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Investigation of ancient copper-alloy and ferrous artefacts from South-eastern Arabia

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Metal artefacts excavated from archaeological sites are often heterogeneous not only in their stylistic features but also in structure and composition. This is ultimately related to a variety of manufacturing processes developed within different socio-technological contexts. The current paper demonstrates how heterogeneous structures and underlying manufacturing techniques can be successfully detected in ancient copper-alloy arrowheads from the Middle-Late Bronze Age site of Sharm in the United Arab Emirates. A non-invasive approach based on the combination of neutron tomography (NT), neutron diffraction stress analysis (NDS) and particle-induced X-ray emission analyses (PIXE) was exploited. Results suggest that the artefacts were made by casting an alloy of copper containing impurities of nickel and arsenic, and then subsequently subjected to different types of forging and heat treatment. The manufacturing process promoted specific types of elemental segregation and subsequent selective oxidation of the metal objects.
This paper also presents the results of NT applied to the investigation of totally corroded ancient ferrous artefacts from the early Iron Age site of Saruq al-Hadid, Dubai. Despite the severe state of degradation of the objects, NT allowed the detection of various features in the artefacts, including: 1) surface irregularities from plastic deformation by hammers and some other tools; 2) different corrosion products, and their specific distribution patterns, some of which can be associated with secondary recycling activities performed upon the objects; 3) various structural inhomogeneities such as mineralized pierced holes, incised patterns and ex-welding lines. Among the listed inhomogeneities, the ex-welding lines represent the major interest during NT investigation of corroded ferrous artefacts. These structural features can be found in almost every artefact, since corrosion preferentially evolves along these lines, and can be conveniently used for the comparison of different ferrous artefacts and their manufacturing techniques. The complementary invasive investigation of ferrous artefacts via analyses of remnant carburized areas using traditional optical microscopy techniques and analyses of slag inclusions by scanning electron microscopy coupled with energy dispersive spectroscopy (SEM-EDS) allowed a developed understanding of the socio-technological factors underlying the use of the identified iron welding techniques. These results provide a broader insight into the technologies and knowledge of the Iron Age societies of the Ancient Near East.

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