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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.

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AND METALLURGY

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PALILIA 33

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Ortwin Dally und Norbert Zimmermann

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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

Evidence of Chalcolithic Copper Ore Mining in Southern Portugal

Searching for a Needle in a Haystack

by *Gert Goldenberg, Erica Hanning* and *Roland Gauß*

Introduction

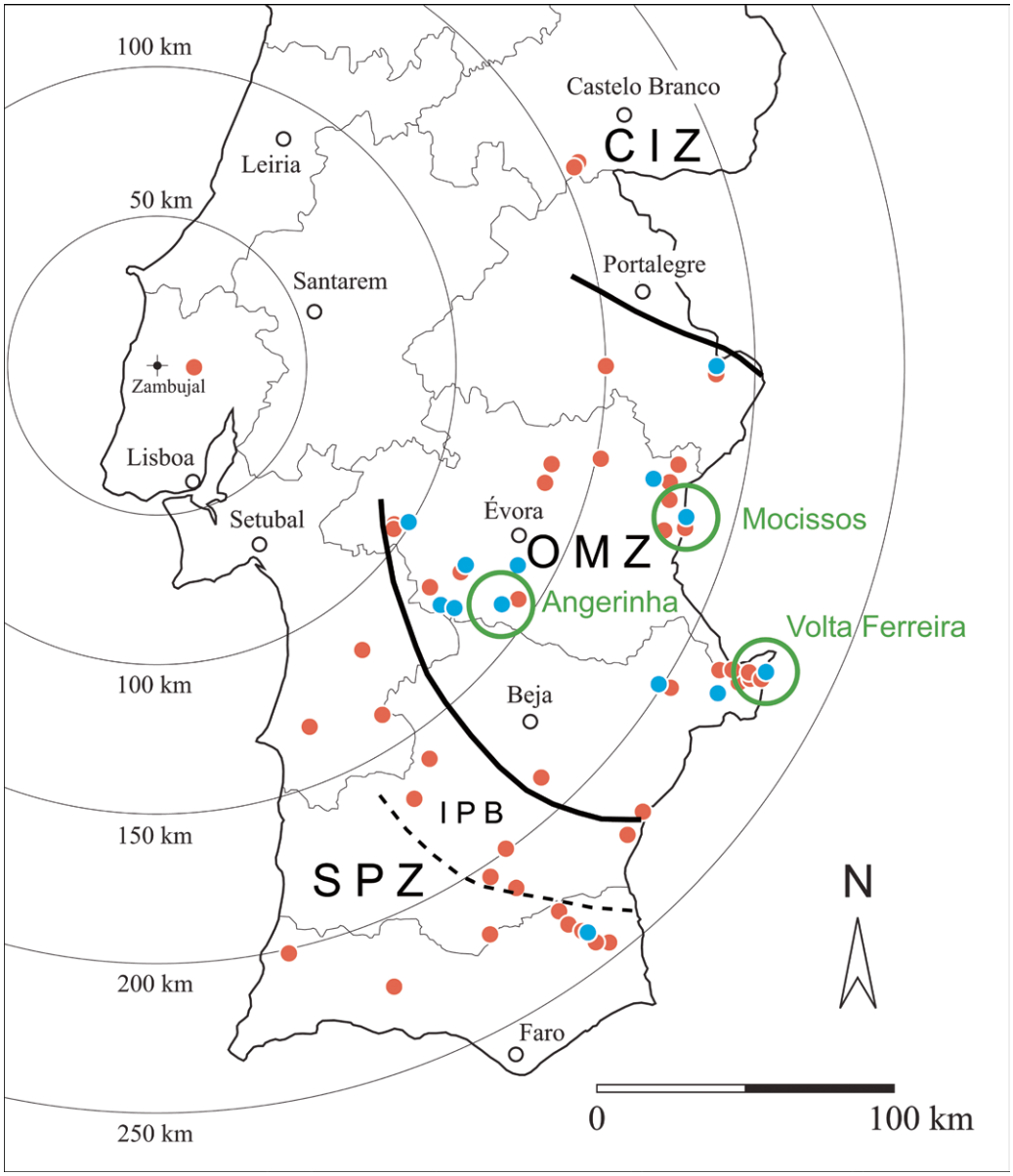
In 2001, a first attempt was made to locate potential copper ore sources for early metal production in the vicinity of Zambujal in the Portuguese Estremadura. This attempt proved to be unsuccessful, partly due to the restricted size of the prospection area on the one hand and the general geological setting on the other, which made it unlikely that any major copper ore deposits were to be expected. Therefore, a research project was created under the leadership of the German Archaeological Institute, Madrid Department, with the aim to carry out a systematic mining-archaeological prospection in the *hinterland* of the Portuguese Estremadura (Alentejo, Algarve, Centro), where a large number of copper ore deposits have been recorded. With the financial support of the German Research Foundation (DFG-project PA 368/8, grant applicants: H. Parzinger, M. Kunst, M. Bartelheim, E. Pernicka) several prospection campaigns could be carried out by the authors between 2004 and 2007, comprising ore sampling, mineralogical and geochemical analysis, as well as archaeological sondages (fig. 1). Close cooperation partners in Portugal included the Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI, Beja, J. Matos) and the Instituto Português de Arqueología (IPA, M. Soares). ^{14}C-dating was carried out at the Leibniz-Laboratory for Radiometric Dating and Isotope Research at the University of Kiel, Germany (P. Grootes).

Copper Ore Deposits in Southern Portugal

Today, Portugal is still an important producer of primary metals (Cu, Pb, Zn, Sn etc.) in the European Union, with the Iberian Pyrite Belt (IPB), located in the South Portuguese Zone (SPZ), as one of the largest ore deposits in the world. The sulfide ore deposits of the IBP[1] are volcano-sedimentary in origin, formed during the Paleozoic (Devon/Carbon) orogenic cycles. The massive ore body is mainly composed of pyrite with economically viable concentrations of copper, lead, zinc and tin, as well as silver and gold. The IPB extends from Alcácer do Sal (Setúbal, Portugal) in the Northwest to Sevilla (Spain) in the Southeast, roughly 250 km in length with a width between 30 and 60 km. Especially notable former mines include Lousal, Aljustrel and São Domingos on the Portuguese side and Rio Tinto and Tharsis on the Spanish side. Some of these large mining districts within the IPB had already played an important role in metal production on the Iberian Peninsula in Roman times[2].

From an archaeological/historical point of view, it has been commonly accepted that the large sulfide ore deposits of the IPB, or rather their former oxidation zones (gossans) were the primary resource for early copper metallurgy in Southwestern Iberia. This statement must now be modified when regarding the results of the prospection campaigns, at least for the prehistoric cultural area of the Portuguese Estremadura and Alentejo. There, the ore deposits of the Ossa-Morena Zone (OMZ) played a dominating role as a source for Chalcolithic copper[3].

1 Barriga 1990; Martins et al. 1998; Matos – Martins 2006.
2 Domergue 1987; Domergue 1990.
3 Müller et al. 2007.



1 Map of the prospection area; red and blue dots: ore samples from mining districts (blue dots signify finds of stone tools in addition to ore samples); circles (green): mining-archaeological sondages in 2006/2007; CIZ: Central Iberian Zone; OMZ: Ossa-Morena Zone; SPZ: South Portuguese Zone; IPB: Iberian Pyrite Belt

The Ossa-Morena Zone (OMZ), another important copper ore province, lies to the north of the SPZ in Southwest Iberia. On the Portuguese side, the OMZ is bordered to the west by the Serra de Ossa mountain range and on the Spanish side by the Sierra Morena and comprises large parts of the geographical regions of the Portuguese Alentejo, the Spanish Extremadura and the northwestern part of Andalusia up to the edge of the Guadalquivir Basin. The OMZ is a complex geo-tectonic unit that has undergone many deformations and super-impositions over the course of time, but is generally composed of polymetamorphic Precambrian to Devonian geological formations[4]. Several polymetallic vein-type copper ore deposits, as well as stratabound and disseminated ore deposits, occur in the orogenic belts of the OMZ. Some of the most important mines that were active in the 19th and 20th centuries[5] include: Miguel Vacas (Vila Viçosa); Bugalho, Mocissos and Zambujeira (Alandroal);

4 Tornos et al. 2004.

5 Monteiro – Barata 1889.

Mostardeira (Estremoz); Aparis, Botefa and Minancos (Barrancos). During the course of the prospection campaigns, it was possible to collect representative copper ore samples from the mining dumps of these mining districts, which could mainly be attributed to the former oxidation zones (copper oxides, carbonates, sulfates and native copper) and cementation zones (copper sulfides) that lay above the primary chalcopyrite/pyrite ore bodies.

Sample Collection and Mineralogical/Geochemical Analysis

One fundamental result of the prospection campaigns was the ascertainment of the large potential for prehistoric copper exploitation in Alto Alentejo, especially in the Ossa-Morena Zone (OMZ). This potential is mainly based on a number of mostly smaller but qualitatively rich copper ore deposits that were initially easy to exploit and thus an ideal starting point for Chalcolithic and also Bronze Age metal production.

Preliminary research for the prospection campaigns was conducted using general literature on the ore geology of Portugal[6], as well as the mineral resources registered in the archives of the INETI in Beja (kindly made possible by J. Matos). A current and very useful overview can be accessed using the on-line database SIORMINP (Sistema de Informação de Ocorrências e Recursos Minerais Portugueses, INETI). During the course of the prospection campaigns, a total of 70 copper ore occurrences in the dictricts of Faro, Beja, Évora, Setúbal, Portalegre, Lisboa, Castelo Branco and Guarda were visited (fig. 1). Overall it was possible to collect a quite representative cross-section of the copper ore deposits, at least in the Portuguese part of the Ossa-Morena Zone, as well as in the South Portuguese Zone (SPZ) including the Iberian Pyrite Belt. In the laboratory, 80 ore concentrates were produced from the mining dump samples and analysed using different mineralogical and geochemical methods (Institute of Geosciences, University of Freiburg, LGRB Freiburg, Curt-Engelhorn-Centre of Archaeometry in Mannheim).

On the basis of the available samples, the various copper ore occurrences could be evaluated with regard to their quality and potential use in prehistory. Geochemical and lead isotope analyses provide criteria that can be used to discuss the provenance and interpretation of copper artefacts[7]. According to the analytical results, the deposits within the OMZ were of particular interest for the prehistoric population; there, qualitative rich secondary copper ores – such as copper carbonates, oxides and sulfates (oxidation zone), as well as simple copper sulfides (cementation zone) – occur. Accompanying minerals are mostly quartz and iron hydroxides. These surface-near copper ores formed an ideal source of raw material for Chalcolithic and Bronze Age metal production.

In contrast, the search for copper ore in the large deposits of the Iberian Pyrite Belt, which would have been representative of the ore used in prehistory, proved to be quite unsatisfactory. This was mainly due to the current state of the outcrops: extensive exploitation – in modern as well as in Roman times – has left the deposits in a deteriorated state. Although it can be assumed that secondary copper minerals were present in the now almost absent gossan, which would have been located above the primary sulfide ore body, the extensive mining and movement of material in the immediate surroundings makes them difficult or impossible to locate. This also holds true for archaeological evidence of possible prehistoric mining: such traces would have been obliterated by younger extensive opencast mining. As a result, sometimes only samples from the primary sulfide ore, mainly pyrite from the modern mining activity, could be collected for comparative analysis.

Mining-Archaeological Prospection

Mining-archaeological prospection produced "evidence of prehistoric mining activity" at 13 sites; 12 of these were located within the OMZ and only 1 in the SPZ. Indications of prehistoric mines were mainly present in the form of stone tools scattered in the mining dumps (notched and grooved cobble stone hammers and stone

6 Thadeu 1965; Martins et al. 1998.

7 Müller et al. 2007; Gauß 2016.

anvils with cup-shaped depressions), while prehistoric ceramic was only very seldom found on the surface of the mining areas. Domergue, in his work *Catalogue des mines et des fonderies antiques de la péninsule ibérique*[8], had already postulated prehistoric exploitation in several different Portuguese mining regions through the presence of grooved stone hammers (*maillet à rainure*). The dating of these stone mining tools, however, remains problematic. Typical attributes, such as pecked notches or grooves, are insufficient for a chronological classification: these stone tools could also have been used in Roman times.

In the third year of the project (2006/2007), sondages were carried out at three selected mining sites within the OMZ, which were chosen on the basis of archaeological surface finds. In two of these sondages, it was possible to uncover archaeological evidence of prehistoric mining dating to the Chalcolithic period. Systematic charcoal sampling for ^{14}C-dating proved to be the most relevant manner to date the sites, since the investigated mining dumps only very rarely contained other datable artefacts like ceramic fragments or metal objects.

Mocissos (Alandroal)

In the summer of 2006, a six-week excavation campaign was carried out in the mining district of Mocissos, near Alandroal (district Évora). The site is located close to the dammed Guadiana River (Alqueva reservoir), which forms the border with Spain. Two larger Chalcolithic settlements are located not far from the Monte dos Mocissos, and could be considered as possible points of origin for concurrent local copper mining activities: the settlement of "Perdigoa", ca. 8 kilometers to the north of Mocissos[9], and the settlement of "San Blas", located on the Spanish side of the Guadiana River, ca. 12 km south of Mocissos[10].

At Mocissos, highly visible traces of mining with extensive dumps run for circa 800 meters along an elongated hillside on top of the southeast-northwest oriented mineralization zone (fig. 2). During the course of the prospection, stone tools (mostly stone hammers) were found there (fig. 3). Mining traces take the form of a more or less linearly-oriented string of pits with collapsed mining trenches, opencast mining and individual shafts which mark the strike of the former zone of the ore veins.

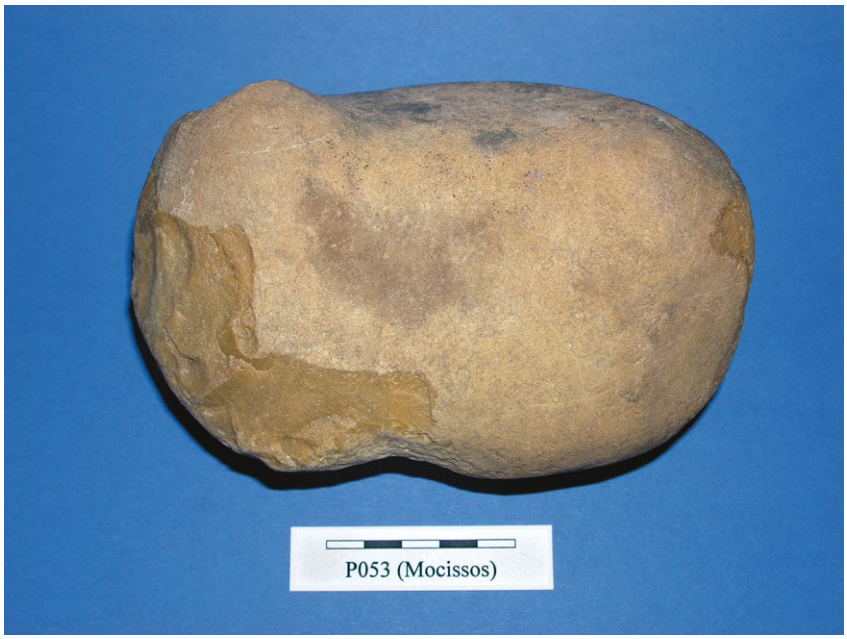
The ore mineralization from Mocissos (also known as "Mociços" or "Granja") is listed as a copper mine in the archives, and along with quartz as gangue material, it also contains mainly iron ore minerals (large amounts of goethite and limonite). Judging from the dump material, a substantial gossan or pronounced oxidation zone must have existed near the surface and lain above a copper sulfide ore body with chalcopyrite as primary ore mineral. Originally, rich copper ores in the form of malachite $Cu_2[(OH_2)/CO_3)]$, pseudomalachite $Cu_5[(OH)_2/PO_4]_2$, cuprite Cu_2O and also native copper Cu could have been extracted near the surface, which is supported by microscopy of the polished ore slides, as well as XRD analyses of the ore samples.

The mining-archaeological sondage was carried out on a small part of the dump located at the southeastern end of the visible mining traces. A quartz-rich and therefore erosion-resistant stone ridge juts several meters above the surrounding land and separated the visible mining traces from the excavation site. The prehistoric classification of this part of the mining dump was impressively confirmed during the course of the excavation, and the stratigraphy of the dump could be followed and documented down to the base rock. Plenty of finds, in the form of stone tools and ceramic fragments, were recovered in the process. Individual ceramic finds from the upper part of the mining dump could be typologically classified to the "Early Iron Age", while the bulk of the finds could be attributed to the "Middle to Late Bronze Age" (typological classification of the ceramic by Rui Mataloto, Redondo).

It was possible to document the profile stratigraphy down to the rock base of a circa two meter thick mining dump (fig. 4). A series of 12 charcoal samples, as well as a sample of an animal tooth (molar from a boar) were extracted from the different layers for ^{14}C-analysis. With the help of the radiocarbon dates, it was possible to prove multiple phases of prehistoric mining activity (fig. 5). The upper, younger layers of the mining dump produced Early-Iron-Age dates (KIA 31368, KIA 31369), while the following middle section dated to the Middle Bronze Age (KIA 30547, KIA 30548). The ceramic artefacts from the corresponding layers support these analytical findings. The base of the Middle Bronze Age dump was formed by a very prominent occupation layer, and was preceded by "older" dump layers. The ^{14}C-samples from the area underneath this occupational layer proved to be Early Bronze Age (KIA 31371, KIA 31372), Chalcolithic (KIA 30545, KIA 30552) and Neolithic

8 Domergue 1987; Hunt Ortiz 2003.
9 Calado 1993.
10 Hurtado Perez 2004.

2 Mocissos mine above the Guadiana River, traces of opencast mining and dumps



3 Quartzite cobble stone hammer with picked grooves and wear marks

(KIA 30549, KIA 30550, KIA 31370) in date, although a clear stratigraphical sequence could no longer be identified. With the exception of fragments from a smelting crucible, no other ceramic objects were found in the older layers. However, two amphibolite stone axes were uncovered. The ceramic crucible fragments exhibit a slagged, bloated rim; microscopic inspection revealed tiny inclusions of metallic copper prills in a glassy

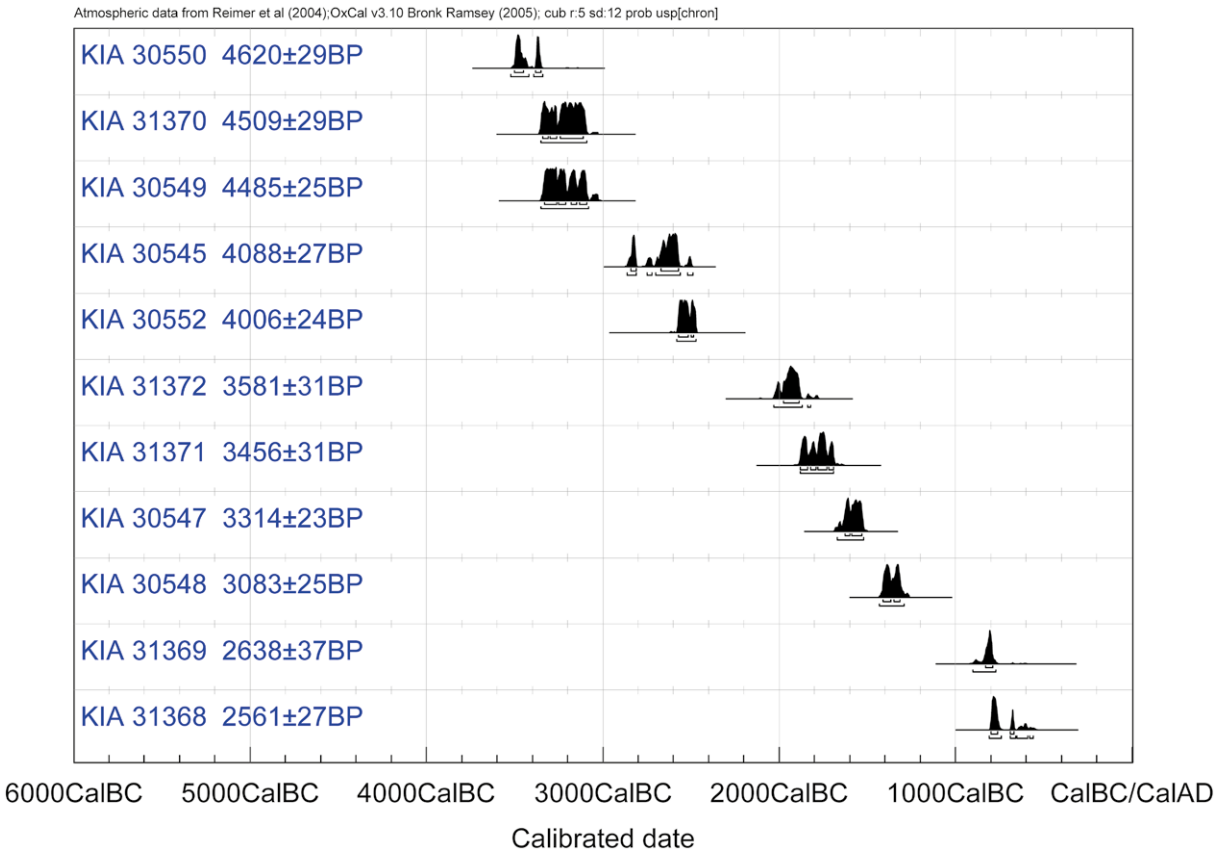
4 Excavation cut from 2006; A: Early Iron Age to Middle Bronze Age strata; B: Early Bronze Age/Chalcolithic/Neolithic strata

matrix. This proves that a pyrometallurgical process took place in the direct vicinity of the exploited ore body – until now, traces of Chalcolithic/Early Bronze Age copper metallurgy have only been known from settlements like Zambujal (Torres Vedras), São Pedro (Redondo) and Cabezo Juré (Huelva)[11].

Further traces of ore extraction were found in the bedrock at the base of the mining dump, where small ore veinlets and nests had apparently formed in the periphery of the main load. In addition to a small, only decimeter-wide "scooped-out" cleft, there was also a ca. 1 meter deep and 1 meter in diameter "mining pit" with traces of malachite and limonite still left in the bedrock. Charcoal samples from the backfill of this small exploitation returned radiocarbon dates from the Early Bronze Age, Chalcolithic, and Neolithic.

In light of the prospection on the mining dumps and excavation results it can be assumed that a considerable, when not predominant part of the mining traces and dumps visible today can be traced back to prehistoric mining activities. This mine shows several phases with activity beginning in the second half of the 4th millenium B.C. and continuing through the Chalcolithic and into the Early Bronze Age. Most of the stone tools and ceramic finds scattered in the mining dump can be attributed to an intensive mining phase which seems to have taken place during the Middle Bronze Age up until the Early Iron Age. This multi-phase find complex and its unexpected early start of mining activity makes the Mocissos mine an ideal starting point for future mining-archaeological investigations, which could bring insights into the beginnings of copper mining and production in Alto Alentejo and the Ossa-Morena Zone but also on the Iberian Peninsula on the whole. An important task for future investigations would therefore be a detailed compilation and interpretation of the prehistoric

11 Nocete 2004; Nocete 2006; Müller et al. 2007; Hanning et al. 2010.



5 Dating of multiphase prehistoric mining activities at the Mocissos mine by means of ^{14}C-analysis of charcoal (and one animal bone, KIA 31369)

stratigraphical sequence of the site. Additionally, pursuing the question of on-site primary metallurgy (smelting) would be of great importance for the reconstruction of the metallurgical *chaîne opératoire*.

Monte da Angerinha (Aguiar, Viana do Alentejo)

This excavation site is located near the farmhouse Monte da Angerinha, between Aguiar and Viana do Alentejo (district of Évora). Stone tool surface finds during the course of the prospections gave a hint to its possible "prehistoric" use. The copper mine near Monte da Angerinha, situated on a slight elevation in the middle of pastureland, contains a WSW-ENE oriented series of large pits with surrounding ring-shaped mining dumps. There is no written documentation of modern or historical mining activity at the site.

In spring 2007, an excavation campaign took place in the area of this mine, during which the depression-like pit with an accompanying dump to the south was investigated at several different points. It was possible to document the former mining structure up to a depth of 3 meters (fig. 6). Sondages carried out in the adjoining mining dump uncovered layers of mining dump material with evidence of at least two different mining phases divided by a well-defined occupation layer (fig. 7). During the course of the excavation, it was possible to uncover part of the roof of a collapsed underground mine, which was most likely accessed by a well-made "shaft" with a preserved "toe hold" sunken into the surrounding bedrock. The excavation was able to reach the collapsed ceiling of the mine at a depth of 1 to 3 meters, which was composed of a chaotic mass of stone blocks with remaining traces of copper ore (malachite crusts) on its surface. The presence of deeper-lying cavities was hinted at by deep fissures and breakup of the stone blocks, as well as the extreme rapidity with which surface water from heavy rain showers drained from the cut. The collapsed mine was filled with water-born sediment from dump material (waste from mining and ore processing) as well as different cultural layers (waste deposits) mainly dated by ^{14}C-analysis to the Early Roman Period (fig. 8). A fragment of currently unclassified decorated pottery in the

6 Uncovering a collapsed mining structure at the Monte da Angerinha mining site during the 2007 excavation campaign

lowermost fill layers, as well as other heavily eroded ceramic fragments from another trial trench points to a prehistoric period of use. Several stone tools, in the form of cobblestone hammers, as well as "multi-function" tools (stone hammers with small cup-shaped pock marks), were also found, but their dating still remains unclear. Such multi-function stone tools are commonly found in Chalcolithic settlements but could also be younger.

At this excavation, it was again possible to establish a multi-phase mine with a "Chalcolithic component". ^{14}C-dating of mining activity showed that the mine and dumps mainly dated from the pre-Roman Iron Age to the Early Roman Period (KIA 33225, KIA 33226, KIA 33228, KIA 33230, KIA 33231, KIA 33232). Additionally, there was also a younger, Islamic component (KIA 33223, KIA 33224) and an early phase dating to the Chalcolithic (KIA 33227, KIA 33229). Two dates from

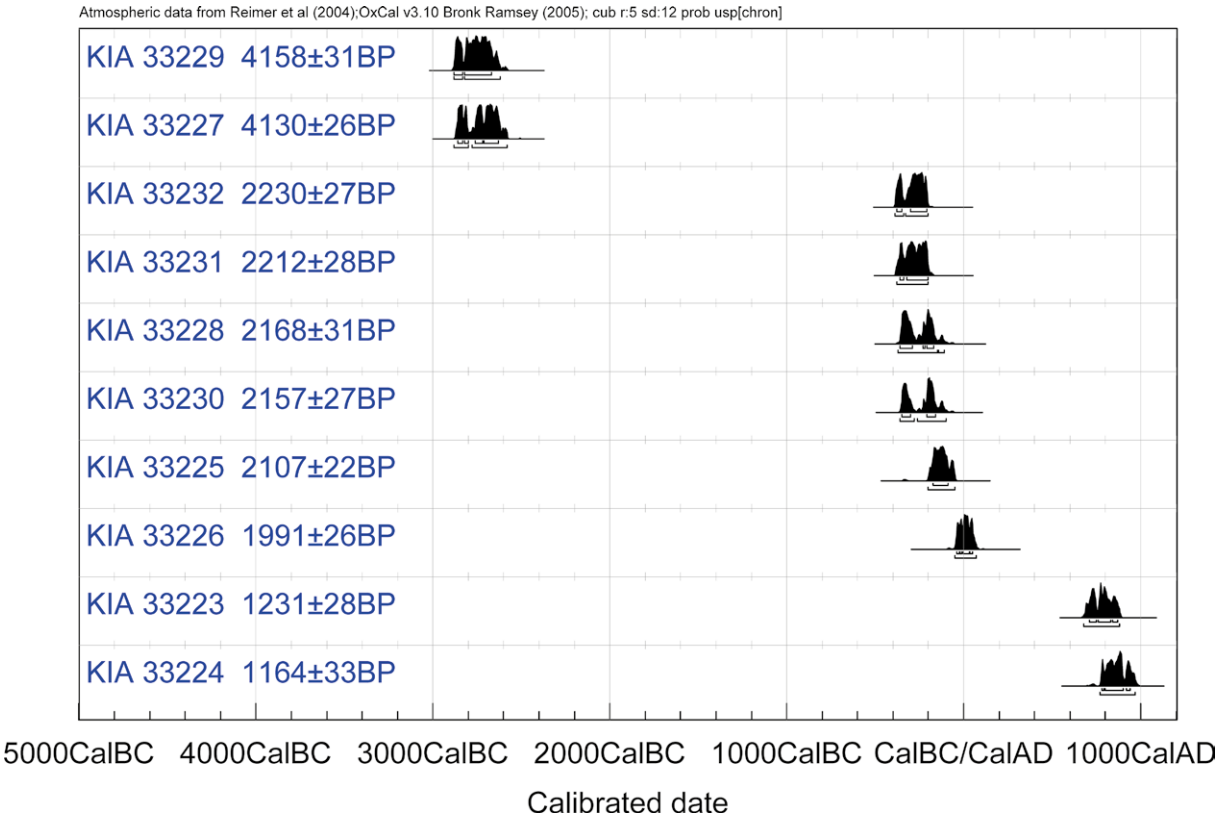
7 Profile of the multi-phase mining dump from Monte da Angerinha with layers dating to the Roman (Layer 3) and Chalcolithic (Layer 6) periods

the deepest occupation horizon prove that there was activity at the site during the first half of the 3rd millenium BC! These findings, as well as those from Mocissos, show that Chalcolithic mines leave only very little traces in the landscape. In those cases such early activities are heavily superimposed by Bronze Age (Mocissos) and/or Roman (Monte da Angerinha) mining activities and are thus very difficult to prove.

Summary and Conclusion

Archaeological excavations during the last decades in Zambujal and other Chalcolithic settlements have brought to light metal artefacts and relicts of metallurgical processes. In addition to the spreading use of metal, the practice of copper metallurgy has been found in the archaeological record in several places, although the differentiation between primary copper metallurgy (smelting) and secondary metallurgy (melting and casting) is not always possible. During the course of the DFG-funded research project, it was possible to investigate the possible source of the copper. This was done by analyzing the natural potential of the surrounding environment through ore mineralogy, geochemistry and mining archaeological prospections.

In Central and Southern Portugal, copper ore mainly occurs in the Ossa-Morena Zone (OMZ), as well as in the South Portuguese Zone (SPZ) including the Iberian Pyrite Belt (IPB). Current lead isotope data from metal artefacts and ore samples point to the use of occurrences in the OMZ (especially in the region of Alto Alentejo) as a main source of raw materials for prehistoric copper production. The Ossa-Morena Zone has many copper ore occurrences that contain qualitative rich copper ores. The surface-near occurrences – especially the secondary copper minerals from the oxidation zone (malachite, copper oxides and sulfates) above the primary sulfide ore bodies (pyrite, chalcopyrite, etc) – would have been easily accessible raw material for prehistoric



8 Dating of multiphase mining activities at the Monte da Angerinha mining site by means of ^{14}C-analysis of charcoal

metal production. With the help of mining-archaeological prospection and archaeological sondages at selected mining districts in Alentejo it was possible to uncover Chalcolithic mining activities (dated via ^{14}C-dating) at two different sites. However, proof of prehistoric mining is generally very difficult to find – like searching for a needle in a haystack – since younger mining activities often destroyed or covered up these early traces. This is true for the widespread and extensive mining activity which took place in Roman times and during the 19th and 20th centuries AD.

The mining district of Mocissos (Alandroal), on the west bank of the Guadiana River, displayed a multi-phase prehistoric stratigraphy in its mining dumps. This prehistoric mining activity could be dated by its find material (ceramic, stone axes, charcoal) to the Late Neolithic, Chalcolithic, Bronze Age and into the Early Iron Age, and represents an ideal starting point for a larger research excavation. Important Chalcolithic settlements are only a few kilometers distant, located on both sides of the Guadiana River (for example, Perdigoa in Portugal and San Blas in Spain).

The copper mine from Monte da Angerinha (Viana do Alentajo) also had evidence of Chalcolithic activity, as dated via ^{14}C-analyses, but was mainly exploited during the Roman Period.

Bibliography

Barriga 1990 F. J. Barriga, Metallogenesis in the Iberian Pyrite Belt, in: R. Dallmeyer – E. Martinez Garcia (eds.), Pre-Mesozoic Geology of Iberia (Berlin 1990) 369–379

Calado 1993 M. Calado, Carta Arqueologica do Alandroal (Alandroal 1993)

Domergue 1987 C. Domergue, Catalogue des mines et des fonderies antiques de la Péninsule Ibérique, Série Archéologie 8 (Madrid 1987)

Domergue 1990 C. Domergue, Les mines de la Péninsule Ibérique dans l'Antiquité romaine, CEFR 127 (Rome 1990)

Gauß 2016 R. Gauß, Zambujal und die Anfänge der Metallurgie in der Estremadura (Portugal). Technologie der Kupfergewinnung, Herkunft des Metalls und soziokulturelle Bedeutung der Innovation, Iberia Archaeologica 15. Früher Bergbau und Metallurgie auf der Iberischen Halbinsel, Faszikel 1 (Tübingen 2016)

Hanning et al. 2010 E. Hanning – R. Gauß – G. Goldenberg, Metal for Zambujal. Experimentally Reconstructing a 5000-Year-Old Technology/Metal para Zambujal. Reconstrucción experimental de una tecnología de 5.000 años, TrabPrehist 67, 2, 2010, 287–304

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

Hurtado Perez 2004 V. Hurtado Perez, San Blas. The Discovery of a Large Chalcolithic Settlement by the Guadiana River, JIbA 6, 2004, 93–116

Martins et al. 1998 L. Martins – V. Borralho – J. Moreira – C.Magno – C. Inverno – V. Oliveira – L. Torres – J. Matos – D. Oliveira (ed.), Mineral Potential of Portugal (Lisbon 1998)

Matos – Martins 2006 J. X. Matos – L. Martins, Iberian Pyrite Belt Mining Region. Regional Study of the Portuguese Sector, Instituto Nacional de Engenharia, Tecnologia e Inovação (INETI) (Alfragide 2006)

Monteiro – Barata 1889 S. Monteiro – J. A. Barata, Catálogo descriptivo da secção de minas. Grupos I e II, Associação Industrial Portugueza, Exposição Nacional das Industrias Fabris (Lisboa 1889)

Müller et al. 2007 R. Müller – G. Goldenberg – M. Bartelheim – M. Kunst – E. Pernicka, Zambujal and the Beginnings of Metallurgy in Southern Portugal, in: S. La Niece – D. Hook – P. Craddock (eds.), Metals and Mines. Studies in Archaeometallurgy (London 2007) 15–26

Nocete 2004 F. Nocete (coord.), 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 2006 F. Nocete, The First Specialised Copper Industry in the Iberian Peninsula. Cabezo Juré (2900–2200 BC), Antiquity 80, 2006, 646–657

Thadeu 1965 D. Thadeu, Carte minière du Portugal. Échelle 1/500 000. Notice explicative (version française de G. Zbyszewski) (Lisboa 1965)

Tornos et al. 2004 F. Tornos – C. M. C. Inverno – C. Casquet – A. Mateus – G. Ortiz – V. Oliveira, The Metallogenic Evolution of the Ossa-Morena Zone. La evolucíon metalogenética de la Zona de Ossa Morena, Journal of Iberian Geology 30, 2004, 143–181

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Zusammenfassung

Im Rahmen des vom Deutschen Archäologischen Institut, Abteilung Madrid, durchgeführten und von der DFG geförderten Forschungsprojektes „Prähistorische Kupfermetallurgie in Zambujal (Portugal) – von der Erzlagerstätte zum Fertigprodukt“ wurden zwischen 2004 und 2007 montanarchäologische Prospektionen im südlichen Teil Portugals durchgeführt. Ziel mehrerer Geländekampagnen war es, das Naturraumpotenzial in Hinblick auf nutzbare Kupfererzvorkommen zu bewerten und archäologische Nachweise von prähistorischem, wenn möglich kupferzeitlichem Bergbau zu erbringen. Hierzu wurden eine repräsentative Anzahl der heute bekannten Kupfererzvorkommen aufgesucht, Erzproben genommen und mineralogisch/geochemisch analysiert sowie archäologische Sondierungsgrabungen in ausgewählten Bergbaurevieren durchgeführt. Als Ergebnis lässt sich die im Alto Alentejo gelegene Ossa-Morena-Zone als hauptsächliches Liefergebiet für das in der portugiesischen Estremadura während der Kupferzeit verwendete Kupfer bestimmen. An zwei Plätzen (Mocissos, Monte da Angerinha) konnten hier erstmals kupferzeitliche Bergbauaktivitäten anhand von ^{14}C-Datierungen an Holzkohle aus Bergbauhalden unmittelbar nachgewiesen werden. Weitere Nachweise wurden für bronzezeitlichen, eisenzeitlichen, römischen und islamzeitlichen Bergbau erbracht.