglichen lokalen Publikationen erweitert, welche zudem häufiger lediglich Vorberichte darstellen. Abgesehen davon aber bieten die Beiträge neue Resultate und Interpretationsansätze.

Gerade auf den Gebieten der Siedlungsarchäologie und ihrer Verbindung mit der Montanarchäologie und der Archäometallurgie sind nämlich sowohl auf der Pyrenäen- wie auch auf der Apenninhalbinsel in den letzten Jahrzehnten bahnbrechende Ergebnisse erzielt worden, die nach weiterem Austausch über die Beziehungen zwischen Italien und Südwesteuropa im Chalkolithikum verlangen. Für diese Thematik haben die beiden Abteilungen des Deutschen Archäologischen Instituts – Rom und Madrid –, deren Aktivitäten diesem geographischen Raum vorwiegend gelten, als Veranstalter der Tagung und als Herausgeber der Publikation ein Forum geboten. Mit der Veröffentlichung der Tagung suchen sie der Diskussion im Bereich der Kupferzeitforschung weitere Impulse zu geben.

Die Tagung wurde zwar von den beiden Abteilungen organisiert, aber sie versteht sich als Projekt von Prähistorikerinnen und Prähistorikern aus vielen europäischen Ländern mit dem gemeinsamen Ziel, einen Beitrag zur Kenntnis der westlichen Hemisphäre der europäischen Kupferzeit zu leisten und Anstöße zu weiteren Zusammenarbeiten zu geben. Dabei ging es darum, die sehr unterschiedliche Situation der iberischen mit jener der Apenninhalbinsel zu vergleichen und zu prüfen, ob hier nur der Erkenntnisstand voneinander abweicht oder wir grundsätzlich zwei unterschiedliche Ausprägungen in einem historischen Horizont vor uns haben.

Die Veranstaltung dieser Tagung gewinnt über die fachwissenschaftliche Bedeutung auch eine forschungspolitische. Die Prähistorische Archäologie, die in den Abteilungen des Deutschen Archäologischen Instituts anfangs nur sporadisch und seit den sechziger Jahren in zunehmendem Maße an Bedeutung erlangte, präsentiert sich hier mit einem eigenen Projekt, dessen Anfänge bis in die Zeit der 1954 gegründeten Madrider Abteilung zurückreichen. Zu den Mitarbeitern der ersten Stunde zählte ein Prähistoriker, zu dessen Schwerpunkten die Kupferzeit gehörte: Edward Sangmeister. Ab 1959 war Hermanfrid Schubart als Prähistoriker an der Madrider Abteilung tätig, die er von 1980 bis 1994 leitete. Ihre Forschungen auf diesem Gebiet, vor allem die von ihnen gemeinsam geleitete Ausgrabung in Zambujal bei Torres Vedras in Portugal sind bis heute wichtige Referenzen für die Kupferzeitforschung geblieben. Ihre Namen und der mit ihnen verbundene Grabungsplatz wurden zum Synonym für den Erfolg internationaler Zusammenarbeit, aus der immer weitere Netzwerke hervorgingen. 1994 übernahm Michael Kunst als Referent die prähistorische Forschung der Madrider Abteilung und führte vor allem auch die Grabungen in Zambujal fort.

Das seit 1829 aktive Instituto di Corrispondenza Archeologica war am Anfang ganz den wissenschaftlichen Zielen Johann Joachim Winckelmanns verpflichtet, die in vieler Hinsicht aus einer philologischen Tradition hervorgegangen waren. Deswegen blieben die Zeiträume ohne Schriftzeugnisse zunächst außerhalb der Überlegungen. Erst später, unter dem Einfluss der Entwicklungen in den skandinavischen und angelsächsischen Ländern, kamen einzelne Aspekte der Prähistorie hinzu, konnten aber nie größere Bedeutung erlangen. Immerhin hat Wolfgang Helbig mit seiner 1879 erschienenen

Schrift über „Die Italiker in der Poebene“ sich in diese Bereiche der archäologischen Wissenschaft vorgewagt und damit auch Luigi Pigorini beeinflusst, der seinerseits oft in den Adunanzen des Instituts in jenen Jahren vortrug. Ein gegenseitiger Austausch war vorhanden, aber die Prähistorie in Italien ging bald eigene Wege und das Germanico blieb in der Folgezeit auf die klassische Antike konzentriert, wenn man einmal von der Zeit des Nationalsozialismus absieht, in der aber stärker die Zeit der Völkerwanderung und damit als Wissenschaft die Frühgeschichte an Bedeutung gewann. Spätere Studien von Seiten der Prähistorie, die innerhalb der Abteilung Rom des DAI entstanden, widmeten sich meist der Eisenzeit und ergänzten somit methodisch die Versuche der Klassischen Archäologie, die Frühphasen der späteren Kulturen Italiens zu erschließen. Zu nennen sind hier etwa die 1959 und 1962 erschienenen Werke Hermann Müller-Karpes zu den Anfängen Roms. Später hat Kerstin Hoffmann als Forschungsstipendiatin der Abteilung im Rahmen des von der Gerda-Henkel-Stiftung geförderten Projekts zu den einheimischen Kulturen in Italien sehr intensiv den internen Dialog gefördert. Aber erst mit Daniel Steininger 2006 startete dann ein eigenständiges Projekt, das mit den traditionellen Forschungsfeldern der Abteilung Rom nichts mehr zu tun hatte und ganz im Chalkolithikum angesiedelt war.

Darin kommt ein umfassender Wandel in den Methoden und der Organisation von Forschung innerhalb des Deutschen Archäologischen Instituts zum Ausdruck, der jüngst zu vielen Veränderungen geführt hat, etwa in der sogenannten Bildung von Clustern, also die Abteilungen übergreifenden Forschungsverbünden. Damit die unterschiedlichen Abteilungen des Instituts in den verschiedenen Kulturregionen Europas und der ganzen Welt untereinander weiterhin einen fruchtbaren Austausch pflegen können, zugleich aber auch für ihre Partner an den diversen Universitäten und übrigen Forschungsstätten anschlussfähig bleiben, muss die Konzentration auf einzelne archäologische Disziplinen zugunsten einer breiteren Fächerung erweitert werden. Dadurch ist es möglich, verschiedene historische Horizonte und Epochen etwa im Bereich des Mittelmeeres, aber auch darüber hinaus, in ihren Gemeinsamkeiten und Unterschieden in den Blick zu bekommen. Zugleich profitieren die Disziplinen voneinander durch ihre methodische Vielfalt.

In einer solchen engen Verschränkung kann die Arbeit des Instituts eine wirkungsvolle Ergänzung zu dem Studien- und Forschungsbetrieb der Universitäten bilden, in denen bei aller Interdisziplinarität durch die Studienerfordernisse und Fächerdefinitionen die Grenzen stärker bewahrt werden müssen.

Die Tagung mit ihrer Thematik stellt einen weiteren Schritt in diese Richtung dar und bezeugt zugleich Öffnung und neue Verbindungen, die dadurch möglich sind. Ihr Konzept haben Daniel Steiniger und Michael Kunst gemeinsam entworfen. Beide beschäftigen sich vorrangig mit der Kupferzeit und beide stammen von der Universität Freiburg, wo der eine 2007 und der andere 1982 promoviert hat, womit sie wiederum in der mittelbaren Tradition Sangmeisters stehen.

Ihnen gilt unser besonderer Dank. Danken möchten wir auch Patrizia Petitti und Christian Strahm für die Mitarbeit zur Vorbereitung der Tagung im wissenschaftlichen Komitee sowie allen jenen Kolleginnen und Kollegen, die durch Vortrag, Diskussion und schriftlichen Bericht zum Erfolg des Unternehmens beigetragen haben. Auch an alle anderen, die sich an der Betreuung der Tagung und an der Redaktion beteiligt haben, richtet sich unser Dank. Für die finanzielle Förderung gilt der Fritz Thyssen Stiftung unser besonderer Dank. Hervorheben möchten wir schließlich die Gastfreundschaft von Rita Paris und Anna Maria Moretti, die für die Tagung am 6. und 7. Oktober 2011 ihren schönen Vortragssaal im Palazzo Massimo in Rom zur Verfügung stellten.

Henner von Hesberg, Rom, und Dirce Marzoli, Madrid, Januar 2013

Early Metallurgy on the Iberian Peninsula

by *Salvador Rovira*

Introduction

When speaking or writing about early metallurgy it is often observed that the authors refer to an extended period of time comprising the Copper Age, Bronze Age and, occasionally, the Iron Age, which is usually understood as Late Prehistory in Europe. Despite the fact that there are many common technological features along such a period (particularly on the Iberian Peninsula), we will try to be more restrictive in the use of the concept "early metallurgy", limiting it to the Chalcolithic period, i. e. referring to copper metallurgy that developed on the Iberian Peninsula during approximately the 3rd millennium cal BC.

There is some evidence of early metallurgy in the Neolithic phase of Cerro Virtud (Almeria) site, where a fragment of a crucible was found with weak porous slag incrustations on the inside in which, when analyzed by XRF, the signal of copper could be identified[1]. Although so far no other traces of such early metallurgy have been found, it is reasonable to ask whether the metallurgy of Cerro Virtud, a site located within a major mining area near the southwestern Spanish coast, emerged as a result of an autochthonous discovery or due to a phenomenon of technology transfer from abroad. Delibes and Montero dedicated a documented article to this interesting problem[2]. From that time among the countries surrounding the Iberian Peninsula no other site is known with the same or older date than Cerro Virtud, which leaves the way open to the hypothesis that first metallurgy could have been a consequence of the autonomous development of an advanced Neolithic society, following the same steps that were given some thousands of years before at the other end of the Mediterranean: from the copper objects from Çäyonü Tepesi (Turkey)[3] to the first metallurgical slags in the Levant dating to the late 6th millennium BC[4]. The "oriental model", which explains the origins of metallurgy, has attributed an important role to the ornamental use of green and blue stones in the inception of metallurgy, particularly malachite and azurite because of their proximity to native copper with which these minerals frequently lie in paragenesis in mineral deposits.

Exploitation of ornamental stones during the Neolithic is represented on the Iberian Peninsula by one of the most spectacular examples: the complex variscite mines at Can Tintorer (Gava, Tarragona)[5]. However, although there is no doubt about the ability of the Neolithic miners to extract minerals from the subsoil, we have no archaeological evidence (for now) which allows for correlating this activity on the Iberian Peninsula with the use of native copper. Thus, the series of events that allegedly happened in the Levant is still incomplete.

Without renouncing the hypothesis that the southeast of the Iberian Peninsula could have been an autonomous focus for the invention of copper metallurgy in the Western Mediterranean[6], we must take into account the discoveries that have come to light on the Italian Peninsula some years ago as for example that copper mining in Liguria dates back to the mid-4th millennium cal BC[7]. These are undoubtedly important findings that may justify our revisionist attitude.

Several Italian slag samples, almost all coming from sites dated to the 3rd millennium cal BC, have been tested a few years ago[8]. However, two of the samples, those from the Ligurian sites of Orti Bottagnone and San Carlo, may be older, contemporary to the Monte Loreto mines[9].

This is not the place to discuss these interesting Italian finds. As for now, we only want to emphasize the importance of slag because it is the best indicator, if not the only indicator of metallurgical activity oriented towards metal extraction from ore and the presence of metal objects does not imply metallurgical practices *in situ*.

The greater volume of information now available has been obtained in the course of the Proyecto de

1 Ruiz Taboada – Montero 1999.
2 Delibes – Montero 1997.
3 Maddin et al. 1991.
4 Roberts et al. 2009. For a summary of the oldest insights see Hauptmann 2007, 157 f.
5 Villalba et al. 1986; Bosch 2005.
6 A broader discussion on this topic can be seen in Rovira 2017, 173–176.
7 Maggi – Pearce 2005; see also Dolfini 2010 and Dolfini 2014.
8 Artioli et al. 2007.
9 Artioli et al. 2007, 3.

Investigación Arqueometalúrgica de la Península Ibérica, a project focusing on the problems of prehistoric metallurgy but also on studies of later times[10]. The overall picture has been substantially expanded in recent years through the work of the research group of the Intituto Tecnológico e Nuclear de Portugal and its associated projects, whose recent contributions have filled gaps in Portuguese prehistoric metallurgy.

Early Archaeometallurgical Debris

Metallurgical activity, even when done on a small scale, is a dirty one that often leaves many residues in the place where it is practiced. The preparation of the ore for its reduction requires the use of crushers and often leaves scattered many fragments of such ore and gangue in the process. The actual reduction is done in some kind of fire structure that can take different forms, from a simple open fire to a true metallurgical furnace. This reduction requires charcoal as fuel and the emission of carbon monoxide (the proper reducer gas). From charcoal combustion results a certain amount of ash and many fragments of incompletely burned charcoal that remain around the working area. The result of ore reduction is metal and slag. Last but not least, fragments of metallurgical ceramics such as crucibles, furnace lining and other siliceous materials are also found in thermally altered condition.

Among all these pyrometallurgical remains, slag is the waste product providing best information about the technology applied and is the main evidence to speak confidently of metallurgical practices for obtaining metal[11]. Strictly speaking we can say that without a proper study of the slag we can not speak with certainty of metallurgy.

Copper Ore Resources in Spain

The Iberian Peninsula is the European region with the highest territorial density of oxidic copper ores (cuprite, malachite, azurite, etc.) (fig. 1)[12]. This has led to intense exploitation until recently, so the current mining landscape has profoundly altered the ancient landscape in areas like the Pyrite Belt in the Southwest, Sierra Morena, Almeria and in other regions where mining was an important economic resource. It must be said, however, that outside the major copper fields there are many outcrops of small mineral veins, some still intact for lack of industrial interest. After exploitation, small ditches or short galleries of these mines have remained, suggesting short-term holdings, probably not prehistoric.

The characteristics of the ore fields, the vast majority visible on the soil surface and subsequently intensely worked in recent times, make it very difficult to locate prehistoric works. An important exception is the mine El Aramo (Asturias), consisting of a complex network of galleries, whose exploitation started at the end of Chalcolithic and continues along the Bronze Age[13]. By contrast, the Loma de la Tejeria mine (Albarracin, Teruel) is a good example to illustrate the difficulty of assigning a prehistoric chronology to small open-cast works. Although most of the ore from this mine has been mined in modern times, a few archaeological remains scattered in the vicinity have allowed recognizing exploitation in the Bell-Beaker phase[14].

In the Southwestern Pyrite Belt numerous surface surveys have been carried out which have resulted in the location of mining tools and other evidence of ancient mining, whose age is difficult to determine[15]. But the existence of numerous Chalcolithic sites and the archaeometric studies performed on materials of some of them speak eloquently, albeit indirectly, of mining practices in the area in the 3rd millennium BC[16]. The same is true for the copper fields of Murcia and Almeria, in which

10 Rovira 2011.
11 For further information on pyrometallurgical materials see Montero Ruiz 2010.
12 More detailed information in Galán – Mirete 1979.
13 Blas Cortina 2005, 203.
14 Montero Ruiz – Rodríguez de la Esperanza 2008.
15 Hunt Ortiz 2003, 111–142.
16 Rodríguez Bayona 2008.

1 Main areas bearing oxidic copper ores in Spain

important Chalcolithic settlements such as Almizaraque and Los Millares are located[17].

Good information as to the species of copper ores used by Chalcolithic metallurgists is available from the XRF- and XRD-analysis of samples found in archaeological sites themselves or in nearby mines[18]. The copper minerals identified are mostly oxidic species: malachite, azurite, pseudomalachite, cuprite, tenorite, paramelaconite and others. However, it should be noted, and this is important, that although there is evidence of use of almost pure copper minerals, most ores show a complex polymetallic content with more significant arsenic compounds such as olivenite, xenevixite, conichalcite and others. Iron-oxide content and other minerals of the host rock are highly variable. Some samples contain a proportion of copper sulphides such as digenite, covellite, pyrite, chalcopyrite and other accompanying oxidic species, giving them fahlore characteristics[19].

The polymetallic nature of copper minerals played an important role in the production of non-intentional arsenical copper alloys in Spanish prehistory[20].

Early Copper Slags

The definition of industrial metallurgical slag used, for example, by H. G. Bachmann in his popular booklet on archaeological slags is not well suited to archaeological reality of earliest slag. That definition implies that slag is the result of an intentional action of smelters to collect impurities from ore, gangue, charcoal ash and a reaction

17 Montero Ruiz 1994.
18 Rovira 2002, 86 tab. 3; Murillo-Barroso et al. 2017, 1544 f.
19 Mueller et al. 2006, 212.
20 Rovira 2005, 16–19; Rovira 2017, 178–182.

vessel in which the reduction occurs, thus separating the metal. Slag should therefore be a material which is not mixed with the metal to be extracted. To optimize separation, slag must be of low viscosity and fluid at the working temperature of the furnace[21].

As we shall see, the oldest Iberian slag fails to fit any of these requirements and, if one were to use Bachmann's classification, it should be classified as furnace conglomerates[22], not as slag.

The correct understanding and interpretation of early slags from the chemical and metallurgical point of view has developed gradually over the last ten or fifteen years as a result of modern excavations and the formation of multidisciplinary research teams[23].

Chalcolithic slags are usually small in size, varied in colour and appearance (fig. 2), with weights seldom exceeding a few tens of grams or less. They are very complex from the structural and mineralogical standpoint, composed of relicts of copper ore, gangue minerals and metallic prills, all embedded in a melt which, in turn, tends to have different compositions within the same sample (fig. 3). Unreacted minerals indicate that the chemical processes occurring during the reduction took place within a global not-in-equilibrium system. They are immature slags when compared with fayalite slags obtained in later most developed smelting processes[24].

Among the unreacted minerals we usually found copper oxide (sometimes partially or completely re-oxidized to malachite) and silica or silicates from the gangue and the container where the reduction was practiced.

A portion of the slag usually reached the necessary conditions to melt and produce new silicates by the reactions occurring among original minerals, container walls and contributions from the ashes of the charcoal used as fuel for heating and as provider of the reducing agent (carbon monoxide). The molten material is usually a silicate or aluminosilicate containing varying amounts of iron, calcium, sodium, potassium and magnesium oxides. Its composition and the overall composition of the slag, is closely tied to the mineralogy of the raw materials used[25]. Figure 4 shows the compositions of a series of Chalcolithic slags represented in the CaO-FeO-SiO2 ternary diagram. Most of the points are scattered on top of the diagram, many of them falling within the area corresponding to pyroxenes, which justifies that such slags are called pyroxene-type to be distinguished from latter fayalite slags.

Quartz is usually the most abundant unreacted mineral in Spanish slags. Typically, the grains have rounded surfaces due to their dissolution when forming the melt. Occasionally it has been observed that, at high temperatures, changes occur in quartz in solid state, which is then transformed into cristobalite and tridymite that is separated from the surface of the solid grains as microscopic rods that dissolve in the bath (fig. 5).

In the molten part of the slag, depending on its composition, crystals of different minerals, pyroxene (wollastonite, hercynite, diopside, hedenbergite) and feldspars (albite, anorthite, monticellite, plagioclase) are formed when cooling (fig. 6). In iron-rich slag, small redoubts of fayalite have been observed but never as the predominant mineral phase.

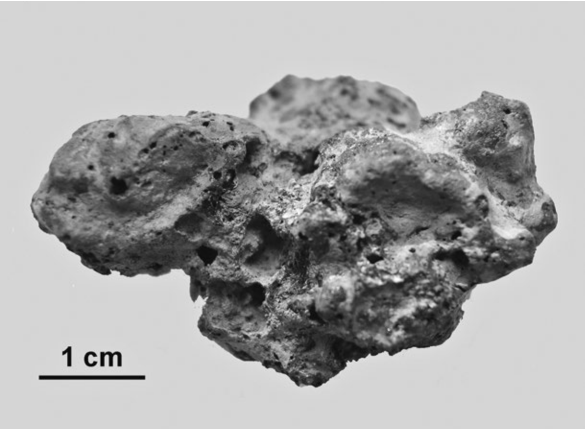
These slags usually show strong magnetism due to the presence of magnetite and other ferromagnetic compounds. The kinetics of such reactions can be seen in detail in Hauptmann[26] and involve slightly oxidizing conditions in the system. Figure 7 illustrates this process: the pyroxene existing in the molten slag is decomposed into cristobalite, tridymite and magnetite, taking the characteristic microstructure of an eutectic phase.

Another abundant mineral is cuprite. When magnetite is in the system, a reaction takes place between cuprite and magnetite to produce another characteristic mineral of Chalcolithic slags: delafossite (fig. 8).

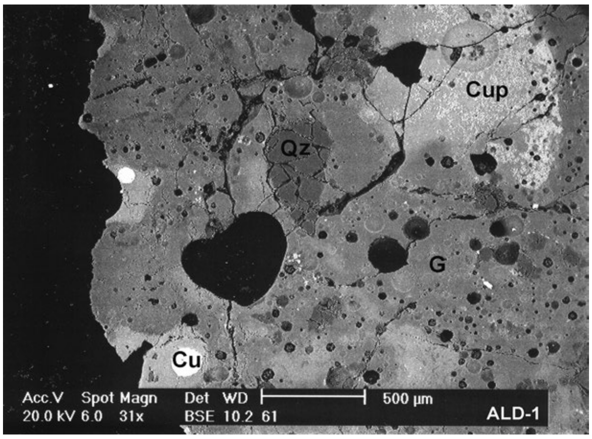
In the previous section, when describing the copper resources of the Iberian Peninsula, we said that one of the characteristics of the copper mineralization is its marked polymetallic nature, particularly for its high content of arsenic as olivenite, chenevixite, conichalcite and others. This is reflected in the slag, where remnants of original mineral or secondary arsenical compounds are detected (fig. 9). Analyses of metallic inclusions in such slags show a highly variable arsenic content: from practically pure copper to percentages higher than 15% of arsenic[27].

Finally, another feature of these slags is its remarkable retention of copper mineral as well as metal prills trapped in the dross. Following the model used by A. Hauptmann[28], with some modifications, we have represented the bulk compositions in a ternary diagram (fig. 10). The points are scattered all over the graph indicating a total lack of standardization that deserves no further comment. In any case it should be noted that this is a feature also present in primitive slag from the Levant[29].

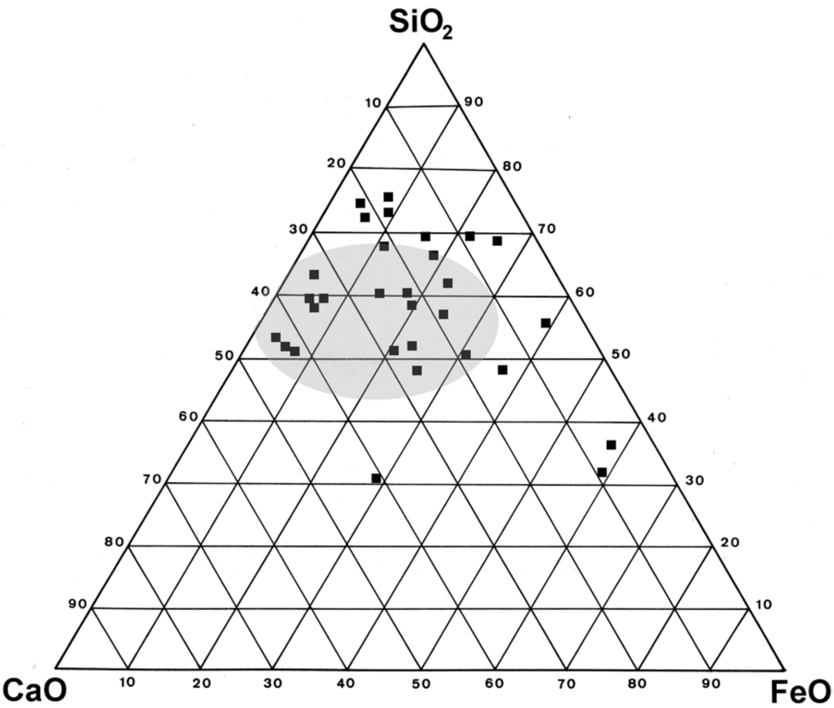
21 Bachmann 1982, 9 f.
22 Bachmann 1982, 21.
23 An updated synthesis on copper archaeometallurgy is in Hauptmann 2007. For the Iberian Peninsula, see Rovira 2002 and Rovira 2016.
24 These aspects have been extensively documented in previous studies; see Hauptmann 2007 and Rovira 2002.
25 See some compositions of these materials in Rovira – Gómez Ramos 1998, 71–73 and Rovira 2002, 95 tab. 7.
26 Hauptmann 2007, 170 f.
27 See Rovira 2003/2004, 97 f. tab. 10.
28 Hauptmann 2003, 461 fig. 1.
29 Hauptmann 2003, 461 fig. 1.



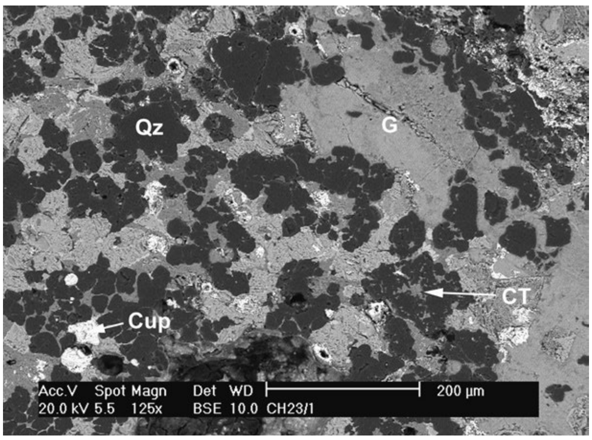
2 Slag from the chalcolithic site of Los Millares (Almeria)



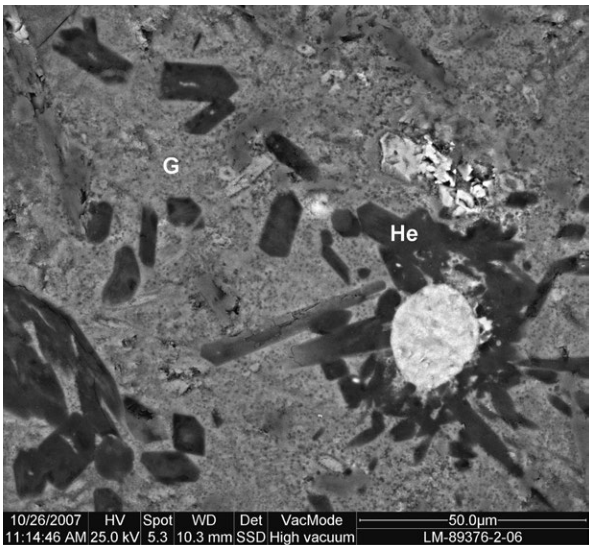
3 Slag from Aldeagordillo (Avila). Complex structure consisting of a glassy matrix (G) in which undecomposed silica (Qz), cuprite (Cup) and copper prills (Cu) are embedded. SEM picture, backscattered electrons



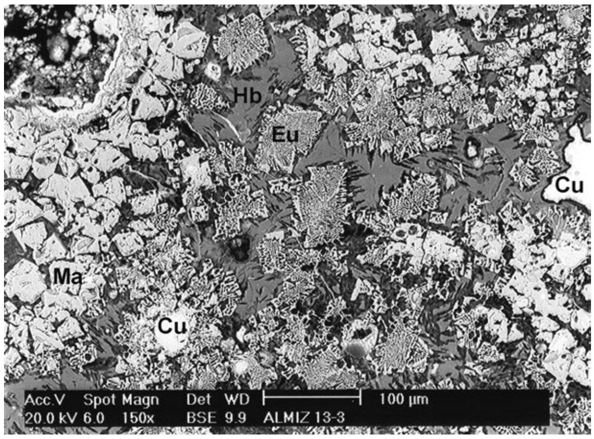
4 Compositions of molten material in the slags represented in the ternary diagram CaO-FeO-SiO2. The shaded area aproximately corresponds to pyroxenes



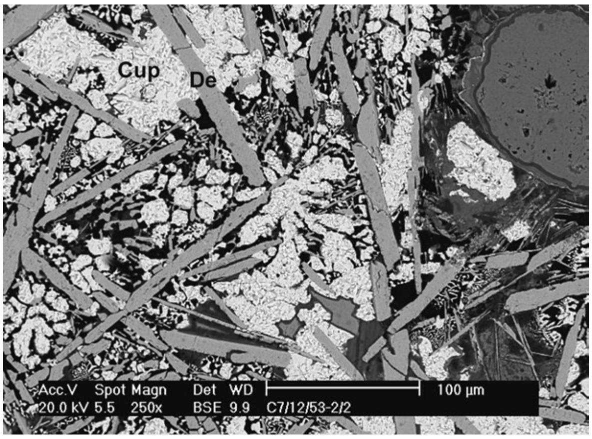
5 Slag from San Blas (Cheles, Badajoz). Undecomposed silica (Qz) showing the transformation to cristobalite-tridymite (CT) in some places. The melt is a glassy matrix (G) with interspersed cuprite (Cup). SEM picture, backscattered electrons



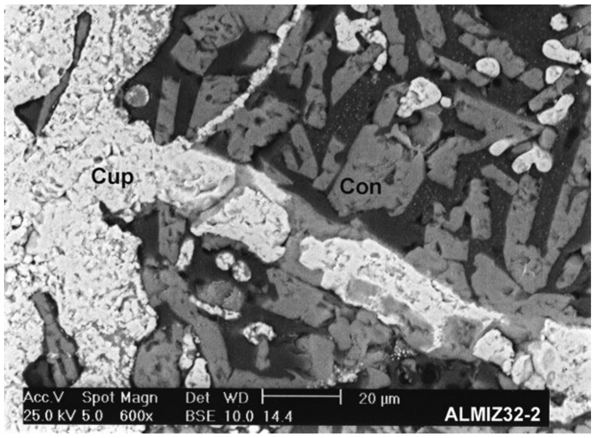
6 Slag from Los Millares (Almeria). Crystals of hedenbergite (He) interspersed in a glassy matrtix (G). SEM picture, backscattered electrons



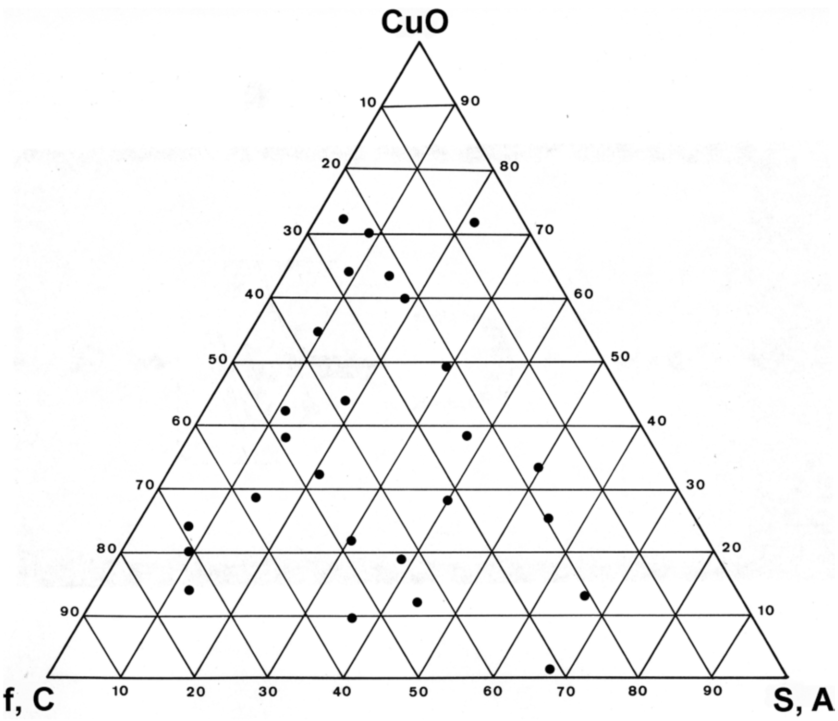
7 Slag from Almizaraque (Almeria). The pyroxene (hedenbergite, He) is decomposed in magnetite (Ma). A phase of eutectic magnetite-cristobalite-tridymite is visible (Eu). (Cu) copper prills. SEM picture, backscattered electrons



8 Slag from San Blas (Cheles, Badajoz). Columnar delafossite (De) and cuprite (Cup). SEM picture, backscattered electrons



9 Slag from Almizaraque (Almeria). Cuprite (Cup) and conichalcite (Con). SEM picture, backscattered electrons



10 Coper content as metal and oxides (analyzed as CuO) in slags from the Iberian Peninsula plotted in the ternary diagram CuO – f, C – S, A. f = FeO + MnO; C = CaO; S = SiO_2; A = Al_2O_3

In summary, we can say that Chalcolithic slags are immature ones that have not completely melted. Solid inclusions give the material a high viscosity, which prevents the separation of the metal that is formed, which is trapped in them, making necessary hand grinding of the slags to select metal portions visible to the naked eye. This partly explains why the amount of slag found at archaeological sites is so small[30].

Although, as noted above, the slags retain much copper and copper ore, the extraction efficiency was certainly acceptable. The experimental replications simulating working conditions similar to those in Chalcolithic times indicated yields ranging between 25% and 50% after smelting ores with grades between 10% and 30% of copper[31]. Obviously, the yield increases as the copper richness does, to the extent that if pure malachite is reduced all the metal is extracted and no slag is formed[32]. Consequently, the higher the purity of the ore the lower the production of slag. The re-smelting of crushed slag still containing copper to extract more metal increases the efficiency of recovery, an idea already launched by Merkel[33] after performing studies of slags from Timna (Israel).

Early Fire Structures for Metallurgy

Certain minerals insistently found in the Chalcolithic slag, such as magnetite and delafossite, and the formation of cuprite outer layers wrapping copper prills embedded in the slag suggest that environmental conditions during the smelting process were not always reducing but often oxidant ones. Such conditions do not appear to correspond to those of a closed metallurgical furnace but are more typical of an airy open fire, fed with charcoal or dry wood.

In previous excavations of Chalcolithic settlements, fire structures related to extractive metallurgy have not been clearly identified, although some old publications talk openly of furnaces and even hypothetical structures were drawn[34]. In reality, however, in relatively recent excavations of sites such as Almizaraque, which had metallurgical debris scattered on the floors of all the huts, no traces of furnaces could be found[35].

The first fire structure well identified related to copper metallurgy was unearthed in Los Millares, in the middle of a hut attached to the inside of the third line of walls (fig. 11). Paul Craddock[36] described its role considering it a domestic fireplace similar to the ones found in other contemporary Chalcolithic sites[37], but in this case used for metallurgical purposes. It consists of a well preserved outer ring of clay of about one meter in diameter and a few centimetres in height, with a hole in the centre of about 30 cm in diameter and 20 cm depth.

Framed within a chronological span that extends from the beginning to the end of the 3rd millennium cal BC, Cabezo Jure (Huelva) is an interesting site that their excavators consider highly specialized in the production of copper. The site has provided a succession of fire structures associated with the reduction of copper minerals. There are no published detailed plans for the moment and the only available information are general descriptions and multiple photos, in which it is not always possible to match literature and graphic image[38]. The best preserved, and apparently the most advanced one shows roughly circular structures that can reach more than one meter outside diameter and is thick-walled (about 40 cm) leaving an internal cavity of up to 62 cm in diameter and a conserved depth of about 30 cm. The chemical and mineralogical characteristics of the slags from Cabezo Jure[39] are similar to those of other Chalcolithic sites, from which it follows that the process of obtaining copper is not substantially different from that used at other contemporary sites[40].

Finally, recent excavations carried out a few years ago in the vast settlement of Valencina de la Concepcion

30 Based on this idea, a flow chart of a chaîne-apératoire model was developed, applied to the metallurgy of La Capitelle du Broum (Peret, France), that we believe may be of general application to all Chalcolithic metallurgy. See Ambert et al. 2009, 294 fig. 8.
31 Rovira 1999, 104–108.
32 This is a logical deduction from stoichiometric equations governing the reduction and have been repeatedly verified experimentally.
33 Merkel 1990, 116.
34 See a synthesis on this subject in Rovira 2003/2004, 152 f.
35 Delibes et al. 1986.
36 Craddock 1995, 133.
37 See a picture of a domestic fireplace from the Las Angosturas (Granada) in Rovira – Renzi 2010, 97 fig. 6.
38 Nocete et al. 2004a, 122–127 fig. 7.12; Nocete et al. 2004b, 280–282 figs. 13,6; 13,7; 13,8.
39 Sáez et al. 2003.
40 Rovira 2016.

11 Metallurgical hut at Los Millares (Almería). Observe the circular fire structure

(Seville) have uncovered a large area with multiple evidence of metallurgical activity radiocarbon dated to 2800–2000 cal BC[41]. Basically there are two types of structures: the larger ones are irregular plan pits, though circular in trend, with diameters between 90 and 130 cm and depths between 40 and 60 cm[42], reminiscent, at least formally, of the metallurgical pits of Ross Island (Ireland) mine[43]. To the second type belong circular adobe structures similar to those of Cabezo Jure[44]. More than 16 kg of pyroxene-type slag have been collected.

Smelting Crucibles

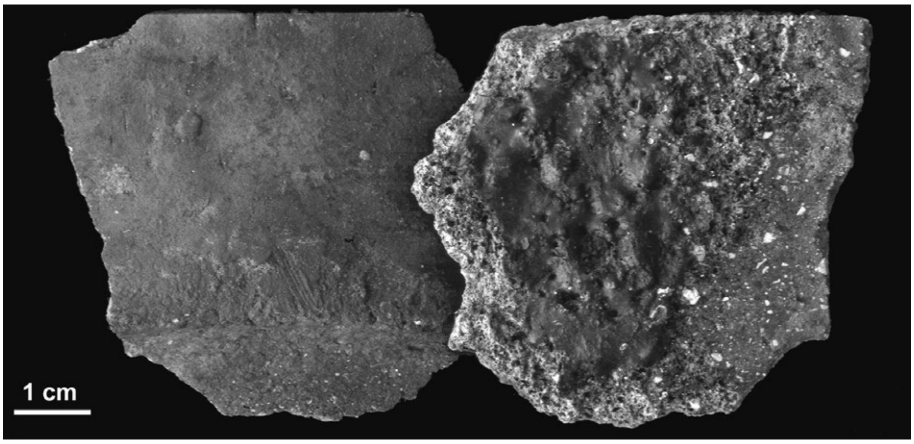
Associated with the above-described fire structures are always ceramic vessel fragments showing a slaggy layer adhered to there inner face (fig. 12). At some other sites such as Almizaraque (Almeria), although these fragments are abundant, no specific fire structure could be identified so far, which emphasizes the domestic character of metallurgical practices.

The sizes and shapes of these containers, as suggested by the fragments, are varied. Generally they are shallow open vessels, some of which have been reconstructed[45]. Although their diameter rarely exceeds 30 cm, there is at least one vessel whose diameter exceeds 40 cm, reconstructed from several significant fragments. It comes from the site La Ceñuela (Murcia), from an Early-Bronze context (fig. 13). In fact, there are pots with 15 cm in diameter or lesser.

When we began analyzing the collection of sherds from Almizaraque in 1984, there were few archaeometallurgical studies that could serve as guidance[46]. Still imbued by the prevailing idea that extractive metallurgy required the use of furnaces, we draw the initial hypothesis that these vessel fragments should correspond to a kind of furnace lining or to a crucible placed into the furnace[47]. Deeper analytical work led us then to hypothesize that they were smelting vessels within which the transformation of ore to metal took place[48].

One of our concerns at the end of the decade of the 1980s was the lack of information regarding this subject in other parts of the Old World. Could it have been a specific technology on the Iberian Peninsula? A reassuring answer to this disturbing question came a few years later when analytical data from the mining area of Feinan (Jordan)

41 Nocete et al. 2008, 720.
42 Nocete et al. 2008, 719.
43 O'Brian 2004, 272–273 figs. 54–61.
44 Nocete et al. 2008, 725.
45 See some reconstructions in Montero Ruiz 1993, 51 fig. 3.
46 See the synthesis published by Zwicker et al. 1985.
47 Delibes et al. 1989, 88.
48 Rovira 1989; Delibes et al. 1991, 306 f.



12 Smelting crucible fragment from Almizaraque (Almería). Observe the slag adhered to the inner surface (right)

13 Reconstructed large smelting crucible from La Ceñuela (Murcia). Museo Arqueológico Nacional, Madrid

began to be published with the result that in the earliest phase corresponding to the beginnings of Chalcolithic metallurgy, in sites like Wadi Fidan 4 smelting crucibles were already used by the second half of the 4th millennium BC[49]. The Proyecto de Arqueometalurgia de la Península Ibérica has analyzed smelting crucibles from many Spanish Chalcolithic sites, and probably represents the most important European database today[50].

The slaggy layers of these crucibles are chemically and mineralogically similar to the slags above described[51].

Conclusion

Chalcolithic metallurgy on the Iberian Peninsula shows traits of a primitive technology, a phenomenon that has been observed in other regions where detailed studies have been conducted, namely Jordan, Iran, France, Italy and the Balkan region. However, in Europe there are many regions for which reliable information is not yet available.

The use of smelting pots is an efficient and simple method that does not require a complex infrastructures. No significant technological change in copper obtaining has been observed on the Iberian Peninsula along the 3rd millennium BC and, what is more interesting, the good adaptation of technology to the social need for metal ensured that smelting crucibles continued to be used until almost pre-Roman times[52]. This adaptation should have had a positive influence on the abundance of available mineral resources and their good quality, making unnecessary the adoption of other more complex technologies.

49 Hauptmann et al. 1996.
50 First complete analyses started to be published in Rovira 2002. Semi-quantitative bulk analyses are also available in Rovira et al. 1997.
51 Rovira – Ambert 2002.
52 Rovira 2005.

Bibliography

Ambert et al. 2009 P. Ambert – V. Figueroa – J. L. Guendon – V. Klemm – M. Laroche – S. Rovira – Ch. Strahm, The Copper Mines of Cabrières (Hérault) in Southern France and the Chalcolithic Metallurgy, in: T. L. Kienlin – B. W. Roberts (eds.), Metals and Societies. Studies in Honour of Barbara S. Ottaway, UPA B 169 (Bochum 2009) 285–295

Artioli et al. 2007 G. Artioli – I. Angelini – E. Burger – D. Bourgarit – F. Colpani, Petrographic and Chemical Investigations of the Earliest Copper Smelting Slags in Italy. Towards a Reconstruction of the Beginning of Copper Metallurgy. Proceedings of the 2nd International Conference "Archaeometallurgy in Europe 2007", Aquileia, 17–21 June 2007 (Milan 2007), CDROM edition, not paginated

Bachmann 1982 H.-G. Bachmann, The Identification of Slags from Archaeological Sites (London 1982)

Blas Cortina 2005 M. A. de Blas Cortina, Un témoinage probant de l'exploitation su cuivre dans le nord de la Péninsule Ibérique. Le complexe minier d'El Aramo (Asturies), in: P. Ambert – J. Vaquer (eds.), La première métallurgie en France et dans les pays limitrophes. Actes du colloque international, Carcasonne, 28–30 Septembre 2002, Société Préhistorique Française, Mémoire 37 (Joué-les-Tours 2005) 195–206

Bosch 2005 J. Bosch, Les techniques d'exploitation des plus anciennes mines d'Europe méditerranéenne; l'exemple de Gavà, Barcelone, in: P. Ambert – J Vaquer (eds.), La première métallurgie en France et dans les pays limitrophes. Actes du colloque international, Carcasonne, 28–30 Septembre 2002, Société Préhistorique Française, Mémoire 37 (Joué-les-Tours 2005) 207–210

Craddock 1995 P. T. Craddock, Early Metal Mining and Production (Edinburgh 1995)

Delibes et al. 1986 G. Delibes – M. Fernández-Miranda – M. D. Fernández-Posse – C. Martín, El poblado de Almizaraque, in: Homenaje a Luis Siret 1934–84 (Sevilla 1986) 167–177

Delibes et al. 1989 G. Delibes – M. Fernández-Miranda – M. D. Fernández-Posse – C. Martín Morales – S. Rovira Llorens – M. Sanz, Almizaraque (Almería). Minería y metalurgia calcolítica en el Sureste de la Península Ibérica, in: C. Domergue (eds.), Minería y metalurgia en las antiguas civilizaciones mediterráneas y europeas 1. Coloquio Internacional Asociado, Madrid 24–28 Octubre 1995 (Madrid 1989) 81–96

Delibes et al. 1991 G. Delibes – M. Fernández-Miranda – M. D. Fernández-Posse – C. Martín – I. Montero – S. Rovira, Almizaraque (Almería, Spain), in: J. P. Mohen – Ch. Éluère (eds.), Découverte du métal (París 1991) 303–315

Delibes – Montero 1997 G. Delibes – I. Montero, Els inicis de la metal.lúrgia a la Península Ibèrica. Transferència de tecnologia o descobriment autònom?, Cota Zero, Revista d'Arqueologia i Ciència 13, 1997, 19–28

Dolfini 2010 A. Dolfini, The Origins of Metallurgy in Central Italy. New Radiometric Evidence, Antiquity 84(325), 2010, 707–723

Dolfini 2014 A. Dolfini, Early Metallurgy in the Central Mediterranean, in: B. W. Roberts – Ch. P. Thorton (eds.), Archaeometallurgy in Global Perspective. Methods and Synthesis (New York 2014) 473–506

Galán – Mirete 1979 E. Galán – S. Mirete, Introducción a los minerales de España (Madrid 1979)

Hauptmann 2003 A. Haptmann, Rationales of Liquefaction and Metal Separation in Earliest Copper Smelting. Basics for Reconstructing Chalcolithic and Early Bronze Age Smelting Processes. Proceedings of Archaeometallurgy in Europe 1, Milan 24–26 September 2003 (Milan 2003) 459–468

Hauptmann 2007 A. Hauptmann, The Archaeo-Metallurgy of Copper (Berlin 2007)

Hauptmann et al. 1996 A. Hauptmann – H. G. Bachmann – R. Maddin, Chalcolithic Copper Smelting. New Evidence from Excavations at Feinan, Jordan, in: S. Demirci – A. M. Özer – G. D. Summers (eds.), Archaeometry 94. The Proceedings of the 29th International Symposium on Archaeometry in Ankara, 9–14 May 1994 (Ankara 1996) 3–10

Hunt Ortiz 2003 M. A. Hunt Ortiz, Prehistoric Mining and Metallurgy in South West Iberian Peninsula, BARIntSer 1188 (Oxford 2003)

Maddin et al. 1991 R. Maddin – T. Stech – J.D. Muhly, Çäyonü Tepesi. The Earliest Archaeological Metal Artifacts, in: Ch. Éluère – J. P. Mohen (eds.), Découverte du Métal (Paris 1991) 375–386

Maggi – Pearce 2005 R. Maggi – M. Pearce, Mid Fourth-Millennium Copper Mining in Liguria, North-West Italy. The Earliest Known Copper Mines in Western Europe, Antiquity 79(303), 2005, 66–77

Merkel 1990 J. Merkel, Experimental Reconstruction of Bronze Age Copper Smelting based on Archaeological Evidence from Timna, in: B. Rothenberg (ed.), The Ancient Metallurgy of Copper. Archaeology – Experiment – Theory. Researches in the Arabah 1959–1984, 2 (London 1990) 78–122

Montero Ruiz 2010 I. Montero Ruiz (ed.), Manual de Arqueometalurgia (Madrid 2010)

Montero Ruiz 1993 I. Montero Ruiz, Bronze Age Metallurgy in Southeast Spain, Antiquity 67, 1993, 46–57

Montero Ruiz 1994 I. Montero Ruiz, El origen de la metalurgia en el Sudeste de la Península Ibérica (Almería 1994)

Montero Ruiz – Rodríguez de la Esperanza 2008 I. Montero Ruiz – M. J. Rodríguez de la Esperanza, Un pequeño asentamiento minero de la Edad del Bronce. La Loma de la Tejería (Albarracín, Teruel), TrabPrehist 65(1), 155–168

Mueller et al. 2006 R. Mueller – Th. Rehren – S. Rovira Llorens, The Question of Copper Production at Almizaraque, SE Spain. 34th International Symposium on Archaeometry, Zaragoza, 3–7 May 2004 (Zaragoza 2006) 209–216

Murillo-Barroso et al. 2017 M. Murillo-Barroso – M. Martinon-Torres – M. D. Camalich Massieu – D. Martin-Socas – F. Molina Gonzalez, Early Metallurgy in SE Iberia. The Workshop of Las Pilas (Mojacar, Almeria, Spain), Archaeological and Anthropological Science 9(7), 2017, 1539–1569

Nocete et al. 2004a F. Nocete – R. Lizcano – A. Orihuela, La excavación de Cabezo Juré (Alosno, Huelva), in: F. Nocete (coord.), Odiel. Proyecto de Investigación Arqueológica para el Análisis del Origen de la Desigualdad Social en el Suroeste de la Península Ibérica (Sevilla 2004) 107–127

Nocete et al. 2004b F. Nocete – R. Sáez – J. M. Nieto, La producción de cobre en Cabezo Juré. Estudio químico, mineralógico y contextual de escorias, in: F. Nocete (coord.), Odiel. Proyecto de Investigación Arqueológica para el Análisis del Origen de la Desigualdad Social en el Suroeste de la Península Ibérica (Sevilla 2004) 273–295

Nocete et al. 2008 F. Nocete – G. Queipo – R. Sáez – J. M. Nieto – N. Inácio – M. R. Bayona – A. Peramo – J. M. Vargas – R. Cruz-Auñón – J. I. Gil-Ibarguchi – J. F. Santos, The Smelting Quarter of Valencina de la Concepción (Seville, Spain). The Specialised Copper Industry in a Political Centre of the Guadalquivir Valley During the Third Millennium BC (2750–2500 BC), JASc 35, 2008, 717–732

O'Brian 2004 W. O'Brian, Ross Island. Mining, Metal and Society in Early Ireland, Bronze Age Studies 6 (Galway 2004)

Roberts et al 2009 B. Roberts – Ch. Thornton – V. Pigott, Development of Metallurgy in Eurasia, Antiquity 83(322), 2009, 1012–1022

Rodríguez Bayona 2008 M. Rodríguez Bayona, La investigación de la actividad metalúrgica durante el III milenio A.N.E. en el Suroeste de la Península Ibérica, BARIntSer 1769 (Oxford 2008)

Rovira 1989 S. Rovira, Recientes aportaciones para el conocimiento de la metalurgia primitiva en la provincia de Madrid. Un yacimiento Campaniforme en Perales del Río (Getafe, Madrid). Actas del XIX Congreso Nacional de Arqueología 1, Castellón de la Plana 1987, (Zaragoza 1989) 355–366

Rovira 1999 S. Rovira, Una propuesta metodológica para el estudio de la metalurgisa prehistórica. El caso de Gorny en la región de Kargaly (Orenburg, Rusia), TrabPrehist 56(2), 1999, 85–113

Rovira 2002 S. Rovira, Early Slags and Smelting By-Products of Copper Metallurgy in Spain, in: M. Bartelheim – E. Pernicka – R. Krause (eds.), Die Anfänge der Metallurgie in der Alten Welt / The Beginnings of Metallurgy in the Old World, Forschungen zur Archäometrie und Altertumswissenschaft 1 (Rahden/Westf. 2002) 83–98

Rovira 2003/2004 S. Rovira, La metalurgia prehistórica de la Península Ibérica en los tiempos de las grandes sepulturas colectivas, Boletín de la Asociación Española de Amigos de la Arqueología 43, 2003/2004, 151–169

Rovira 2005 S. Rovira, Tecnología metalúrgica y cambio cultural en la Prehistoria de la Península Ibérica, Norba 17, 2005, 9–40

Rovira 2011 S. Rovira, Contribution of the Analitical Work to the Knowledge of the Early Metallurgy in the Iberian Peninsula, in: C. Giardino (ed.), Archaeometallurgia. Dalla conoscenza a la fruizione (Santo Spirito 2011) 43–55

Rovira 2016 S. Rovira, La metalurgia calcolítica en el suroeste de la Península Ibérica. Una interpretación personal, Menga. Revista de Prehistoria de Andalucía 7, 2016, 53–67

Rovira 2017 S. Rovira, Innovación y continuidad en la metalurgia prehistórica de la Península Ibérica, in: J. L. García-Pulido – L. Arboledas Martínez – E. Alarcón García – F. Contreras Cortés (eds.), Presente y futuro de los paisajes mineros del pasado (Granada 1017) 173–189

Rovira et al. 1997 S. Rovira Llorens – I. Montero Ruiz – S. Consuegra Rodríguez, Las primeras etapas metalúrgicas en la Península Ibérica 1 (Madrid 1997)

Rovira – Ambert 2005 S. Rovira – P. Ambert, Les céramiques à réduire le minerai de cuivre. Une technique métallurgique utilisée en Ibérie, son extension en France meridionales, Bulletin de la Société Préhistorique Française 99(1), 2002, 105–126

Rovira – Gómez Ramos 1998 S. Rovira – P. Gómez Ramos, Metalurgia calcolítica en Carmona (Sevilla), Spal 7, 1998, 69–80

Rovira – Renzi 2010 S. Rovira – M. Renzi, Las operaciones pirometalúrgicas y sus subproductos, in:

I. Montero Ruiz (coord.), Manual de Arqueometalurgia (Madrid 2010) 87–122

Ruiz Taboada – Montero 1999 A. Ruiz Taboada – I. Montero, The Oldest Metallurgy in Western Europe, Antiquity 73, 1999, 897–903

Sáez et al. 2003 R. Sáez – F. Nocete – J. M. Nieto – M. A. Capitán – S. Rovira, The Extractive Metallurgy of Copper from Cabezo Juré, Huelva, Spain. Chemical and Mineralogical Study of Slags Dated to the Third Millenium B.C., Canadian Mineralogist 41, 2003, 628–638

Villalba et al. 1986 M. J. Villalba – L. Bañolas – J. Arenas – M. Alonso, Les mines neolítiques de Can Tintorer, Gavà. Excavacions 1978–1980 (Barcelona 1986)

Zwicker et al. 1985 U. Zwicker – H. Greiner – K. H. Hoffmann – M. Reithinger, Smelting, Refining and Alloying of Copper and Copper Alloys in Crucible-Furnaces During Pre-Historic up to Roman Time, in: P. T. Craddock – M. J. Hughes (eds.), Furnaces and Smelting Technology in Antiquity (London 1985) 103–116

Illustration Credits

Fig. 1 drawing: S. Rovira
Fig. 2 photo: A. Moreno and F. Contreras
Fig. 3 photo: S. Rovira
Fig. 4 drawing: S. Rovira
Fig. 5 photo: S. Rovira
Fig. 6 photo: S. Rovira
Fig. 7 photo: S. Rovira
Fig. 8 photo: S. Rovira
Fig. 9 photo: S. Rovira
Fig: 10 drawing: S. Rovira
Fig. 11 photo: A. Moreno and F. Contreras
Fig. 12 photo: S. Rovira
Fig. 13 photo: S. Rovira

Address

Salvador Rovira
Museo Arqueológico Nacional
Universidad Autónoma de Madrid
Calle Espartero 50 2 pta 6
E-46450 Benifaió (Valencia, Spain)
s_rovirallorens@hotmail.com

Abstract

Chalcolithic metallurgy of the Iberian Peninsula is characterized by the exploitation of oxidic copper ores like cuprite, malachite, azurite, chrysocolla and others easy to obtain given the nature of local outcrops. Mineralization often provides polymetallic ores, being arsenic compounds (olivenite, conichalcite) the most common. Analytical studies depict a primitive technology: slags are chemical and structurally complex pyroxene-type slags that retain much copper, as well as metal prills or as unreduced mineral relicts.

Remains of true smelting furnaces are not known. Instead, open fires sometimes having a circular shield structure measuring few centimetres high were used as fireplaces for smelting ore inside common clay crucibles.

Keywords: Chalcolithic metallurgy, copper ores, smelting crucibles, slags, Iberian Peninsula.