Michael Kunst, Martin Bartelheim, Roland Gauß

Copper Age Metallurgy at Zambujal and the Southwest Iberian Peninsula

in: Kunst et al. - Früher Bergbau und Metallurgie auf der Iberischen Halbinsel: Faszikel 2: From the Object to the Mine. Papers from the Project and Conference »Prehistoric Copper Metallurgy in Zambujal (Portugal)« 11–26

https://doi.org/10.34780/69g1c298

Herausgebende Institution / Publisher:
Deutsches Archäologisches Institut

Michael Kunst | Martin Bartelheim | Roland Gauß (eds.)
FROM THE OBJECT TO THE MINE. PAPERS FROM THE PROJECT AND CONFERENCE »PREHISTORIC COPPER METALLURGY IN ZAMBUJAL (PORTUGAL)«

IBERIA ARCHAEOLOGICA 15, 2

DEUTSCHES ARCHÄOLOGISCHES INSTITUT
Madrid

IBERIA ARCHAEOLOGICA BAND 15

FRÜHER BERGBAU UND METALLURGIE AUF DER IBERISCHEN HALBINSEL

DEUTSCHES ARCHÄOLOGISCHES INSTITUT
Madrid

Michael Kunst | Martin Bartelheim | Roland Gauß (eds.)

FASZIKEL 2: FROM THE OBJECT TO THE MINE. PAPERS FROM THE PROJECT AND CONFERENCE »PREHISTORIC COPPER METALLURGY IN ZAMBUJAL (PORTUGAL)«

REICHERT VERLAG

XXI, 406 Seiten mit 272 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 Madrid des Deutschen Archäologischen Instituts

Umschlagfoto: The mine of Mocissos (Portugal) with pioneer plants, 25 April 2005. In the background the river Guadiana, the border between Portugal (left) and Spain (right), photograph: Michael Kunst.
Die Mine von Mocissos (Portugal) mit Pionierpflanzen, 25.4.2005. Im Hintergrund der Guadiana, die Grenze zwischen Portugal (links) und Spanien (rechts), Foto: Michael Kunst.

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

Dr. Ludwig Reichert Verlag Wiesbaden · www.reichert-verlag.de

ISBN 978-3-7520-0016-0

Gedruckt auf säurefreiem und alterungsbeständigem Papier
Printed in Germany

Widmung

Mit herzlichem Glückwunsch
Herrn Prof. Dr. Dres. h. c. Hermanfrid Schubart
zu seinem 90. Geburtstag am 1. Dezember 2020

Hermanfrid Schubart, im Hintergrund der Puig Llorença – Cumbre del Sol, Benitachell, Comunidad Valenciana, Spanien
(Foto: Annie Schubart, April 2004).
Hermanfrid Schubart, no background Puig Llorença – Cumbre del Sol, Benitachell, Comunidad Valenciana, Espanha
(Foto: Annie Schubart, Abril 2004).

Die archäometallurgischen Untersuchungen, die im Zentrum dieses Bandes stehen, gingen von den Ausgrabungsergebnissen in Zambujal aus. Zambujal gehört zu den besonders intensiv erforschten kupferzeitlichen befestigten Siedlungen der Iberischen Halbinsel. Das verdanken wir Hermanfrid Schubart, der 1963 von Seiten der Madrider Abteilung des Deutschen Archäologischen Instituts die Untersuchungen in Zambujal begann und zusammen mit Edward Sangmeister und Leonel Trindade sowie einem großen, internationalen Team von 1964 bis 1973 sechs umfangreiche Ausgrabungen in dieser prähistorischen Siedlungsanlage durchführte. Ohne seine Initiative wären die interdisziplinären und internationalen Forschungen, die inzwischen schon sechs Monographien gefüllt haben, nicht möglich gewesen. Auch dieser Band wäre gar nicht zustande gekommen. Die Grabungskampagnen von 1964-1973 in Zambujal und ihre Veröffentlichung in Band 5, 1 der Madrider Beiträge markieren einen Wendepunkt in der Erforschung der Kupferzeit der Iberischen Halbinsel! Vor allem hat Hermanfrid Schubart aber einen wichtigen Grundstein zu gegenseitigem Vertrauen und zu intensiven wissenschaftlichen wie freundschaftlichen Kontakten zwischen den deutschen Wissenschaftlern und denen der Iberischen Halbinsel gelegt, Kontakte, die sich schließlich auch in der vorliegenden Veröffentlichung wiederspiegeln.

As pesquisas arqueo-metalúrgicas, que constituem o tema central deste volume, partiram dos resultados das escavações de Zambujal. Zambujal apresenta-se como um dos povoados calcolíticos fortificados da Península Ibérica com investigação mais intensa. Tal devemos a Hermanfrid Schubart, que iniciou em 1963, com o Instituto Arqueológico Alemão, as investigações em Zambujal, e realizou, em conjunto com Edward Sangmeister e Leonel Trindade com uma equipa grande e internacional, seis campanhas de escavação entre 1964 e 1973 nesse povoado pré-histórico. Sem a sua iniciativa, as investigações interdisciplinares e internacionais, que, entretanto, produziram seis monografias, não teriam sido possíveis. Também este volume não se teria realizado. As campanhas de escavação de 1964 a 1973 em Zambujal e a sua publicação em volume 5,1 da série Madrider Beiträge marcam um ponto decisivo na investigação da Idade do Cobre na Península Ibérica! Sobretudo, Hermanfrid Schubart preparou um fundamento importante para a confiança mútua e para contatos intensivos científicos e amigáveis entre os científicos alemães e da Península Ibérica, contatos que, finalmente, são também refletidos nesta publicação.

Inhaltsverzeichnis / Índice / Table of Contents

Copper Age Metallurgy at Zambujal and the Southwest Iberian Peninsula

Martin Bartelheim – Roland Gauß – Michael Kunst

1. Introduction

The fortified settlement of Zambujal (Torres Vedras, district Lisbon) lies within one of the best studied Copper Age settlement agglomerations of the Iberian Peninsula. Due to the many metal objects and production waste found at the site, the excavators Edward Sangmeister and Hermanfrid Schubart first concluded that copper metallurgy must have been of outstanding importance for the Copper Age economy[1] and connected it to the Bell Beaker phenomenon. At that time, however, the extent and the economic and social weight of the metallurgical chaîne opératoire associated with it could not yet be assessed; neither the origin of the ore, the mining and the associated work processes, the organisation of production, the distribution of the end products nor recycling were known. In order to clarify these questions, the project of the German Research Foundation (DFG) »Prähistorische Kupfermetallurgie in Zambujal (Portugal) – Von der Erzlagerstätte zum Fertigprodukt (Prehistoric Copper Metallurgy in Zambujal (Portugal) - From Ore Deposit to Finished Product)« was launched in 2003[2]. This project consisted of surveying potential ore deposits in central and southern Portugal from a mining-archaeological point of view and characterising these deposits with the help of geochemical and isotope-geochemical methods. Through the comparison of the ore signatures with those of copper artefacts, the provenance of the Zambujal copper should be determined. In addition, analyses of the metallurgical finds of the settlement site should enable a reconstruction of the metal extraction- and processing techniques.

Several specific objectives were formulated:

a. Central to the research tasks was the mining archaeological survey and sample collection (copper ores), the documentation of prehistoric mining traces as well as the mineralogical, geochemical and isotope-geochemical characterisation of the copper ore deposits in Central and Southern Portugal, which were possibly exploited in prehistory. Based on the geological and geographic circumstances a division into four surveying areas was planned: I. Ossa Morena Zone (Alto and Baixo Alentejo), II. Iberian Pyrite Belt (Baixo Alentejo), III. Algarve, and IV. the Portuguese Estremadura. The collected ore samples should be analysed on their mineralogical contents, element composition and lead isotope ratio. Mainly elements and element ratios which remain stable throughout the metallurgical production process were studied.
b. The results should be compared with those of lead isotope analyses of metallurgical remains and finished products from Zambujal and its surroundings in the Portuguese Estremadura. Analyses of the element composition of some of these objects had already been carried out under the »Studien zu den Anfängen der Metallurgie« (Studies of the Beginnings of Metallurgy) project and own investigations that were conducted in preparation of the project. The new and extended data set should allow to identify those copper deposits that delivered copper to Zambujal and the other Estremadurian sites.
c. The study of the archaeometallurgical residues from different prehistoric settlements in the Portuguese Estremadura should help to determine which manufacturing technologies were used.
d. Finally, it was planned to compile and analyse all indications for a reconstruction of the organisation of copper extraction and processing, as well as the distribution of finished products.

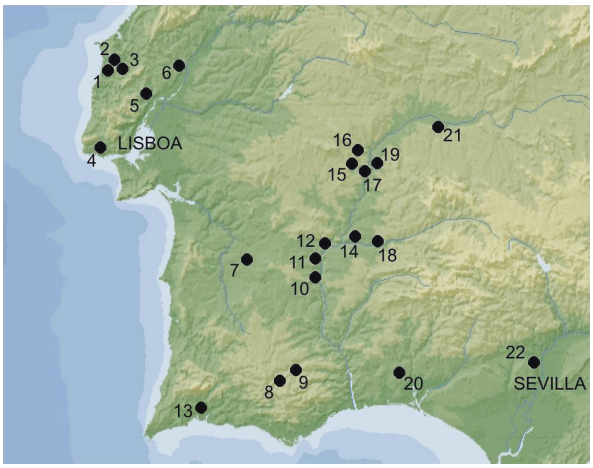
1 Sangmeister 1965, 555–556; Sangmeister 1972, 192. 196–197. 199–200; Sangmeister 1995, 4; Sangmeister – Schubart 1981, 254–255.

2 Number of refence BA 2280/1-1, PA 368/8-1.

2. The settlement context at Zambujal

The excavations by Edward Sangmeister and Hermanfrid Schubart at Zambujal from 1964 to 1973 were a milestone in the research of the Copper Age of the Iberian Peninsula[3]. In this time period, also other large fortified settlements were identified and excavated, especially in Andalusia[4]. Nevertheless, with its walls still reaching up to 4 metres high, Zambujal is uniquely well-preserved amongst its contemporary sites. In fact, as Zambujal is today located in an agrarian area, surrounded by vineyards, the settlement has been spared from modern constructions. Zambujal may not have had the same political importance as the biggest comparable settlements such as Valencina de la Concepción on the edge of the Guadalquivir Valley or Leceia, near Lisbon in the Tejo estuary area. However, thanks to its good preservation this site is particularly suitable for archaeological research.

The excavations showed that the fortifications of Zambujal were constructed in five phases[5], that is, respecting different strategic defence concepts. Construction phases 1 and 2 were accompanied by ceramics of the early Portuguese Chalcolithic, whereas phases 3 and 4 pertain to the Bell Beaker times; phase 5 dates to the Early Bronze Age. The calibration of ^{14}C-dates so far has yielded an absolute chronology between the 9th century of the 3rd millennium BC and the first half of the 2nd millennium BC[6]. Relatively little is known so far about the structures between the big fortified walls, where people settled[7]. Apart from domestic areas, there were also vacant spaces. Copper processing has been proven also for most of the other fortified settlements (see here chapter 5. and fig. 1); indeed, this is typical for the whole south of the Iberian Peninsula. Nevertheless, so far the publications about Zambujal contain several different analyses of the site's copper metallurgy, i. e. particularly of its copper finds. Not least because of this, Zambujal is still in the centre of attention of Chalcolithic research on the Iberian Peninsula and especially in Portugal.



1 Distribution of the sites with chalcolithic metallurgical finds in the southwest of the Iberian Peninsula mentioned in the text. Portugal: 1. Zambujal; 2. Fórnea; 3. Penedo; 4. Leceia; 5. Pedra do Ouro; 6. Vila Nova de São Pedro; 7. Porto Torrão; 8. Cerro do Castelo de Corte João Marques; 9. Santa Justa; 10. São Brás; 11. Três Moinhos; 12. Sala I; 13. Alcalar; 14. Porto Mourão; 15. Fonte Ferrenha; 16. São Pedro; 17. Perdigões; 18. Castelo Velho de Safara; Spain: 19. San Blas; 20. Cabezo Juré; 21. La Pijotilla; 22. Valencina de la Concepción.

3. Studies of the Zambujal settlement area

Many Chalcolithic sites are known from Zambujal's hinterland (settlements and graves). In the course of a coastal research project financed by the Volkswagen Foundation, geoarchaeological investigations took place in the Sizandro River Valley in 1986. The tributary stream of this river, Ribeira de Pedrulhos, forms the valley around the hilltop on which Zambujal lies. The project also focused on the settling in Zambujal's hinterland, as well as on sketching a diachronic history of the overall Sizandro River catchment area[8]. Therefore, in the past years pedological investigations of the Ribeira de Pedrulhos Valley have been undertaken, which yielded pollen analyses, too[9]. The pedological investigations are useful on the one hand for the reconstruction of the landscape history, on the other hand they also help in the search for metal traces, mainly copper, in the prehistoric sediments. Thus, a more and more precise reconstruction of the settling and landscape structure in the Chalcolithic can be

3 Sangmeister – Schubart 1981; Parreira 1985, 209.
4 E. g. Márquez Romero – Jiménez Jáimez 2010; García Sanjuán et al. 2013; 2017; Aranda Jiménez et al. 2016.
5 See also Kunst in this volume.
6 See also Kunst in this volume.
7 Sangmeister – Schubart 1981, 255–262.
8 Kunst – Trindade 1990.
9 Dambeck et al. 2010.

created, which provides a strong basis for assessing the significance of metallurgy within Chalcolithic society.

During surveys carried out by Gerd Goldenberg and Alexander Maass the copper ore deposit of Matacães (Torres Vedras, district Lisbon), within Zambujal's settlement area, was examined. Although the survey was carried out just within a month, it provided many promising indications for a use of this deposit in prehistory, further research could not prove this conclusively. All research attempts so far have made it clear that the significance of Zambujal can be studied only within an interdisciplinary project, in which the former environment is reconstructed. Moreover, it is important to include Zambujal's connections to nearby prehistoric settlements, as well as the provenance of different raw materials, especially copper.

4. Metallurgy in Zambujal

4.1 Why investigate metallurgy?

Throughout research history, the rise and development of Zambujal and other Chalcolithic settlements on the Iberian Peninsula (e. g. Vila Nova de São Pedro (Azambuja, Santarém), Los Millares (Almería), Leceia (Oeiras), Penedo (Torres Vedras), Fórnea (Torres Vedras); see fig. 1) have been brought in close connection with the emergence of copper metallurgy. This has to do, for one, with the relatively high amount of copper objects found there, particularly from the 3rd millennium onwards. Additionally, remains of metallurgical production were found in nearly all settlements and, in some cases, the sites are situated in a striking vicinity to copper ore deposits. Having said that, it seems to be clear, at first glance, that the intensified economic developments, demographic growth and social differentiation, which can be deduced from the archaeological findings, would be linked to the emergence of metallurgy in the region on a technological and social level. Today, it is common sense that metallurgy is complex, requires special knowledge and logistics, and has a multi-staged production chain, which needs many different raw materials. In many aspects, one would assume that metallurgy brings a new dimension of trade to a society, opening up new levels of interaction. As this innovation first becomes visible in the southwest of the Iberian Peninsula at the beginning of the 3rd millennium, practically simultaneously to the construction of fortified settlements of large dimensions, for decades it seemed a logical conclusion to state that metallurgy and fortified settling were imported by colonists from the Eastern Mediterranean (along with high quality ceramics and stone idols, see below).

However, before the start of the project, barely any more specific metallurgical investigations of the Portuguese assemblages had been carried out, that is, regarding the production of metal and metal objects and their provenance. Therefore, one could only speculate about the actual complexity of the metallurgical processes, the provenance of the raw materials, and thereby the economic and social role that metallurgy played in Zambujal and beyond.

4.2 Why investigate Zambujal and its assemblage?

Zambujal is one of the best studied examples among big fortified Chalcolithic settlements on the Iberian Peninsula. Thanks to the detailed documentation of its stratigraphy it offers a good case for exemplary research of the development of metallurgy, at least for the Portuguese Estremadura. Already during the excavations from 1964 to 1973, some of the ca. 900 copper objects were sampled, 363 of which were submitted to spectrometric studies[10]. This was carried out in the framework of the European-wide project »Studien zu den Anfängen der Metallurgie – SAM« (Studies into the Beginnings of Metallurgy), containing over 22.000 metal analyses, of the Württemberg State Museum Stuttgart. This project also analysed the results in relation to those of other Chalcolithic and Early Bronze Age sites in Portugal (another, over 700 analyses) and published them[11]. The goal was to elaborate material groups by means of trace element signatures, which were meant to make possible both, the research of diachronic-regional typological developments as well as trans-regional sociocultural connections. One of the most important results was the description of how differ-

10 Sangmeister 1995, 37.

11 Junghans et al. 1968; 1974; Krause – Pernicka 1996.

ent the alloy development was on the Iberian Peninsula in comparison with large parts of Europe. Using the trace element distribution on chronologically relevant leading forms of the Copper- and Bronze Age metal production it was deduced that pure copper was replaced by arsenical copper in the course of the Estremadurian Copper Age. The latter remained dominant on the Iberian Peninsula until the Late Bronze Age[12]. It was not possible to retrieve information regarding the production techniques, the provenience of the raw materials, or the significance of archaeometallurgical finds in terms of social organisation and economic impact. The interpretation of archaeometallurgical finds and features was still in its infancy.

The investigated material groups were repeatedly criticised by the research community. Today, it appears that the authors were well ahead of their times and that in those days it was barely possible to objectively validate and contextualise the results: neither were there similar measurements for comparison, nor computers and modern statistical methods available that could have helped the interpretation of the massive set of data[13]. Meanwhile, it has been possible to demonstrate the quality of the analysed data thanks to more recent analytical results obtained through other methods and projects[14]. A systematic comparison of the SAM data with the two other big analytic sets of early copper finds from the Iberian Peninsula – that of the British Museum[15] and of the Project »Arqueometalurgia de la Península Ibérica« of the Consejo Superior de Investigaciones Científicas (CSIC)[16] remains pending. The series of analyses of the DFG Project concerning Zambujal's metallurgy discussed here was able to confirm the validity of the SAM analyses[17].

Sangmeister dedicated a separate study to the 871 copper finds of Zambujal[18]. He concluded that throughout the five building phases of Zambujal a continuity in the metallurgical production can be recognized, which left traces in several parts of the settlement. The regionally specific interpretation of the SAM data showed that the Chalcolithic was clearly dominated by the low-trace element of arsenical copper. In the Early Chalcolithic also pure copper seems to have been used in greater quantities, whereas in the Late Chalcolithic and Early Bronze Age arsenical copper with antimony, silver and/or nickel appears to have been more common.

Back then, it was not possible to identify traces of mining and metal extraction, neither in Zambujal nor its surroundings. After the analyses of several slags, Gerhard Sperl suggested that there had been no smelting of copper ores in Zambujal[19]. Sperl argued that the microstructure of the slag samples would have indicated only a slightly reducing atmosphere in the metallurgical process, which would have been typical for casting. Indicators for metal production, such as crucibles, casting drops and clay rings, which were deemed to have been used as casting places, were found in many locations in Zambujal[20]. Therefore it was concluded that extensive further processing of crude copper took place here[21], defining the economic character of the settlement as a »centre of the earliest copper production«[22].

4.3 A foreign or a local origin of metallurgy?

Especially in the 1960s and 1970s Zambujal and other fortifications were interpreted as colonies of Eastern Mediterranean settlers and metallurgical explorers, because of cultural elements that were perceived as foreign: the architecture and the burial rites of nearby necropoles and parts of the archaeological sites, for which parallels from the Eastern Mediterranean were found. It was assumed that these ›foreigners‹ had been attracted by the wealth in copper of the South and West of the Iberian Peninsula. They were thought to have exploited the copper resources, which the indigenous population was not able to use due to their assumed low cultural and technological development. It was thought that the rendered copper would have been shipped to the Eastern Mediterranean region from the isolated settlements, located near the shores[23]. Nevertheless, it was not clear from which deposits Zambujal's copper had been extracted. No evidence indicating large-scale mining, processing or smelting were found. Traces of copper processing were documented, but it was not possible to describe or interpret this in detail.

In the course of the introduction of ^{14}C dating in large parts of Europe and the increasingly improving calibration throughout the 1960s and 1970s it became clear, mainly thanks to Colin Renfrews work, that many of the elements from the Eastern Mediterranean area, which

12 Junghans et al. 1968, 127.
13 See the discussion in Pernicka 1984; 1990.
14 See Ottaway1982; Pernicka 1984; 1987; 1990.
15 Harrison – Craddock 1981.
16 Rovira et al. 1997.
17 See Müller – Pernicka 2009; Gauß 2013.
18 Sangmeister 1995.
19 Sperl 1981.
20 Sangmeister 1995, 32–35.
21 Sangmeister 1995.
22 Sangmeister – Schubart 1981, 252.
23 Sangmeister 1960; 1975; Blance 1961; 1971; Almagro – Arribas 1963; Almagro 1966; Junghans et al. 1968; Savory 1968; Sangmeister – Schubart 1981.

had been interpreted as examples for elements found in the Iberian Peninsula, were not actually older[24]. Thus, a substantial argument for the assumed early colonisation of the West was lost. In addition, archaeologists did not find significant amounts of imported materials from the Eastern Mediterranean in the Iberian Peninsula.

In the following decades, new discoveries showed that the fortified settlements, which had been assumed to be colonies, were not at all that isolated from their cultural surroundings[25]. Throughout the 1980s other settlements were discovered, such as Leceia (Oeiras), Santa Justa (Alcoutim) und Alcalar (Portimão) in Portugal, in Spain Valencina de la Concepción (Sevilla), La Pijotilla (Badajoz), Albalate (Jaén), Los Alcores (Jaén), and later Marroquíes Bajos (Jaén) and San Blas (Badajoz). They showed similar characteristics and a comparable size to the known fortified settlements. Many of these sites were located in the hinterland of the coast and thus no longer complied with the criteria used in the identification of typical colonies: vicinity to the coast, ore deposits and fortifications[26]. Even if nowadays an Eastern Mediterranean origin of the inhabitants of those fortifications is no longer discussed, the close connection between their emergence in the early 3rd millennium with those of copper metallurgy remains striking.

Since the 1980s, local characteristics of the Chalcolithic metallurgy of the Iberian Peninsula have been emphasized. It was argued for example, that there are no indications for an external origin of the Peninsula's metallurgy, but rather that all developments that occurred during the transition from the Neolithic to the Chalcolithic were local[27]. To support this argument one object has been mentioned specifically: a ceramic fragment with slag adherences (probably from a crucible) from the stratigraphy of the Final Neolithic settlement of Cerro Virtud (Almería, Spain). This site is located close to the famous Chalcolithic settlement of Almizaraque (Almería, Spain) and is dated to the 5th millennium BC[28].

5. Other sites

Contemporary to Zambujal, Vila Nova de São Pedro (VNSP) (Azambuja, Santarém) and Leceia are the other Portuguese Estremaduran Chalcolithic type-sites. Vila Nova de São Pedro plays an important role in terms of research history, that is, not only with respect to archaeometallurgy, but also Chalcolithic research generally. This site is the first fortified Chalcolithic settlement in Portugal with the characteristic semicircular towers that was excavated and published on a large scale[29]. During these excavations many complete copper objects (mainly copper daggers, Palmela points, axes, chisels and awls) as well as square crucibles on pedestals, moulding residues, blowpipe fragments, and 13,5 kg of copper ores were found. The first metallographic and chemical analyses of these metal objects and slag residues on the crucibles were conducted as early as the 1950s[30]. The metal finds and the metallurgical remains of VNSP were re-assessed within the context of our DFG research project[31]. Altogether, the amount of copper detected at the site was quantified to 5–6 kg. In addition, slags and thin-walled crucibles – most likely used in copper extraction processes – were identified by chemical and mineralogical analyses. Trace element and lead isotope analyses indicate that the copper of VNSP originated from the same sources as Zambujal's copper.

Excavations at Leceia were conducted from the 1980s onwards. Remarkably, significantly fewer copper finds as in VNSP, and only one crucible fragment were retrieved from the Middle and Early Chalcolithic levels[32]. The material composition of a big part of the in total 130 copper samples (artefacts, casting remains, and casting lumps) were analysed via neutron activation analyses (NAA)[33]. The DFG metallurgy project quantified the amounts of copper found at the site, which is less than one kilogram. Smelting slags were not identified. Trace element and lead isotope analyses indicate that also the metal of Leceia originated from the same geological sources as Zambujal copper.

24 Renfrew 1967; 1969, 1970; 1972a; 1972b; 1973.
25 Silva – Soares 1977, 261–267.
26 See Martínez Navarrete 1998; Arteaga 2001; Kunst 2001; Márquez Romero – Jiménez Jáimez 2010; García Sanjuán et al. 2017.
27 Chapman 1990; Martín de la Cruz 1994; Montero Ruiz 1994.
28 Montero Ruiz – Ruiz Taboada 1996; Ruiz Taboada – Montero Ruiz 1999; Rovira 2002; Müller et al. 2004.
29 Do Paço – Jalhay 1939; Jalhay – do Paço 1945; do Paço – Sangmeister 1956; Savory 1972; Arnaud – Gonçalves 1990; 1995.
30 Do Paço 1955; Gauß 2015.
31 Müller – Soares 2008.
32 Cardoso 1997; Müller – Cardoso 2008.
33 Cardoso – Guerra 1997/98; Müller – Cardoso 2008.

Conclusive results regarding the production of raw copper and copper objects, or the provenance of the raw materials in the Portuguese Chalcolithic were not obtained through the analyses of the SAM project or other series of analyses. Moreover, the archaeometallurgical finds were neither systematically identified nor analysed entirely. The comparative chemical analyses of copper ores and final products that were carried out by Maria da Luz Ferreira de Oliveira and João Xavier Matos for mining archaeological surveys in the south of the country[34] and some isolated analyses of the production of objects[35] are an exception. This gap of research is peculiar as the archaeologist Sebastião Philippes Martins Estácio da Veiga at the end of the 19th century treated the copper objects from the megalithic monuments of the Algarve not only as antiquarian materials, but was already also interested in material analytics[36]. He investigated as well the remains of metal production and ores from Chalcolithic contexts, which were analysed chemically, just like the brothers Luis and Henri Siret did for the south-eastern Spanish Chalcolithic[37]. Estácio da Veiga also pointed out that the earliest Portuguese metal finds were from settlements contexts, which were still rooted in local Neolithic traditions[38]. Other than the Sirets, he questioned the sweeping ›Ex-Oriente-Lux-Model‹ already then[39]. For the rest, archaeometallurgical research in the south of Portugal was initially practised mainly by geologists and mining engineers, as is the case for the whole southwest of the Iberian Peninsula. This happened especially after the re-opening of many old mines from the mid-19th century onwards. Especially the remains of Roman mining and metallurgical activities in the entrances of the mines came into light[40]. Prehistoric mining activities, on the other hand, are considerably harder to identify than the Roman ones. This is partially due to the fact that they, especially in the case of the mining remains, leave considerably less traces as they were of a smaller scale. Such remains would be rapidly destroyed in the case of a modern (or Roman) use of the mines. Moreover, prehistoric ore mining and smelting remains are often hard to date. This is because the techniques developed very slowly at those times and thus leave us with few indications for a chronological classification. On top of this, areas with mining activities are often located far away from prehistoric settlement contexts and yield little material that can be dated with the help of settlement chronologies, which are still the basis for chronological classifications. Claude Domergue provides us with an overview of the indications of prehistoric and antique mining in the Iberian Peninsula[41].

Before the start of the project, no Chalcolithic ore mines were known from the Iberian Peninsula, except El Aramo and El Milagro in Asturias[42]. Some evidence for the processing of ores, on the other hand, were known from various sites. In the Iberian Chalcolithic mainly oxidic ores (primarily malachite, azurite, but also arsenic copper ores) were used. In Portugal this is supported mainly by ore remains collected from settlements, such as Castelo Velho de Safara (Moura), Porto Mourão (Mourão), Porto Torrão (Ferreira do Alentejo) and Perdigões (Reguengos de Monsaraz)[43]. No smelting furnaces have been found so far. However, in some settlements slagged remains of crucibles were found, apart from the aforementioned settlements of the Estremadura, also, for example, at the sites Penedo (Torres Vedras)[44], Pedra do Ouro (Alenquer)[45], Santa Justa (Alcoutim)[46], Cerro do Castelo de Corte João Marques (Loulé)[47], Castelo Velho de Safara (Moura), Porto Mourão (Moura), Três Moinhos (Beja), Sala I (Vidigueira), São Brás (Serpa), Alcalar (Portimão), Perdigões (Reguengos de Monsaraz), Fonte Ferrenha (Redondo)[48], São Pedro (Redondo)[49] and San Blas (Spain)[50]. But the question remained, in what kind of metallurgical process were these crucibles used. The DFG project identified two types of crucibles: a rather thick-walled, less vitrified crucible used for the melting and casting of copper; and a rather thin-walled, heavily vitrified and slagged crucible type used for copper extraction (smelting). Remarkably, in terms of crucible typology the Portuguese Chalcolithic metallurgy differs from that found in Andalusia and other parts of the southern Iberian Peninsula, where all kinds of domestic ware were used for smelting and casting. This difference may indicate a subtle variation in metallurgical traditions.

34 Briard et al. 1998a; Briard et al. 1998b; Oliveira – Matos 2002.
35 Pereira, F. et al. 2013; 2017; Valério et al. 2017.
36 Estácio da Veiga 1889; 1891.
37 Siret – Siret 1890.
38 Estácio da Veiga 1889, 98–101. 117.
39 Estácio da Veiga 1889, 9–10; also see Gauß 2015.
40 Domergue 1987.
41 Domergue 1987.
42 Blas 1998.
43 Soares et al. 1994, 167. 181; Lago et al. 1998; Gómez Ramos 1999; Hunt Ortiz 2003.
44 Spindler 1969, 105.
45 Leisner – Schubart 1966, Abb. 10; also Gómez Ramos 1999, 55.
46 Gonçalves 1989, 194. 278. 310.
47 Alarcão 1990, 174–175.
48 Gauß 2015; also Gauß et al. in this volume; further bibliography see Kunst 2013, 186–193; Tab 1 Nos. 85, 86, 88, 89, 90, 92; Morán 2018, 175–177.
49 Ibid.
50 Gonçalves 1989; Alarcão 1990, 175; Soares et al. 1994; Lago et al. 1998; Gómez Ramos 1999, 54–55; Hunt Ortiz 2003, 296–299. 377; Hurtado 2004; Soares 2005; Müller – Soares 2008; Gauß 2015; also Gauß et al. in this volume.

A special highlight are the blowpipes identified at the sites of Vila Nova de São Pedro, Pedra do Ouro and Três Moinhos, although they do not contain slag adherences.[51] Blow pipes are very rarely found in Chalcolithic contexts[52].

6. Southern Spain

In southern Spain, mining archaeological and archaeometallurgical research has been practised more intensively, especially since the 1980s. Results from there can be extrapolated to the south of Portugal because of the similar landscape and cultural conditions.

The Huelva Archaeological Project, directed by Beno Rothenberg and Antonio Blanco Frejeiro, played an important role in the intensive mining archaeological and archaeometallurgical research in the south of the Iberian Peninsula. Especially the mountainous region in the hinterland of the harbour city of Huelva was key and directly connected to the Portuguese southeast border. The production centre of Riotinto, active until recent times, was a special point of focus.

In the course of their intensive mining archaeological research Rothenberg and Blanco Frejeiro established that (copper) ore mining could be traced back to the Chalcolithic for that region[53]. They based this partially on the presence of groove mallets, which they attributed to the Chalcolithic based on analogies to the Israelian site of Timna. The accompanying of these groove mallets by ceramics in the Chinflón mine, which was thought to be Chalcolithic, strengthened this. Apart from this, the proximity of ores and megaliths is remarkable, especially in the case of Chinflón. The presence of megalithic graves in the otherwise barren landscape led them to assume that the copper resources were the cause for the local Chalcolithic presence in the form of megalithic graves. According to them this represented an important change in the economy and societal structure, that is, a strictly livestock-based nomadic lifestyle becoming settled. According to thermoluminiscence datings and new typological research of the Chinflón ceramics in the 1990s, however, it turned out that the site was to be dated to the Final Bronze Age[54].

Nevertheless, Chalcolithic metal extraction and production in this region can be proved, even if so far no datable mine has been found. Excavations in the settlement on the Cabezo Juré, northwest from Huelva, yielded not only indications of metal processing, but also copper slags, evidencing the extraction of the metal from ores[55]. Some of the excavators interpreted clay rings and pits with traces of heating, which were found in the settlement, as metallurgical furnaces, which is very doubtful. No characteristic slagging traces can be distinguished on the walls and the structures are clearly too large for a prehistoric furnace reaction chamber, which would require the use of an advanced bellow technology to maintain temperature and redox conditions[56]. The present structures rather seem to have been casting installations, similar to the ones found at Zambujal and other sites, or pits in which crucibles were placed to smelt copper ores. Structures found at Valencina de la Concepción, in front of the Seville gate are very similar[57]. This form of smelting in reaction vessels is the only one that has been clearly identified so far and has been found rather frequently, especially in the south of the Iberian Peninsula[58].

The beginnings of metallurgy have been investigated in Spain through the broad analysis programme »Arqueometalurgia de la Península Ibérica«[59] since the 1990s, presenting and evaluating the full archaeological register of early metallurgy in regional studies[60]. This was completed by the publication and discussion of all then published prehistoric metallurgic finds from the Iberian Peninsula by Pablo Gómez Ramos[61] and the de-

51 See the aforementioned literature on metallurgical finds of these settlements. Cf. with the discussion in Gauß 2015.

52 One of the few sites where they were found in larger amounts is Valencina de la Concepción (Seville), see Nocete et al. 2008. Blow pipes identified at Cabezo Juré (Huelva) are very unlikely to have ever been used in a metallurgical process. They rather represent ceramic stands, see Nocete et al. 1999a.

53 Rothenberg – Blanco Frejeiro 1981.

54 Pérez Macías 1996, 157–158.

55 Nocete et al. 1999a; Nocete et al. 1999b; Sáez et al. 2001; Nocete 2004.

56 Bartelheim 2007, 357–360; Gauß 2013; Gauß 2015; see Rovira in this volume.

57 Nocete et al. 2008; Rodríguez Bayona 2008; Costa Caramé 2010; Costa Caramé 2013; see Rovira in this volume.

58 Rovira 2002; Müller et al. 2004.

59 Rovira et al. 1997, VII.

60 Rovira et al. 1997; Delibes de Castro – Montero Ruiz 1999.

61 Gómez Ramos 1999.

tailed documentation of the archaeometallurgical state of research, especially for the Iberian southwest, by Mark A. Hunt Ortiz[62], Moisés Rodríguez Bayona[63] and Manuel Eleazar Costa Caramé[64] (including unpublished finds and fieldwork). From these studies it becomes clear that, so far, it has not been possible to reconstruct completely the metallurgical production and respective social organisation in any of those regions (e. g. in Andalusia, the northern Meseta or the Comunidad Valenciana).

7. Key findings of recent archaeometallurgical research on Zambujal copper

Even if the research of the beginnings of metallurgy has made important steps forward in the past years, especially in the south of Spain[65], our state of knowledge regarding Copper Age metal production is still limited in extensive parts of the Iberian Peninsula and especially Portugal.

In the course of the DFG project a holistic research approach was implemented in order to describe and understand the beginning of the copper metallurgy innovation in Portugal from an economic and social historical point of view:

a. *Sourcing*: Zambujal copper derives from the Ossa Morena Zone. The local, smaller occurrence of Matacães as well as the famous massive sulphide deposits of the Iberian Pyrite Belt can be excluded as major sources for Zambujal copper. This is indicated by trace element and lead isotope analyses (comparing ores and artefacts from potential source regions with those of Zambujal copper), and the mineralogy of the (few) ores and slags found at some of Portuguese Estremadurian settlements. In addition, amphibolite – the hard rock material found in large amounts in the Estremadurian settlements – originates from the Ossa Morena Zone, too. The Zambujal artefacts and metallurgy were compared to finds and structures from settlements in the Ossa Morena Zone: the finds and metallurgical debris there resemble those of Zambujal.
b. *Mining*: For the first time, specific places can be identified where copper ores were mined during the Chalcolithic[66]. For example, at the mine of Mocissos (Alandroal) a small pit was identified below metres of waste rock, dumped in the course of the mine's multi-period lifetime. The pit, radiocarbon dated to the 3rd millennium, contained among others two polished amphibolite axes and a slagged thin-walled crucible fragment almost identical to those artefacts found at Zambujal and many other Portuguese Estremadurian settlements. Whilst this is evidence for one of the oldest metal ore mining in Iberia, mining as such can be traced back to the 6th millennium BC on the Peninsula (c.f. silex mining at Casa Montero, near Madrid; variscite mining at Gavà, nearby Barcelona)[67].
c. *Extractive metallurgy*: In the framework of the Zambujal project it has been possible to record ›completely‹ the archaeometallurgical remains found at Zambujal and many other Chalcolithic sites and to establish criteria for a systematic division between remains of primary and secondary metallurgy[68]. At Zambujal, smaller amounts of copper were most likely extracted in crucibles using oxides and carbonates. We have similar evidence from Vila Nova de São Pedro, which is the other Copper Age type site of the Estremadura. Crucible smelting, i. e. the high temperature process of turning ore into metal and slag in ceramic containers, is a well-documented process in many Copper Age settlement sites, particularly in the southern Iberian Peninsula, and many regions of the 4th and 3rd millennium Mediterranean. The Zambujal project identified almost identical metallurgical de-

62 Hunt Ortiz 2003.
63 Rodríguez Bayona 2008.
64 Costa Caramé 2010.
65 Rodríguez Bayona 2008; Costa Caramé 2010; Murillo-Barroso – Montero Ruiz 2012; Gauß 2013; Kunst 2013; Rovira – Montero Ruiz 2013; Montero Ruiz – Murillo Barroso 2014; Murillo Barroso – Montero Ruiz 2017; Murillo-Barroso et al. 2015; Orestes Vidigal et al. 2015.
66 Müller et al. 2007; Müller – Cardoso 2008; Müller – Soares 2008; Gauß 2015; see also Goldenberg – Hanning in this volume; Gauß – Mataloto – Calado in this volume; for comparison, on Bell Beaker mining evidence in other parts of Europe see Fitzpatrick 2019.
67 Consuegra Rodríguez et al. 2004; Díaz-del-Río et al. 2006; Borrell et al. 2015; Bosch et al. 1996; Villalba et al. 1986.
68 Gauß 2015.

bris in the contemporary mine of Mocissos mentioned above as well as at the small fortified site of São Pedro and the hilltop of Fonte Ferrenha near the today town of Redondo (see Gauß – Mataloto – Calado, this volume)[69]. The earliest evidence for metallurgical furnaces in the Iberian Peninsula date to the Iron Age[70]. The experimental work by Erica Hanning[71] confirmed the idea of crucible smelting using copper oxide ores from the identified sources in the Ossa Morena Zone, which were deemed to be extracted in the Copper Age. Her experiments produced almost identical metallurgical remains as found at Zambujal and the other Chalcolithic sites.

d. *Copper Processing*: In terms of metallurgy, copper processing was much more of a dominant activity than smelting at Zambujal and the other Portuguese Estremadurian settlements. In the beginning, copper was cast in open forms, cut, grinded and polished to produce simple objects like flat axes, awls, and thin blades. Metal specific objects were developed like saws and elongated awls and needles as well as – in the Bell Beaker context – standardized tanged daggers and Palmela points. Specific natural arsenic alloys were – once extracted – deliberately chosen to produce specific artefact types.

   Based on old and new trace element analyses of copper artefacts, the material group research of the 1960s, 70s and 80s was brought back and the relation to the stratigraphy of Zambujal was established quantitatively[72]. Arsenic copper, poor in trace elements, clearly dominates the copper objects of Zambujal throughout the settlement's occupation. Apart from this, some pure copper objects were found mainly in contexts of the Early Chalcolithic, and arsenical copper with silver, antimony and/or nickel was found predominantly in contexts of the Late Chalcolithic and the Early Bronze Age.

   The experimental work by Marcus Schreiner (this volume) demonstrated that the copper droplets and lumps detected at Zambujal derived from melting and casting copper in open sand moulds. Strikingly, some of the copper lumps showed a twin microstructure, indicating that these pieces of copper, most likely, had been hammered before they were remelted. If this was the case, these copper lumps would represent remnants of a recycling process. This observation corresponds well to the fact that, indeed, many fragmented copper objects were found and that many of them showed cut marks[73].

   Quanyu Wang and Barbara S. Ottaway (this volume) conducted another systematic study on the metallography of Zambujal copper artefacts. Using this approach, they could identify patterns in the working cycles for producing specific types of metal objects. Most of the awls were cast, cold-worked, and annealed again, which means they were left in soft state. Chisels on the contrary were mostly cold hardened at the end of the work cycle to produce a hard edge.

e. *Social aspects of Zambujal metallurgy and its economic impact*: Reconstructing the metallurgical processes and identifying the geological source regions of the raw materials makes it possible to better understand and contextualize metallurgy as craftsmanship and a social activity. The metal arrived in the Portuguese Estremadura along a well-established, Late Neolithic amphibolite trade route, that is, most likely in exchange for goods from the coastal area, including gold, flint, and exotic items, such as ivory that originated from Africa[74]. Zambujal – and the dense Estremadurian settlement network altogether – was not built because of a rich nearby copper deposit; but most likely due to its favourable position in terms of logistics, located right in the middle of an estuary and fruitful lands. The metallurgical processes were not more complex than those of other craftsmanships of the time, including the making of high quality, polished, thin-walled ceramic vessels or erecting and maintaining the complex fortification systems. Like in many other Chalcolithic sites, metallurgy took place in domestic contexts – no specific workshop was found at Zambujal, but metallurgical debris is evident in many different fireplaces across the site.

The Zambujal evidence substantiates the general picture of Chalcolithic metallurgy in Iberia: the small-scale, primitive type of copper metallurgy that dominated the 3rd and 2nd millennium seems to contradict the vast richness in metal ore deposits of the Peninsula. Even tin is abundant, but true tin bronzes are scarce until the Late Bronze Age.

69 Mataloto 2005.
70 Bartelheim 2007, 138.
71 Hanning et al. 2010 and Hanning – Goldenberg this volume.
72 Müller – Cardoso 2008; Müller – Pernicka 2009; Gauß 2015.
73 Sangmeister 1995; Gauß 2015; see Schreiner and Wang – Ottaway in this volume.
74 Schuhmacher 2016; 2017.

Bibliography

Alarcão 1990 J. de Alarcão, Nova história de Portugal I (Lisboa 1990)

Almagro 1966 M. Almagro Basch, Las estelas decoradas del Suroeste peninsular, Bibliotheca Praehistorica Hispana 8 (Madrid 1966)

Almagro – Arribas 1963 M. Almagro Basch – A. Arribas, El poblado y la necrópolis megalíticos de Los Millares (Santa Fé de Mondújar, Almería), Bibliotheca Praehistorica Hispana 3 (Madrid 1963)

Aranda Jiménez et al. 2016 G. Aranda Jiménez – Á. Lozano Medina – J. Escudero Carrillo – M. Sánchez Romero – E. Alarcón García – S. Fernández Martín – M. Díaz-Zorita Bonilla – V. Barba Colmenero, Cronología y temporalidad de los recintos de fosos prehistóricos: el caso de Marroquíes Bajos (Jaén), Trabajos de Prehistoria 73, 2, 2016, 231–250

Arnaud – Gonçalves 1990 J. M. Arnaud – J. L. M. Gonçalves, A fortificação pré-histórica de Vila Nova de S. Pedro (Azambuja) – balanço de meio século de investigações (1ª Parte), Revista de Arqueologia 1, 1990, 25–48

Arnaud – Gonçalves 1995 J. M. Arnaud – J. L. M. Gonçalves, A fortificação pré-histórica de Vila Nova de S. Pedro (Azambuja) – balanço de meio século de investigações (2ª Parte), Revista de Arqueologia 2, 1995, 11–40

Arteaga 2001 O. Arteaga, Fuente Álamo im Territorium von El Argar, in: H. Schubart – V. Pingel – O. Arteaga (Hrsg.), Fuente Álamo I, Madrider Beiträge 25, 1 (Mainz 2001) 161–203

Bartelheim 2007 M. Bartelheim, Die Rolle der Metallurgie in vorgeschichtlichen Gesellschaften. Sozioökonomische und kulturhistorische Aspekte der Ressourcennutzung. Ein Vergleich zwischen Andalusien, Zypern und dem Nordalpenraum / The Role of Metals in Prehistoric Societies. Socioeconomic and Culture-Historical Aspects of the Use of Resources. A Comparison between Andalusia, Cyprus and the North Alpine Area. Forschungen zur Archäometrie und Altertumswissenschaft 2 (Rahden/Westfalen 2007)

Blance 1961 B. Blance, Early Bronze Age Colonists in Iberia, Antiquity 35, 1961, 192–202

Blance 1971 B. Blance, Die Anfänge der Metallurgie auf der Iberischen Halbinsel, Studien zu den Anfängen der Metallurgie 4 (Berlin 1971)

Blas 1998 M. A. De Blas Cortina, Producción e intercambio de metal. La singularidad de las minas de cobre prehistóricas del Aramo y El Milagro (Asturias), in: G. Delibes de Castro (Hrsg.), Minerales y metales en la prehistoria reciente. Algunos testimonios de su explotación y laboreo en la Península Ibérica, Studia Archaeologica 88 (Valladolid 1998) 71–103

Briard et al. 1998a J. Briard – J.-R. Bourhis – M. van Schoor, La paléométallurgie campaniforme du Portugal. Nouvelles données sur ses compositions métalliques et ses relations atlantiques, Bulletin de la Société Préhistorique Français 95, 3, 1998, 393–401

Briard et al. 1998b J. Briard – J.-R. Bourhis – J. Happ – G. Querré – M. van Schoor, Paléométallurgie du Portugal. Minerais, analyses et archéologie expérimental, in: M.-C. Frère-Sautot (Hrsg.), Paléométallurgie des cuivres. Actes du colloque de Bourg-en-Bresse et Beaune 17–18 Octubre 1997 (Montagnac 1998) 53–57

Borrell et al. 2015 F. Borrell – J. Bosch – T. Majó, Life and Death in the Neolithic Variscite Mines at Gavà (Barcelona, Spain), Antiquity 89, 343, 2015, 72–90

Bosch et al. 1996 J. Bosch Argilagós – A. Estrada Martín – M. J. Noain Maura, Minería neolítica en Gavà (Baix Llobregat, Barcelona), Trabajos de Prehistoria 53, 1, 1996, 59–71

Cardoso 1997 J. L. Cardoso, O povoado de Leceia sentinela do Tejo no terceiro milénio antes Cristo, Instituto Português de Museus (Oeiras 1997)

Cardoso – Guerra 1997/1998 J. L. Cardoso – M. F. Guerra, Análises químicas não destrutivas do espólio metálico do povoado pré-histórico de Leceia, Oeiras e seu significado no quadro da intensificação económica calcolítica da Estremadura Portuguesa, Estudos Arqueológicos de Oeiras 7, 1997/1998, 61–87

Chapman 1990 R. Chapman, Emerging Complexity. The Later Prehistory of South-East Spain, Iberia and the West Mediterranean (Cambridge 1990)

Consuegra Rodríguez et al. 2004 S. Consuegra Rodríguez – M. M. Gallego García – N. Castañeda Clemente, Minería neolítica de Sílex de Casa Montero (Vicálvaro, Madrid), Trabajos de Prehistoria 61, 2, 2004, 127–140

Costa Caramé 2010 M. E. Costa Caramé, Las producciones metálicas del III y II milenio Cal ANE en el Suroeste de la Península Ibérica, British Archaeological Reports. International Series 2106 (Oxford 2010)

Costa Caramé 2013 M. E. Costa Caramé, La actividad metalúrgica en Valencina de la Concepción (Sevilla): problemática y situación actual de la investigación, in: L. García Sanjuán – J.M. Vargas Jiménez – V. Hurtado Pérez – M. T. Ruiz Moreno – R. Cruz-Auñón Briones (Hrsg.), El asentamiento

prehistórico de Valencina de la Concepción. Investigación y tutela en el 150 Aniversario del descubrimiento de La Pastora (Sevilla 2013) 459–468

Dambeck et al. 2010 R. Dambeck – H. Thiemeyer – A. J. Kalis – A. Lord – H.-P. Stika – A. Stobbe – N. Herrmann, Holozäne Talentwicklung und Landschaftswandel am Rio Sizandro. Geoarchäologische Beiträge zum Projekt »Sizandro – Alcabrichel« (Torres Vedras, Portugal), Madrider Mitteilungen 51, 2010, 9–41

Delibes de Castro – Montero Ruiz 1999 G. Delibes de Castro – I. Montero Ruiz (Hrsg.), Las primeras etapas metalúrgicas en la Península Iberica II. Estudios regionales (Madrid 1999)

Díaz-del-Río et al. 2006 P. Díaz-del-Río – S. Consuegra – N. Castañeda – M. Capote – C. Criado – M. A. Bustillo – J. L. Pérez Jiménez, The Earliest Flint Mine in Iberia. Antiquity Project Gallery 80.307. http://www.antiquity.ac.uk/projgall/diazdelrio307/

Domergue 1987 C. Domergue, Catalogue des mines et des fonderies antiques de la Péninsule Ibérique (Paris 1987)

Estácio da Veiga 1889 S. Philippes Martins Estácio da Veiga, Antiguidades Monumentaes do Algarve. Tempos Prehistoricos I (Lisboa 1889)

Estácio da Veiga 1891 S. Philippes Martins Estácio da Veiga, Antiguidades Monumentaes do Algarve. Tempos Prehistoricos III (Lisboa 1891)

Fitzpatrick 2019 A. P. Fitzpatrick, Mining, Making, and Stone Tools: the Earliest Metal Objects in Britain and Ireland, in: D. Brandherm, Aspects of the Bronze Age in the Atlantic Archipelago and Beyond. Proceedings from the Belfast Bronze Age Forum 9–10 November 2013. Archæologia Atlantica – Monographiæ III, 177–202.

García Sanjuán et al. 2013 L. García Sanjuán – J. M. Vargas Jiménez – V. Hurtado Pérez – T. Ruiz Moreno – R. Cruz-Auñón Briones (Hrsg.), El asentamiento prehistórico de Valencina de la Concepción (Sevilla). Investigación y tutela en el 150 Aniversario del descubrimiento de La Pastora (Sevilla 2013)

García Sanjuán et al. 2017 L. García Sanjuán – C. Scarre – D. Wheatley, The Mega-Site of Valencina de la Concepción (Seville, Spain). Debating Settlement Form, Monumentality and Aggregation in Southern Iberian Copper Age Societies, Journal of World Prehistory 30, 3, 2017, 239–257

Gauß 2013 R. Gauß [formerly Müller], The Development of Metallurgy on the Iberian Peninsula. Technological and Social Patterns of a Long-term Innovation Process, in: S. Burmeister – S. Hansen – M. Kunst – N. Müller-Scheeßel (Hrsg.), Metal Matters. Innovative Technologies and Social Change in Prehistory and Antiquity, Menschen – Kulturen – Traditionen, Studien aus den Forschungsclustern des Deutschen Archäologischen Instituts 12 (Rahden/Westfalen 2013) 209–229

Gauß 2015 R. Gauß [formerly Müller], Zambujal und die Anfänge der Metallurgie in der Estremadura (Portugal). Technologie der Kupfergewinnung, Herkunft des Metalls und soziokulturelle Bedeutung der Innovation, Iberia Archaeologica 15, 2 (Mainz 2015)

Gómez Ramos 1999 P. Gómez Ramos, Obtención de metales en la prehistoria de la Península Ibérica, British Archaeological Reports. International Series 753 (Oxford 1999)

Gonçalves 1989 V. S. Gonçalves, Megalitismo e metalurgia no Alto Algarve Oriental. Uma aproximação integrada, Estudos e Memórias, UNIARCH 2 (Lisboa 1989)

Hanning et al. 2010 E. Hanning – R. Gauß – G. Goldenberg, Metal para Zambujal. Reconstrucción experimental de una tecnología de 5.000 años, Trabajos de Prehistoria 67, 2, 2010, 287–304

Harrison – Craddock 1981 R. J. Harrison – P. T. Craddock, A Study of the Bronze Age Metalwork from the Iberian Peninsula in the British Museum, Ampurias 43, 1981, 113–179

Hunt Ortiz 2003 M. Hunt Ortiz, Prehistoric Mining and Metallurgy in the South-West Iberian Peninsula, British Archaeological Reports. International Series 1188 (Oxford 2003)

Hurtado 2004 V. Hurtado, El asentamiento fortificado de San Blas (Cheles, Badajoz). III milenio a. C, Trabajos de Prehistoria 6, 1, 2004, 141–155

Jalhay – do Paço 1945 E. Jalhay – A. do Paço, El Castro de Vilanova de San Pedro, Actas y memorias de la Sociedad Española de Antropología, Etnografía y Prehistoria 20, 1945, 5–92

Junghans et al. 1968 S. Junghans – E. Sangmeister – M. Schröder, Kupfer und Bronze in der frühen Metallzeit Europas. Studien zu den Anfängen der Metallurgie 2, 1–3 (Berlin 1968)

Junghans et al. 1974 S. Junghans – E. Sangmeister – M. Schröder, Kupfer und Bronze in der frühen Metallzeit Europas, Studien zu den Anfängen der Metallurgie 2, 4 (Berlin 1974)

Krause – Pernicka 1996 R. Krause – E. Pernicka, Das neue Stuttgarter Metallanalysenprojekt ›SMAP‹, Archäologisches Nachrichtenblatt 1, 1996, 274–291

Kunst 2001 M. Kunst, Die Kupferzeit der Iberischen Halbinsel, in: M. Blech – M. Koch – M. Kunst (Hrsg.), Denkmäler der Frühzeit, Hispania Antiqua (Mainz 2001) 67–100

Kunst 2013 M. Kunst, The Innovation of Copper Metallurgy on the Iberian Peninsula. Its Significance

for the Development of Social Complexity in the 3rd Millennium BC, in: S. Burmeister – S. Hansen – M. Kunst – N. Müller-Scheeßel (Hrsg.), Metal Matters. Innovative Technologies and Social Change in Prehistory and Antiquity. Menschen – Kulturen – Traditionen, Studien aus den Forschungsclustern des Deutschen Archäologischen Instituts 12 (Rahden/Westfalen) 2013) 181–208

Kunst – Trindade 1990 M. Kunst – L. J. Trindade, Zur Besiedlungsgeschichte des Sizandrotals. Ergebnisse aus der Küstenforschung, Madrider Mitteilungen 31–1990, 1991, 34–82. Taf. 3–14

Lago et al. 1998 M. Lago – C. Duarte – A. Valera – J. Alberaria – F. Almeida – A. F. Carvalho, Povoado dos Perdigões (Reguengos de Monsaraz). Dados preliminares dos trabalhos arqueológicos realizados em 1997, Revista Portuguesa de Arqueologia 1, 1, 1998, 45–152

Leisner – Schubart 1966 V. Leisner – H. Schubart, Die kupferzeitliche Befestigung von Pedra do Ouro/ Portugal, Madrider Mitteilungen 7, 1966, 9–60

Márquez Romero – Jiménez Jáimez 2010 J. E. Márquez Romero – V. Jiménez Jáimez, Recintos de fosos. Genealogía y significado de una tradición en la prehistoria del Suroeste de la península Ibérica (IV–III milenios AC) (Málaga 2010)

Martín de la Cruz 1994 J. C. Martín de la Cruz, Los primeros contactos entre Grecia y la Península Ibérica. La problemática planteada por los hallazgos de Montoro (Córdoba), in: D. Vaquerizo (Hrsg.), Arqueología de la Magna Graecia, Sicilia y Península Ibérica (Córdoba 1994) 111–146

Martínez Navarrete 1998 M. I. Martínez Navarrete, The Development of Spanish Archaeology in the 20th century, Archaeologia Polona 35–36, 1998, 319–342

Mataloto 2005 R. Mataloto, Meio Mundo 21: a fortificação do Alto de São Gens (Redondo/Estremoz, Alentejo Central), Revista Portuguesa de Arqueologia 8, 2005, 5–19

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

Montero Ruiz – Ruiz Taboada 1996 I. Montero Ruiz – A. Ruiz Taboada. Enterramiento colectivo y metalurgia en el yacimiento neolítico de Cerro Virtud (Cuevas del Almanzora, Almería), Trabajos de Prehistoria 53, 1996, 55–75

Montero Ruiz – Murillo Barroso 2014 I. Montero Ruiz – M. Murillo Barroso, Difusión o innovación tecnológica: los inicios de la metalurgia en la Península Ibérica, in: E. García (Hrsg.), Movilidad, contacto y cambio. Actas del II Congreso de Prehistoria de Andalucía (Sevilla 2014) 65–75

Müller et al. 2004 R. Müller [now Gauß]– Th. Rehren – S. Rovira, Almizaraque and the Early Copper Metallurgy of Southeast Spain: New Data, Madrider Mitteilungen 45, 2004, 33–56

Müller et al. 2007 R. Müller [now Gauß] – G. Goldenberg – M. Kunst – M. Bartelheim – E. Pernicka, Zambujal and the Beginnings of Metallurgy in Southern Portugal, in: S. La Niece – D. Hook – P. Craddock (Hrsg.), Metals and Mines. Studies in Archaeometallurgy. Selected papers from the conference Metallurgy – a touchstone for cross-cultural interaction, British Museum, 28–30 April 2005 (London 2007) 15–26

Müller – Cardoso 2008 R. Müller [now Gauß] – J. L. Cardoso, The Origin and Use of Copper at the Chalcolithic Fortification of Leceia, Portugal, Madrider Mitteilungen 49, 2008, 64–93

Müller – Soares 2008 R. Müller [now Gauß] – A. M. Monge Soares, Traces of Early Copper Production at the Chalcolithic Fortification of Vila Nova de São Pedro, Portugal, Madrider Mitteilungen 49, 2008, 94–114

Müller – Pernicka 2009 R. Müller [now Gauß] – E. Pernicka, Chemical Analyses in Archaeometallurgy. A View on the Iberian Peninsula, in: T. L. Kienlin – B. Roberts (Hrsg.), Metals and Societies. Studies in honour of Barbara S. Ottaway, Universitätsforschungen zur prähistorischen Archäologie 169 (Bonn 2009) 296–306

Murillo Barroso – Montero Ruiz 2012 M. Murillo Barroso – I. Montero Ruiz, Copper Ornaments in the Iberian Chalcolithic: Technology versus Social Demand, Journal of Mediterranean Archaeology 25, 1, 2012, 53–73

Murillo Barroso – Montero Ruiz 2017 M. Murillo Barroso – I. Montero-Ruiz, The Social Value of Things. Amber and Copper in the Iberian Chalcolithic, in: M. Bartelheim – P. Bueno Ramírez – M. Kunst (Hrsg.), Key Resources and Sociocultural Developments in the Iberian Chalcolithic, RessourcenKulturen 6 (Tübingen 2017) 273–290

Murillo Barroso et al. 2015 M. Murillo Barroso – M. E. Costa – M. Díaz Guardamino – L. García Sanjuán – C. Mora, A Reappraisal of Iberian Copper Age Goldwork. Craftmanship, Symbolism and Art in a Non-Funerary Gold Sheet from Valencina de la Concepción, Cambridge Archaeological Journal, 25, 3, 2015, 565–596

Nocete 2004 F. Nocete (Hrsg.), Odiel. Proyecto de investigación arqueológica para el análisis del origen de la desigualdad social en el Suroeste de la Península Ibérica, Monografías de Arqueología 19 (Sevilla 2004)

Nocete et al. 1999a F. Nocete – P. Escalera – J. A. Linares – R. Lizcano – A. Orihuela – R. Otero – J. C.

Romero – R. Sáez, Estudio del material arqueológico de la primera campaña de excavación de Cabezo Juré (Alosno, Huelva). Proyecto Odiel, Anuario Arqueológico de Andalucía 1994, 1999, 93–104

Nocete et al. 1999b F. Nocete – R. Lizcano – A. Orihuela – J. A. Linares – R. Otero – P. Escalera – P. Parrales – J. C. Romero, Primera campaña de excavación arqueológica de Cabezo Juré (Alosno, Huelva), Anuario Arqueológico de Andalucía 1994, 1999, 86–92

Nocete et al. 2008 F. Nocete – G. Queipo – R. Saéz – J. M. Nieto – N. Inácio – M. Rodríguez 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), Journal of Archaeological Science 35, 2008, 717–732

Oliveira – Matos 2002 M. L. Ferreira de Oliveira – X. M. Matos, The Exploitation of Copper Ores in the South of Portugal During the Chalcolithic, Revista de Ciências Históricas da Universidade de Portucalense Infante D. Henrique 17, 2002, 123–138

Orestes Vidigal et al. 2015 R. Orestes Vidigal – P. Valério – M. F. Araújo – A. M. Monge Soares – R. Mataloto, Micro-EDXRF Study of Chalcolithic Copper Based Artefacts from Southern Portugal, X-ray Spectometry, 45, 2016, 63–68

Ottaway 1982 B. Ottaway, Earliest Copper Artefacts of the Northalpine Region. Their Analysis and Evaluation, Schriften des Seminars für Urgeschichte der Universität Bern 7 (Bern 1982)

do Paço 1955 A. do Paço, El Castro de Vila Nova de S. Pedro (VII). Considerações sobre o problema da metalurgía, Zephyrus 6, 1955, 27–40

do Paço – Jalhay 1939 A. do Paço – E. Jalhay, A póvoa eneolítica de Vila Nova de S. Pedro, Brotéria 29, 1939, 86–99

do Paço – Sangmeister 1956 A. do Paço – E. Sangmeister, Vila Nova de S. Pedro. Eine befestigte Siedlung der Kupferzeit in Portugal, Germania 34, 1956, 211–231

Parreira 1985 R. Parreira, Notas de leitura. Edward Sangmeister; Hermanfrid Schubart, Zambujal. Die Grabungen 1964 bis 1973, O Arqueólogo Português (Series 4) 3, 1985, 207–211.

Pereira, F. et al. 2013 F. Pereira – R. J. Silva – A. M. Monge Soares – M. F. Araújo, The Role of Arsenic in Chalcolithic Copper Artefacts. Insights from Vila Nova de São Pedro (Portugal), Journal of Archaeological Science 40, 2013, 2045–2056

Pereira et al. 2017 F. Pereira – R. J. Silva – A. M. Monge Soares – M. F. Araújo – J. L. Cardoso, Metallurgical Production from the Chalcolithic Settlement of Moita da Ladra, Portugal, Materials and Manufacturing Processes 32, 2017, 781–791

Pérez Macías 1996 J. A. Pérez Macías, Metalurgia extractiva prerromana en Huelva (Huelva 1996)

Pernicka 1984 E. Pernicka, Instrumentelle Multi-Elementanalyse archäologischer Kupfer- und Bronzeartefakte. Ein Methodenvergleich, Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 31, 1984, 517–531

Pernicka 1987 E. Pernicka, Erzlagerstätten in der Ägäis und ihre Ausbeutung im Altertum. Geochemische Untersuchungen zur Herkunftsbestimmung archäologischer Metallobjekte, Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 34, 1987, 607–714

Pernicka 1990 E. Pernicka, Gewinnung und Verbreitung der Metalle in prähistorischer Zeit, Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz 37, 1990, 21–129

Renfrew 1967 C. Renfrew, Colonialism and Megalithismus, Antiquity 41, 1967, 276–288

Renfrew 1969 C. Renfrew, The Autonomy of the South-East European Copper Age, Proceedings of the Prehistoric Society 35, 1969, 12–47

Renfrew 1970 C. Renfrew, The Tree-Ring Calibration of Radiocarbon. An Archaeological Evaluation, Proceedings of the Prehistoric Society 36, 1970, 280–311

Renfrew 1972a C. Renfrew, The Emergence of Civilisation. The Cyclades and the Aegean in the Third Millennium BC (London 1972)

Renfrew 1972b C. Renfrew, Carbon 14 and the Prehistory of Europe, in: C. C. Lamberg-Karlovsky (Hrsg.), Old World Archaeology (San Francisco 1972) 201–209

Renfrew 1973 C. Renfrew, Before Civilisation. The Revolution of C14 in Prehistoric Europe (London 1973)

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: la arqueometalurgia y la aplicación de análisis metalográficos y composicionales en el estudio de la producción de objetos de metal, British Archaeological Reports. International Series 1769 (Oxford 2008)

Rothenberg – Blanco Frejeiro 1981 B. Rothenberg – A. Blanco Frejeiro, Studies in Ancient Mining and Metallurgy in South-West Spain. Explorations and Excavations in the Province of Huelva, Metals in History 1 (London 1981)

Rovira 2002 S. Rovira, Early Slags and Smelting By-Products of Copper Metallurgy in Spain, in: M.

Bartelheim – E. Pernicka – R. Krause (Hrsg.), Die Anfänge der Metallurgie in der Alten Welt / The Beginnings of Metallurgy in the Old World, Forschungen zur Archäometrie und Altertumswissenschaft 1 (Rahden/Westfalen 2002) 83–98

Rovira – Montero Ruiz 2013 S. Rovira – I. Montero Ruiz, Iberia. Technological Development of Prehistoric Metallurgy, in: S. Burmeister – S. Hansen – M. Kunst – N. Müller-Scheeßel (Hrsg.), Metal Matters. Innovative Technologies and Social Change in Prehistory and Antiquity. Menschen – Kulturen – Traditionen, Studien aus den Forschungsclustern des Deutschen Archäologischen Instituts 12 (Rahden/Westfalen 2013) 231–239

Rovira et al. 1997 S. Rovira – I. Montero – S. Consuegra, Las primeras etapas metalúrgicas en la Península Ibérica I. Análisis de materiales (Madrid 1997)

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

Sáez et al. 2001 R. Sáez – F. Nocete – J. M. Nieto – M. A. Capitan – S. Rovira – A. Ruiz-Conde – P. J. Sánchez-Soto, Metalurgia del Cu en Cabezo Juré (Alosno, Huelva). Estudio mineralógico de escorias del 3er milenio a.n.e., Boletín de la Sociedad Española de Mineralogía 24, 2001, 171–179

Sangmeister 1960 E. Sangmeister, Metalurgia y comercio del cobre en la Europa prehistórica, Zephyrus 11, 1960, 131–139

Sangmeister 1965 E. Sangmeister, Die Bronzezeit im Westmittelmeer, in: Ursprung und Frühkulturen. Primäre Zentren der Hochkultur. Weltgeschichtliche Berührungszonen, Saeculum Weltgeschichte 1 (Freiburg 1965) 551–563

Sangmeister 1972 E. Sangmeister, Sozial-ökonomische Aspekte der Glockenbecherkultur, in: I. Schwidetzky (Hrsg.), Beiträge zur Prähistorischen Anthropologie und Urgeschichte Europas. Festschrift Kurt Gerhardt zum 60. Geburtstag, Homo 23, 1–2, 1972, 188–203.

Sangmeister 1975 E. Sangmeister, Spätes Neolithikum und Kupferzeit der Iberischen Halbinsel, in: K. J. Narr (Hrsg.), Handbuch der Urgeschichte II (Bern 1975) 545–632

Sangmeister 1995 E. Sangmeister, Zambujal. Kupferfunde aus den Grabungen 1964 bis 1973, in: E. Sangmeister – M. C. Jiménez Gómez, Zambujal. Kupferfunde aus den Grabungen 1964 bis 1973. Los amuletos de las campañas 1964 hasta 1973, Madrider Beiträge 5, 3 (Mainz 1995) 1–153

Sangmeister – Schubart 1965 E. Sangmeister – H. Schubart, Grabungen in der kupferzeitlichen Befestigung von Zambujal/Portugal 1964, Madrider Mitteilungen 6, 1965, 39–63

Sangmeister – Schubart 1981 E. Sangmeister – H. Schubart, Zambujal. Die Grabungen 1964–1973, Madrider Beiträge 5, 1 (Mainz 1981)

Savory 1968 H. N. Savory, Spain and Portugal (London 1968)

Savory 1972 H. N. Savory, The Cultural Sequence at Vila Nova de S. Pedro, Madrider Mitteilungen 13, 1972, 23–37

Schuhmacher 2016 T. X. Schuhmacher, Elefanten und Elfenbein auf der Iberischen Halbinsel und in Nordwest-Afrika. Interdisziplinäre Studien zu Austauschsystemen im 3. und der ersten Hälfte des 2. Jts. v. Chr., Iberia Archaeologica 16, 3 (Tübingen 2016)

Schuhmacher 2017 T. X. Schuhmacher, Ivory Exchange Networks in the Chalcolithic of the Western Mediterranean, in: M. Bartelheim – P. Bueno Ramírez – M. Kunst (Hrsg.), Key Resources and Sociocultural Developments in the Iberian Chalcolithic, RessourcenKulturen 6 (Tübingen 2017) 291–312

Silva – Soares 1977 C. Tavares da Silva – J. Soares, Contribuição para o conhecimento dos povoados calcolíticos do Baixo Alentejo e Algarve, Setúbal Arqueológica 2–3, 1977, 179–272

Siret – Siret 1890 E. Siret – L. Siret, Las primeras edades del metal en el Sudeste de España (Barcelona 1890)

Soares 2005 A. M. Monge Soares, A metalurgia de Vila Nova de São Pedro. Algumas reflexões, in: J. M. Arnaud – C. V. Fernandes (Hrsg.), Construindo a memória. As colecções do Museu Arqueológico do Carmo (Lisbon 2005) 179–188

Soares et al. 1994 A. M. Monge Soares – M. F. Araújo – J. M. P. Cabral, Vestígios da práctica de metalurgia em povoados Calcolíticos da bacia do Guadiana, entre o Ardila e o Chança, in: J. M. Campos Carrasco – J. A. Pérez Macías – F. Gómez Toscano, Arqueología en el entorno del Bajo Guadiana. Actas del encuentro internacional de arqueología del suroeste (Huelva 1994) 165–200

Sperl 1981 G. Sperl, Untersuchungen von Resten eines Kupfer-Gießplatzes in Zambujal, in: E. Sangmeister – H. Schubart, Zambujal. Die Grabungen 1964 bis 1973, Madrider Beiträge 5, 1 (Mainz 1981) 341–345

Spindler 1969 K. Spindler, Die kupferzeitliche Siedlung von Penedo/Portugal, Madrider Mitteilungen 10, 1969, 45–116

Valério et al. 2017 P. Valério – R. Orestes Vidigal – M. F. Araújo – A. M. Monge Soares – R. J. C. Silva – R. Mataloto, The Manufacture of Copper Weapons and Tools from the Chalcolithic Settlement of São Pedro (Portugal), Materials and Manufacturing Processes 32, 2017, 775–780

Villalba et al. 1986 M. J. Villalba – L. Bañolas – J. Arenas – M. Alonso, Les mines neolítiques de Can Tintorer, Gavà, excavacions 1978–1980, Excavacions Arqueològiques a Catalunya 6 (1986)

Abstracts

In the course of research history, Zambujal and other comparable fortified Chalcolithic sites of the Iberian Peninsula have been associated with copper production and processing. Until the late 1970s, these sites were interpreted as colonies of Eastern Mediterranean metallurgists. However, especially thanks to the work of Colin Renfrew, it became clear that the chronological primacy of the proposed Eastern Mediterranean archetypes of these fortifications does not exist. This was shown by the introduction of ^{14}C dates and their calibration in large parts of Europe during the 1960s and 1970s. Among the big fortified settlements, Zambujal is one of the best investigated. Due to its well documented stratigraphy, it offers the possibility to investigate the development of metallurgy exemplarily, at least for the Chalcolithic Estremadura. Already during the excavations between 1964 and 1973, samples for chemical analyses were taken from the copper artefacts found at the site. After years of intensive research, at least on the Iberian Peninsula, there is a unique data set characterising the metal assemblage of a Chalcolithic site, including trace element and lead isotope data, as well as metallographic and mineralogical studies. The current paper situates the DFG (German Research Council) project on the metallurgy of Zambujal within the wider context of research history and points out some major conclusions of the recent investigations.

Keywords: Chalcolithic, Portugal, Economic History, Archaeometallurgy, Mining

Ao longo do historial de investigação, o Zambujal e outros povoados fortificados equiparáveis do Calcolítico situados na Península Ibérica, têm sido fortemente associados ao processamento de cobre. Até ao final dos anos 1970, estes povoados eram interpretados como sendo colónias de metalurgistas provenientes do Este mediterrâneo. Com a introdução de dados de ^{14}C em extensas partes da Europa e através da sua calibração no decorrer dos anos 1960–70, tornou-se evidente, em grande parte graças à investigação de Colin Renfrew, que não se verificava de facto uma primazia cronológica dos supostos modelos do espaço oriental mediterrâneo em relação aos elementos existentes na Península Ibérica. Entre os maiores povoados fortificados destaca-se o Zambujal como um dos mais bem estudados. O elevado grau de pormenor da sua estratigrafia constitui uma boa base para o estudo do desenvolvimento da metalurgia, pelo menos no que concerne ao contexto da Estremadura portuguesa. Já durante as escavações do Zambujal de 1964 a 1973 foram recolhidas amostras dos objetos de cobre encontrados. Após vários anos de investigação exaustiva do Zambujal e do seu espólio metalúrgico, existe atualmente um conjunto de dados arqueometalúrgicos único no espaço peninsular. Este acervo inclui análises de elementos vestigiais e isótopos de chumbo, assim como estudos metalográficos e mineralógicos de artefactos em cobre e restos metalúrgicos. O presente ensaio descreve o historial da investigação do projeto científico sob a égide da DFG (Associação Alemã para a Investigação) relativo à metalurgia do Zambujal, fazendo referência às principais conclusões retiradas das mais recentes investigações.

Palavras-chave: Calcolítico, Portugal, História da Economia, Arqueometalurgia, Exploração Mineira

Zambujal und andere vergleichbare befestigte kupferzeitliche Siedlungen auf der Iberischen Halbinsel sind im Laufe der Forschungsgeschichte eng mit der Kupferproduktion in Verbindung gebracht worden. Noch bis in die späten 1970er Jahre wurden sie als Kolonien ostmediterraner Metallurgen gedeutet. Im Zuge der Einführung von ^{14}C-Daten in weiten Teilen Europas und ihrer zunehmenden Kalibration im Verlauf der 1960er und 1970er Jahre wurde vor allem durch die Arbeiten Colin Renfrews deutlich, dass das zeitliche Primat vieler als Vorbilder für entsprechende Elemente auf der Iberischen Halbinsel angesehener Befunde im ostmediterranen Raum nicht mehr bestand. Unter den großen befestigten Siedlungen ist Zambujal eines der besterforschten Exemplare und bietet durch seine detailliert dokumentierte Stratigraphie eine gute Möglichkeit, die Entwicklung der Metallurgie exemplarisch, zumindest für die portugiesische Estremadura, zu untersuchen. Bereits während der Ausgrabungen von 1964 bis 1973 wurden Proben von den dort gefundenen Kupferobjekten genommen. Nach Jahren intensiver Forschung liegt für Zambujal und seine Metallfunde mittlerweile ein zumindest für den Iberischen Raum einmaliger Satz archäometallurgischer Daten vor, der Spurenelement- und Bleiisotopenanalysen sowie metallographische und mineralogische Studien von Kupferartefakten und metallurgischen Resten umfasst. Der vorliegende Aufsatz stellt den forschungsgeschichtlichen Kontext des DFG-Forschungsprojekts zur Metallurgie Zambujals dar und verweist auf einige wesentliche Schlussfolgerungen der neueren Untersuchungen.

Schlagwörter: Kupferzeit, Portugal, Wirtschaftsgeschichte, Archäometallurgie, Bergbau

Image rights: Martin Bartelheim

Authors' addresses: Prof. Dr. Martin Bartelheim, Institut für Ur- und Frühgeschichte und Archäologie des Mittelalters, Abteilung Jüngere Urgeschichte und Frühgeschichte, Schloss Hohentübingen, Burgsteige 11, D-72070 Tübingen. E-mail: martin.bartelheim@uni-tuebingen.de; Dr. Roland Gauß, EIT RawMaterials, Tauentzienstraße 11, 10789 Berlin. E-mail: roland.gauss@eitrawmaterials.eu; PD Dr. Michael Kunst Tivolistr. 18, 79104 Freiburg im Breisgau. E-mail: M.Kunst@em.uni-frankfurt.de.

General Index

1 The classifications and terminologies of the Bronze Age phases and their absolute chronology differ from region to region and author to author. Therefore you find here the terminology used by the single authors, and sometimes, if it is not the Iberian Peninsula or general, an indication of region or culture.

2 For casting, smelting and melting in the Spanish and Portuguese texts sometimes is used fundición / fundido / fundição. It will say: Fundición of ore = smelting; fundición of metal = melting; fundición of metal into objects = casting.

3 See also the Geographical Index, letter M following the local name. Most of the indicated mines contain various minerals. Because of this, they are not classified as copper mines.

Geographical Index

The names of countries and places are given in the language of the country or in English. Differences between English, German, Portuguese and Spanish are indicated.

Abbreviations:
AS Archaeological site
A Administrative place name
D. District /Distrito
G Geography, Geology
M Mine, Mining region or Mining group, Mineralization

Personal Name Index

Entries in bold print indicate names and corresponding page numbers in the main text. Other entries indicate names and corresponding page numbers in the bibliography, footnotes or picture captions. Abbreviated publication details are given in brackets for contributors whose names do not appear in the bibliographical reference. Whenever possible, the biographical dates are provided.