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Archaeometallurgical Study of Pre and Protohistoric Production Remains and Artefacts from Southern Portugal

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ABSTRACT

This work provides an integrated study of the ancient metallurgy in southern Portugal comprising the characterisation of 241 production remains and artefacts, mostly belonging to the Late Bronze Age (LBA) and Early Iron Age (EIA). Analytical studies involve energy dispersive X-ray fluorescence spectrometry (EDXRF) and micro-EDXRF to determine elemental composition, together with optical microscopy, scanning electron microscopy with X-ray microanalysis and Vickers microhardness testing for microstructural characterisation and hardness determination.

Main results include identification of heterogeneous and immature LBA slags containing tin oxides and metallic prills (copper and bronze) with low iron contents. Additionally, relic mineral inclusions indicate co-smelting of copper ores, probably with cassiterite. Poor reducing conditions shall be responsible by lower iron contents of LBA artefacts (<0.05%) when compared with EIA artefacts (0.15-1.3%). Further features distinguish these clusters – indigenous collection is composed mostly by binary bronzes ($10.0 \pm 2.5\%$ Sn), while Orientalising collection also presents copper and leaded bronzes. Furthermore, latter binary bronzes exhibit lower tin contents ($5.1 \pm 2.1\%$ Sn) probably due to the increased use of scrap. Operational sequences usually include cycles of forging and annealing, often completed with a final hammering that hardens the artefact. Higher tin content artefacts with typologies that do not require high mechanical strength were often left as-cast evidencing some selection of alloys. Despite being poorer in tin, some EIA artefacts exhibit higher hardness due to a more efficient use of hammering and annealing cycles, suggesting that low tin contents were not a problem for this type of artefacts.

Gold metallurgy analyses allow the identification of Chalcolithic gold with minor amounts of silver, while LBA and EIA gold present increased silver and copper contents, indicating the use of alloyed gold. Forging and annealing during the Chalcolithic, besides welding with partial melting/solid state diffusion during the EIA is also established.

KEYWORDS

Copper-based; gold; elemental composition; operational sequence; Late Bronze Age; Early Iron Age