21st January | 2025

21 Janeiro | 2025

Encontro do «Boom ao Colapso»

"From Boom to Bust" meeting

«Forjando Conexões: Circulação de Metal, Tecnologia e Redes Sociais entre a Europa Atlântica e o Mundo Mediterrânico no 2.º e 1.º Milénios AC»

"Forging Connections: Metal Circulation, Technology, and Social Networks between Atlantic Europe and the Mediterranean World in the 2nd and 1st Millennia BC"

Ex-votos antropomórficos. Idade do Ferro. | Ex-votos zoomórficos. Idade do Ferro. (Foto: © MNFMC/MMP, E.P.E.)

A entrada é livre mas as inscrições obrigatórias para: geral.mnfmc@museusemonumentos.pt

Free entrance with mandatory registration to: geral.mnfmc@mususemonumentos.pt

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Book of abstract

Introduction

The 'From Boom to Bust' meeting “Forging Connections: Metal Circulation, Technology, and Social Networks between Atlantic Europe and the Mediterranean World in the 2nd and 1st millennia BC” aims to foster in-depth discussions on the complex interrelationships between metallurgy, trade, and social change in different European regions.

The event will bring together leading scholars to examine how metallurgical practices shaped socio-economic structures, promoted cultural exchange and facilitated the creation of extensive networks linking diverse communities in the Atlantic and Mediterranean worlds during the 1st and 2nd millennia BC.

Designed to stimulate interdisciplinary dialogue, the meeting will integrate perspectives from archaeology, archaeometry, geochemistry and social anthropology to enrich our understanding of these crucial interactions in later prehistory and protohistory.

Discussions will focus on the following key themes:

- Metal exchange and trade routes: Examining metal exchange routes and their crucial role in fostering social change and interregional connectivity.

- Technological advances in metalworking: Offering a comprehensive overview of innovations in metalworking and their impact on strengthening interregional linkages and promoting technology diffusion.

- Social networks and metal circulation: Investigating how the circulation of metals contributed to the development of complex social networks, shaping cultural interactions and social evolution.

- New developments in the isotopic analysis of metal artefacts: Presenting recent breakthroughs in isotopic analysis that enhance our understanding of metal provenance and circulation.

The meeting is funded by the FCT project "From Boom to Bust on the Atlantic Fringe - Copper Supply Networks in the Irish Late Bronze Age" (https://doi.org/10.54499/2022.04844.PTDC) and will be held at the University of Évora and the Frei Manuel do Cenáculo National Museum in Évora on 21 January 2025.

Timetable

Venue: Palácio do Vimioso, Universidade de Évora | Room 205

09h00 – 09h25 Opening session
Sandra Leandro
José Mirão
Carlo Bottaini
Dirk Brandherm

09h25 – 09h50 Igor Villa, Suzette Timmerman. *Evaluating the provenance of bronze objects by isotopic and compositional analyses.*

09h50 – 10h15 Xosé-Lois Armada.
Metal Circulation, Technology, and Social Networks in Northwestern Iberia during the Late Bronze and Early Iron Ages: an overview of recent research.

10h15 – 11h15 Coffee break and visit to the HERCULES Laboratory,

Venue: Museu Nacional Frei Manuel do Cenáculo, Évora

11h15 – 11h40 António Monge Soares, Pedro Valério, Rui Monge Soares.
A multifaceted system of metal supply for the EIA metallurgical workshop of Cabeço Redondo (Moura).

11h40 – 12h05 Elin Figueiredo.
Tin mining and metallurgy in Western Iberia: a state of the art.

12h05 – 12h30 Sofia Serrano, Elin Figueiredo.
Fine gold and silver metallurgy: a view from the Gold.PT project.

12h30 – 14h30 Lunch

14h30 – 14h55 Francis Albarède, Gillan Davis, Haim Gitler, Janne Blichert-Toft, Liesel Gentelli.
Levantine Hacksilber and the Flow of Silver in Early Mediterranean Commerce.

14h55 – 15h20 Ignacio Montero-Ruiz.
Sardinia and the Iberian Peninsula: a two-way model for copper trade?

15h20 – 15h45 Massimo Cultraro.
Metalworking in the Late Bronze Age Sicily: Recent developments.

15h45 – 16h10 Ralph Araque Gonzalez.
From the Atlantic to the Mediterranean and Back: Sardinia, Iberia, and the Transfer of Knowledge in Late Bronze Age Networks.

16h10 – 16h35 João Firmino
Reconstruction of bronze idols present in the collection of Manuel do Cenáculo - a photogrammetric approach.

16h35 – 17h30 Coffee break and visit of the Museu Nacional Frei Manuel do Cenáculo.

ABSTRACTS

Evaluating the provenance of bronze objects by isotopic and compositional analyses

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Abstract: The task of identifying the provenance of archeological objects can be called "fingerprinting". In contrast to human fingerprints, which according to present forensic knowledge are unique, archeometric fingerprinting requires human expertise for a context-oriented interpretation. Amongst the tools currently used are chemical and isotopic compositions.
Copper and bronze objects crafted in pre-industrial times all contain traces of Pb, which practically always accompanies Cu because of similar geochemical properties of the two elements. The isotopic composition of Pb (PbIC) is variable in natural ores, because it is controlled both by the age of the mineral deposit (but never by the age of the archeological artefact!) and by the presence of traces of uranium in the country rocks surrounding the ore deposit. This variability makes it possible to distinguish mining regions by the PbIC of the Cu-bearing minerals (e.g. cuprite, chalcopyrite, malachite, tennantite, tetrahedrite, etc.). A note of caution is that regions having similar geological histories can have similar or even overlapping isotopic signatures. Thus, most copper mines exploited in the Bronze Age in Europe were formed in the Late Paleozoic and therefore show broad similarities. An additional difficulty is that all ore deposits are always formed by circulating fluids that precipitate ore minerals gradually over an extended time interval, which results in small but detectable PbIC variations in one and the same mine. Last but not least, copper-bearing minerals collected today, on which all reference data bases must rely, are not necessarily the same that were available to prehistoric miners 6000 years ago. Exclusion is more decisive than inclusion: according to archeometric arguments an artifact can be certainly incompatible with a number of sources but can be possibly compatible with a number of others. By Occam's razor one can retain the hypothesis that makes the smallest number of unreasonable assumptions.
In order to reduce ambiguities, the option of supplementing the PbIC data with trace element concentration could appear decisive. However, unsupervised software seldom provides correct identifications, as automatic statistical

routines do not take into account geological and mineralogical facts. It is therefore necessary to judiciously select geochemically constrained element ratios, e.g. Sb/As, related to the genesis of the ore (it reflects the tetrahedrite/tennantite ratio). Additional geochemical discrimination plots can help recognize mixtures, such as recycling of bronze artefacts, doping with additives to improve material quality, mixing heterogeneous ore batches, etc. It must be stressed that isotopic and compositional data pertain to very different processes. The primary PbIC is controlled by a geological process (ore formation), whereas the primary trace element ratios are controlled by the human, cultural choice of available minerals that can be extracted and processed with the know-how of the relevant time and place.
Finally, recycling makes archeometric interpretations more adventurous.

Metal Circulation, Technology, and Social Networks in Northwestern Iberia during the Late Bronze and Early Iron Ages: a overview of recent research

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Abstract: The aim of this contribution is to offer an updated overview of the production and circulation of metals in northwestern Iberian Peninsula during the Late Bronze and the Early Iron Ages, discussing the role played by this territory within the Atlantic network. We will use as the main proxy some of the metal hoards identified in this territory. These hoards, composed mainly of palstaves, provide relevant insights about the technology and provenance of copper-based metalwork, as well as on the social networks established around this activity. They were produced using tin-bronze and leaded-bronze alloys, which probably reflects chronological differences between them. In addition, lead isotope analyses carried out on several palstaves suggest that both copper and lead come from the south of the Iberian Peninsula. The scale of production, as well as the geographical distribution and the location patterns of these hoards, also contribute to understand the changing patterns in metal circulation, metallurgical technology and social interaction that occur in the Atlantic area during these periods.

A multifaceted system of metal supply for the EIA metallurgical workshop of Cabeço Redondo (Moura)

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Abstract: Esta comunicação tem por base, essencialmente, dois trabalhos, um já publicado e o outro em publicação, cujos "Abstracts" se transcrevem:

Valério P, Soares RM, Soares AMM, Gomes SS, Araújo MF (2024) Copper-based metallurgy from an Early Iron Age workshop in the Middle Guadiana basin (Portugal): first evidence of imports of Mediterranean copper ingots using Pb isotopes. Archaeol Anthropol Sci 16:160. https://doi.org/10.1007/s12520-024-02065-7

Cabeço Redondo is a fifth century BC archaeological site located on the left bank of the Guadiana river in the municipality of Moura (southern Portugal). The site was severely damaged by agricultural works in 1990, but among the preserved remains recorded by later archaeological surveys, a set of copper-based debris from a metallurgical workshop stands out. The set includes copper ingots, namely a large 6.4 kg fragment, a small plano-convex bronze ingot and numerous metal lumps and prills. Metal lumps and prills have a diverse elemental composition, characterised as pure copper, binary and ternary bronzes, very probably being intermediate or waste products from the manufacture of artefacts. In order to determine the provenance of the copper used by this workshop, nine samples including ingot fragments were selected for Pb isotope analysis by MC-ICP-MS, which results were complemented by minor and trace element contents determined by ICP-QMS. Crossing analytical data with archaeological evidence suggests that the majority of those metal items has an extra-peninsular provenance located on the Central Mediterranean. However, the small bronze ingot may have copper from the Iberian Peninsula, namely from the Torrubia mine (Los Pedroches Batholith

complex, Central Iberian Zone). The combination of this evidence with other known imports from this period suggests an important trade originating in Central Mediterranean regions, whose products reach the inland regions of southwestern Iberian Peninsula via routes that are still uncertain.

Pedro Valério, Rui Monge Soares, António M. Monge Soares, Susana Sousa Gomes, Maria Fátima Araújo (no prelo) - " Early Iron Age metal trade networks of the workshop of Cabeço Redondo (southern Portugal). Tracing the origin of lead of ternary bronzes".
Recent research has identified two regions for the supply of copper to the 5th century workshop of Cabeço Redondo (Moura), namely the island of Sardinia (Central Mediterranean region) and the Los Pedroches Batholith complex (Central Iberian Zone). The important collection of metal debris recovered by archaeological surveys includes not only copper and bronze ingots and lumps, but also leaded bronze examples, which study can provide answers regarding the provenance of lead of ternary bronzes in this metallurgical workshop. Therefore, a fragment of a possible ingot and two lumps were characterised by SEM-EDS, ICP-QMS and MC-ICP-MS to establish the microstructural features, trace elemental compositions and Pb isotope signatures. These leaded bronze samples show similar microstructural compositions, comprising a dendritic morphology with significant presence of the α+δ eutectoid and Pb-rich and Cu-S inclusions. The trace element profiles are also comparable, apart from the higher content of Ni and As of the ingot. The Pb isotope signature of this ingot is also significantly different from that of the two lumps, but all of them overlap with lead sources from different regions bordering the Mediterranean Sea. The calculation of the nearest Euclidean neighbours and geologic parameters, crossed with archaeological and historical data, was used to find the most likely sources of lead of these ternary bronzes. The provenances identified correspond to distinct regions of the Iberian Peninsula (Ossa-Morena Zone, Betic Cordillera and Basque-Cantabrian Mountains). Considering also the sources of copper of this Early Iron Age metallurgical workshop, these new results evidence a complex metal supply system that includes both intra and extra-peninsular trade networks covering the Western and Central Mediterranean regions.

Tin mining and metallurgy in Western Iberia: a state of the art

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Abstract: The study of metals, considering their origins and uses, has always aroused great interest in European Protohistoric research. The Western Iberian Peninsula has very important sources of tin (in addition to gold) which in turn are scarce in most of Mediterranean areas as well as in Northern Europe. Research interest in tin mining and metallurgy in Western Iberia goes beyond a detailed knowledge of ancient societies at a local level. It extends to the study of cultural and economic interactions between ancient societies over medium and long distances, both in the Atlantic and Mediterranean areas.
During 2018-22, the IberianTin project (Production, use and circulation of tin in the Iberian Northwest in ancient times) consolidated a series of preliminary studies by a multidisciplinary team (archaeometallurgists, archaeologists, conservators, geographyers, geologists), with several results published at international level. During the project, various archaeological and geological sites in Portugal and Galicia (Spain) were studied, as well as metallurgical collections from various museums. Various documentary sources were also consulted, including mining records.
This communication summarises some of the results of the IberianTin project and gives an insight into the subsequent studies carried out by the team on the subject. Knowledge on the subject before and after the project will be compared, focussing on the main contributions made to research on this subject at national and international level.

Fine gold and silver metallurgy: a view from the Gold.PT project

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Abstract: The Gold.PT project is studying over 100 protohistoric gold and silver artifacts from the National Archaeological Museum (MNA) in Lisbon (Portugal) dating mainly to the Iron Age and incorporating old acquisitions as well as more recent discoveries. The corpus of artifacts emphasizes a variety of stylistic and metallurgical traditions, reflecting both Atlantic and Mediterranean influences, alongside indigenous Iberian practices.
For the material and manufacturing studies analytical techniques such as multifocus optical microscopy, pXRF, micro-XRF, PIXE, and SEM-EDS have been employed.
In this presentation some case-studies will be presented: (i) five gold and silver Late Bronze Age/Iron Ige lunulae (crescent-shaped necklaces) distinct from the Early Bronze Age gold lunulae from the most common Irish and British typologies, that reveals a later Iberian stylistic innovation with a broader use of alloys; (ii) six gold earrings with granulated spheres, characterized by Near Eastern stylistic and technological traditions, widespread across Egypt, Cyprus, and Sardinia, highlighting the dissemination of luxury goods and aesthetic practices to western Europe during Iron Age; and (iii) eight penannular gold rings (open-ended rings) of small size and traditionally associated with Late Bronze Age contexts, that may have served as ornaments or pre-monetary currency, connecting Iberia to both Mediterranean (Egypt) and Atlantic Western Europe through material exchanges and/or cultural influences.

Levantine Hacksilber and the Flow of Silver in Early Mediterranean Commerce

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Abstract: The origin and distribution of silver in the ancient Mediterranean played a fundamental role in shaping the region's economic and political landscapes. This study examines the provenance of ancient silver artifacts from the southern Levant, mapping trade and supply patterns from the Middle Bronze Age to the end of the Iron Age through lead (Pb) isotope analysis. During the Tertiary Period, tectonic movements formed mineral-rich zones around the Mediterranean, notably in Asia Minor, Greece, Sardinia, and Iberia. These regions, abundant in silver deposits, were essential to the Mediterranean economy, especially for the Levant, which, lacking local sources of the metal, depended on extensive trade networks to obtain the resources needed for purchasing essential goods, metals, and hiring mercenaries.

By the Middle Bronze Age, silver had become a primary medium of value in the Levant, as indicated by hoards and Hacksilber (cut silver fragments) that predated widespread maritime trade and the introduction of coinage. Building on recent studies[1-2], this research analyzes Pb isotopic ratios from 281 fragments across 23 Levantine hoards and compares them to a database of approximately 7,000 Pb isotope samples from potential mining sources. A newly developed algorithm[3] offers enhanced corrections for mass-dependent fractionation, enabling more accurate provenance identification and recognition of mixed bullion. This study addresses two main challenges in isotope-based provenance research: establishing a statistical "distance" for reliably matching artifacts with sources and adjusting for isotopic fractionation due to environmental or lab-induced factors.

Shifts in silver sources across different periods indicate changing trade dynamics and connections. In the Middle to Late Bronze Ages, Aegean, Sardinian, and Iberian sources were prevalent in Levantine hoards. As the Iron Age progressed, sources from the Balkans and southern Carpathians also emerged, aligning with evidence of Phoenician trade into the western Mediterranean. By Iron Age II (~925-586 BCE), connections with the western Mediterranean waned, with Aegean sources again dominant, mirroring broader

shifts in Mediterranean commerce as Egyptian and Mesopotamian powers reasserted influence in the Levant.

The study also reveals the importance of silver remelting, particularly during periods of transition like the end of the Bronze Age, when reprocessing helped blend various sources. However, by the end of the Iron Age, remelting practices declined, coinciding with increased Aegean silver sources and the rise of standardized coinage, which streamlined commerce by providing a reliable exchange medium. This shift likely reflects a need for rapid silver circulation to support high-volume trade and the increasing stability of Mediterranean trade networks by the Iron Age's end.

Beyond technical provenance insights, this research highlights the Mediterranean silver trade as a complex economic system linking diverse regions and cultures. As standardized coinage replaced Hacksilber, transactions became more efficient, reducing costs and facilitating the employment of mercenaries—factors that shaped the political landscape of the ancient Mediterranean. Pb isotope studies of ancient silver not only clarify trade networks but also underscore silver's role as a central economic asset that connected distant societies, contributing to the foundations of Western civilization.

[1] Eshel T. et al. (2024) J Archaeol Res, 1-40 [2] Gentelli L. et al. (2021), J Archaeol Res **134**, 105472 [3] Albarede F. et al. (2024) J Archaeol Res **163**, 105919.

Sardinia and the Iberian Peninsula: a two-way model for copper trade?

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Abstract: The first half of the first millenium BC reveals an intensive copper trade in the western Mediterranean. It may have started a little earlier, but Phoenician colonization boosted this trade also with other metals (silver and tin). Sardinia and the south of the Iberian Peninsula have in common the availability of copper resources that were potentially traded between them. However, if this trade model was not based on the supply and demand of raw materials, since both regions can supply themselves, it must have been organized on other commercial principles. This paper attempts to analyze the foreign copper objects identified in each region based on lead isotopic analysis and discuss whether there was contemporaneity or a sequential pattern in the direction of trade.

Metalworking in the Late Bronze Age Sicily: Recent developments

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Abstract: The large number and variety of the metallurgical finds found in recent years in Sicily have to a large degree changed the traditional picture. Evidence for metallurgical activities was rarely noticed in older excavations. However, the evidence found in several recent excavations, e.g. Mokarta and Erbe Bianche in Western Sicily, have contributed to address the main questions toward the development, technological changes and introduction of new models in local metallurgy during the Late Bronze Age (1350-1100 BC ca, according to the calibrated dates).

This study aims at to collect all published data on metalworking and to present a comprehensive view of its development in the island, including the results of about 50 new archaeometric analyses.

Among these finds a special place is occupied by the metallurgy of gold and silver which has not received the proper attention. Precious items suggest the circulation of imported products from Aegean-Mycenaean world. However, new data invites to investigate the presence of silver sources in Northern Sicily, as well as in Calabria, where traces of ore extraction have been identified.

From the Atlantic to the Mediterranean and Back: Sardinia, Iberia, and the Transfer of Knowledge in Late Bronze Age Networks

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Abstract: Sardinia was a hub of sea routes in the Final Bronze Age (c. 1200–850 BC) and Early Iron Age (c. 850-550 BC), connecting the Aegean and the Levant in the East with the Iberian Atlantic façade in the West at its latitudinal extremes. Although situated some 1,200 nautical miles apart, bronze working techniques on the island, specific decorations, and object typologies were clearly related to those in western Iberia, which was a pivotal node connecting the Atlantic and Mediterranean worlds. Without doubt, individuals have travelled between and beyond both regions, and transported objects alongside technological as well as theoretical information. Although serious challenges accompanied the multi-directional intensification of interactions, the local communities had innovative responses to them, managing to integrate new people and knowledge. The general aim of this contribution is to provide a theoretical framework with which to analyse the motivations and social mechanisms for cooperation and communication that facilitated technology transfer in an environment of dispersed, socially heterogeneous communities. The exchanges and interactions within this decentralised network must have been self-organised by individuals and communities, and encompassed all forms of entanglement. Consequently, practises of self-governance, hospitality, conflict management, and inter-group communication as well as shared symbols are of central interest.

Keywords: technology, networks, hospitality, cooperation, intercultural communication

Reconstruction of bronze idols present in the collection of Manuel do Cenáculo - a photogrammetric approach

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Abstract: A coleção de Frei Manuel do Cenáculo apresenta-se hoje como das mais versáteis coleções a nível nacional. A finalidade da presente comunicação prende-se com a divulgação dos métodos e das técnicas que vão - e estão - a ser colocadas em prática no âmbito da catalogação tridimensional da coleção arqueológica do Museu. No âmbito do projecto From Land to Landscape, from Landscape to the Museum - focado em novas técnicas comunicação patrimonial - serão feitos levantamentos digitais de peças-chave da coleção referida.
A fotogrametria é uma técnica bastante difundida e acessível, mas ainda assim falível. Nesta comunicação, teremos como principal objectivo demonstrar o fluxo e o processo de captura de modelos arqueológicos de pequena e média escala. De modo a averiguar a metodologia utilizada, serão aplicadas e comparadas diversas técnicas de alinhamento de fotografias de peças votivas de bronze expostas no Museu Nacional Frei Manuel do Cenáculo.

TECHINCAL INFORMATION

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Free participation upon registration via the following email address: geral.mnfmc@museusemonumentos.pt

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