



# A first appraisal on copper sources for Chalcolithic settlements in southern Portugal using Pb isotope analysis

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## ABSTRACT

This work presents the first provenance study on copper in use by 3rd millennium BC communities in southern Portugal. Copper ores from small mines and copper artefacts from Chalcolithic settlements were subjected to Pb isotope analysis. Some of Pb isotope ratios obtained in ores from the Ossa-Morena Zone, but also from the South Portuguese Zone, evince the existence of deposits with highly radiogenic Pb, which was previously considered rare in the Iberian Peninsula. Pb isotope ratios of artefacts were compared with Pb isotope fields of closer geological/tectonostratigraphic zones, namely the South Portuguese Zone, Ossa-Morena Zone and Central Iberian Zone. The assessment suggests that most artefacts were produced with copper from the Ossa-Morena Zone. Nevertheless, a flat axe of the Três Moinhos settlement is a remarkable exception due to its highly radiogenic Pb signature, which only has parallels in the Iberian Peninsula on copper ores of the Chalcolithic mines of La Profunda and El Milagro (northern Spain). Consequently, this flat axe constitutes the first indication of a possible long-distance trade of copper between the Cantabrian region and southwestern Iberian Peninsula during the 3rd millennium BC.

## 1. Introduction

The archaeometallurgical research regarding the southwestern end of Iberian Peninsula has been identifying the use of copper with varying content of arsenic to produce metallic artefacts during the 3rd millennium BC, i.e. during the Chalcolithic period when the first metallurgical manifestations made their appearance in this region (Valério et al., 2016, 2019). The study of artefacts and metallurgical remains suggests the smelting of copper ores naturally containing arsenic (Rovira and Montero Ruiz, 2013), although copper sources exploited by local settlements are still unknown. The pioneer work of Gauß (2016) identified a supply of copper from mines in Ossa-Morena Zone to Chalcolithic settlements in central Portugal, but the provenance of copper used in Chalcolithic sites of southern Portugal, with the exception of an insight concerning the settlement of São Pedro (Redondo, Alentejo), were not investigated. Therefore, the present work depicts a first appraisal on copper sources to Chalcolithic settlements of this southwestern region of the Iberian Peninsula using new lead isotope analysis (LIA) of copper

ores and artefacts, in addition to LIA databases of copper ores from close tectonostratigraphic zones, namely the South Portuguese Zone (SPZ), Ossa-Morena Zone (OMZ) and Central Iberian Zone (CIZ).

## 2. Lead isotope ratios in provenance studies

LIA of ores and metallic artefacts have been the most widely used and reliable tool to identify the geological origin of prehistoric metal. The LIA reliability arises from the absence of Pb isotopic fractionation in metallurgical operations conducted to convert the ore into a metal and from the metal on the finished artefact. Provenance studies employ four stable Pb isotopes, namely <sup>204</sup>Pb, <sup>206</sup>Pb, <sup>207</sup>Pb and <sup>208</sup>Pb. The <sup>204</sup>Pb is a stable primeval isotope and, consequently, it shows a constant content in mineral deposits (c. 1.4%), while <sup>206</sup>Pb, <sup>207</sup>Pb and <sup>208</sup>Pb are final decay products of <sup>238</sup>U, <sup>235</sup>U and <sup>232</sup>Th, respectively. These three stable isotopes, whose content in the ore depends on the age of the mineral deposit, are called radiogenic isotopes.

The isotope ratios <sup>206</sup>Pb/<sup>204</sup>Pb, <sup>207</sup>Pb/<sup>204</sup>Pb and <sup>208</sup>Pb/<sup>204</sup>Pb are

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