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Editorial: Transdisciplinary approaches to metal procurement and exchange in archaeology

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Editorial on the Research Topic
Transdisciplinary approaches to metal procurement and exchange in archaeology

This Research Topic aims to initiate a new season of theoretically oriented and science-informed studies on the life histories of ancient metals. These studies must harness the potential of recently developed multi-method, interdisciplinary, and transdisciplinary research approaches to explore the geological origin, workshop provenance, social procurement, alloying, transformation, circulation, exchange, recycling, and re-fashioning of ferrous and non-ferrous metals in ancient societies. Modern scientific training, funding, resources, and disagreements over methods and interpretations–even what are appropriate research questions–have led to a fractured research environment. This Research Topic provides an opportunity to assess the current state of research and draw together broader ideas of what are useful ways forward.

To many, these may seem like problems that have been addressed many times before. After all, researchers have tried to answer questions such as “What does this scientific dataset mean?” and “How does this dataset help us determine where the metal comes from?” since the dawn of archaeometallurgy. Yet, part of the inspiration for this Research Topic was these editors’ attempt to rephrase these questions in more nuanced terms, e.g., “What team and information is required to fully understand this scientific dataset?” and “Does this dataset reveal complex social phenomena going beyond geological sourcing and metal circulation?” We believe that interdisciplinary collaboration is the only way to address these problems and fully appreciate the complexity of past metallurgical practices.

It gives us comfort that we are not the first researchers to advocate interdisciplinary collaboration in the field of archaeometallurgy. If we had to choose one scholar among the many who advocated this stance, it would perhaps be Cyril Stanley Smith (1903–1992). After acting as the head of the Metallurgy Group, Los Alamos Laboratories, within the wartime Manhattan Project, Smith’s interests branched widely following World War II to encompass art, ancient texts, aesthetics, archaeology, and philosophy (Smith, 1970; Smith, 1981). Throughout his career, he held several academic positions including concurrent roles in the humanities and metallurgy at MIT. A quote towards the end of the *apologia* of his 1981 classic *A Search for Structure* shows Smith’s blend of passionate advocacy and pragmatism.

> "These papers are probably to be called interdisciplinary—an "'in"' word these days—but any value they may have derives from the fact that the author started with a rather deep immersion in a single discipline. One cannot hope to understand the nature of interaction between impinging areas without a firm knowledge of at least one of them. Only on such a basis can one appreciate when or where a given body of understanding has ceased to be fully applicable. *Interdisciplinary activity is as dangerous for the undergraduate as it is essential for the mature professional in any field.*" (Smith, 1981: x, our emphasis)

Over 40 years later, the "in" word of 1981 continues to be relevant. Perhaps interdisciplinarity has to be continually rediscovered as each generation achieves the 'deep disciplinary immersion' required to open up new conversations. Collaboration does not weaken or dilute archaeometallurgy–on the contrary, it secures its strength. In the last few years, the quest for interdisciplinarity in metallurgical research has often morphed into transdisciplinarity, or the ability of research teams to cross disciplinary boundaries and create holistic approaches. The need for better methodological integration and synthesis has been thrown into sharp relief by ever-deepening constraints on funding, the closure of university departments, and recent significant advances in other fields of archaeological science, e.g., Zooarchaeology by Mass Spectrometry (ZooMS), ancient DNA, radiocarbon dating, and dietary isotopes. As these advances show, transdisciplinary work leads to better questions, better science, better funding, and therefore a more secure future for archaeological science.

Earlier in their careers, the editors of this Research Topic have made sustained attempts to blaze new trails in transdisciplinary research. Heide W. Nørgaard, for example, has forged new connections between the natural sciences and archaeology to investigate the workshop-related metal supply systems that arose in Denmark from 1,500–1300 BC. Through an original evaluation of trace elements and the Lead Isotope Analysis (LIA) of workshop-specific artefacts, she postulated that differences in metallic features are not due to technical reasons but are a sign of workshop-specific metal supply networks (Nørgaard, 2018; Nørgaard et al., 2021). Her study was grounded in an identification of interaction groups of craftspeople based on preserved traces of the crafting *and* a perception-based approach in which modern trace elemental measurements are translated into perceptive categories that could be seen and felt by prehistoric people, such as colour, castability, and strength (Mödlinger et al., 2017). Interestingly, the research shows that the metal supplied to specific workshops correlates with an increase in human mobility into this region, as indicated by Strontium isotope measurements (Frei et al., 2019).

Peter Bray's research links experimental metallurgy, mining evidence, archaeological context, and chemical analysis of artefacts to attempt to move beyond the provenance debate. By defining and understanding 'chemical character' and the potential for chemical change through different processes, we can identify chains of ancient technology more comprehensively. We should still aim to understand the source of metal where possible but also include if and how the metal was reshaped, reused, retained, and mixed over time. Bray and co-workers' original use of scientific data, geographical approaches, small-finds analysis, and archaeological theory has led to a wide range of archaeological applications (Bray and Pollard, 2012; Bray et al., 2015; Pollard et al., 2018; Bray, 2019; Bray, 2020; Bray, 2022).

Dolfini and his team have applied, in two separate studies, both Bray's 'copper space and metal flow' approaches and LIA to research metal procurement and exchange in Chalcolithic Italy, 3,650–2200 BC (Perucchetti et al., 2015; Dolfini et al., 2020). Strikingly, both methods revealed similar patterns in otherwise very different datasets. They highlighted, for instance, an enduring east-west split in exchange networks that cut across the expansive river system of the Po plain and two substantial mountain ranges, i.e., the Alps and northern Apennines. These studies show the importance of integrating different approaches and methods to shed new light on the life histories of early metals.

It is certainly true that whether the data are chemical or isotopic or of another nature, the utmost scientific rigour is required in their production. Indeed, we need precise, accurate, reliable, and reproducible data, but the data thus produced must then be played with, discussed, reimagined, modelled, pulled apart, and debated by everyone. However, are we archaeometallurgists sharing enough? Are we being imaginative enough with our data? Are we still too constrained by ideas of geological source, provenance, and the search for unaltered signals? Are we really aiming to lead new debates across heritage science? Finally, can we see in-depth structures in our datasets, fulfilling the full breadth of Smith's vision?

The papers published in this Research Topic show that this ambitious goal is within our grasp. In the article titled *The rise of bronze in Central Asia*, Berger et al. discuss trace element patterns and the isotopic composition of lead, tin, and copper in a large object sample from the Andronovo Culture and the Bactria-Margiana Archaeological Complex of Central Asia. These data enable them to reconstruct the complex dynamics of copper and tin exchange and how these varied over time. Moreover, the tin isotope analysis of Central Asian ores, which they performed as part of the research, revealed compelling evidence of copper and tin extraction from the polymetallic ore deposit of Mushiston, Tajikistan. This deposit would have supplied the Bronze Age communities living within a 500 km radius with a 'natural' bronze that was seemingly obtained from the smelting and refining of mixed copper-tin ores.

In a further article, Berger et al. refute the recent proposal that the tin ingots from the Late Bronze Age Uluburun shipwreck (found off the southern coast of Anatolia) would derive from the Mushiston ore deposits discussed above (Powell et al., 2022). Grounding their argument in a skilful blend of isotopic, chemical, and archaeological data, Berger et al. suggest instead that part of the ingots would likely originate from Southwest Britain, a part would derive from the tin deposits of Afghanistan, and part should perhaps be traced to another source that is yet to be identified.

Moving to Europe, Nowak et al. tackle the contentious issue of the earliest exploitation of the ore deposits of Southwestern Poland. Through a multi-method approach comprising evidence of pre-modern mining, the GIS analysis of prehistoric sites, and the LIA of bronze and lead artefacts from the Urnfield period (*c.*1300-

500 BC), these scholars demonstrate that while the bronze objects were made with copper from various geological sources (confirming the breadth of Urnfield-period exchange networks), the lead ornaments were instead of local origin. Remarkably, this is the earliest evidence coming to light of the working of Polish lead mines.

Finally, Eliyahu-Beha et al. answer the longstanding question of the origin of the iron worked in the Southern Levant in the Iron Age. Noting that high-grade ore was required to smelt iron through bloomery technology, they characterised selected ore deposits from the region both chemically and isotopically, focusing on osmium isotopic ratios. While not all the results obtained by the team are conclusive, the study does show that their multi-proxy approach can positively differentiate ore sources, opening the door to further research.

Overall, these studies indicate, if proof be needed, that past metal technologies and objects did not exist in a cultural vacuum. Metal objects were crafted, often from composite materials, through multiple techniques, by real people operating in real places. They were then used, appreciated, valued, traded, maintained, mended, and used again, and the matter they were made of could be altered, recycled, and mixed over time. Recovering, describing, and understanding this complexity requires patient, rigorous, accessible, multi-authored, multi-strand, and multi-proxy research–in a word, transdisciplinarity. May this long be the hallmark of 21st-century archaeometallurgy.

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