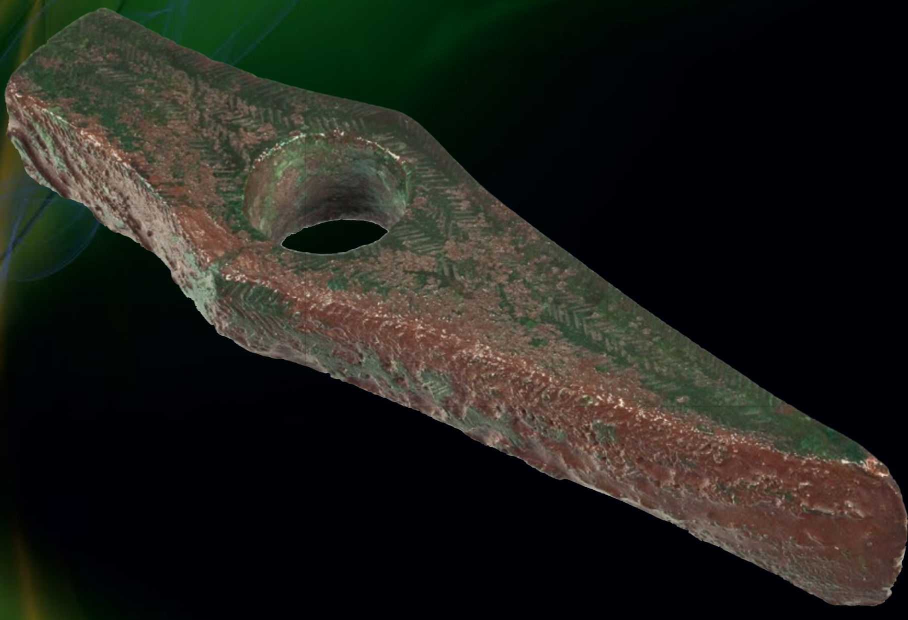
The Rise of Metallurgy in Eurasia

Evolution, Organisation and Consumption of Early Metal in the Balkans



Edited by

Miljana Radivojević, Benjamin W. Roberts, Miroslav Marić, Julka Kuzmanović Cvetković and Thilo Rehren

Miljana Radivojević holds the Archaeomaterials Lectureship at the UCL Institute of Archaeology (UK), where she graduated in Archaeometallurgy. She has spent more than 20 years publishing on early metallurgy in the Balkans and southwest Asia and the role of aesthetics in the invention of novel technologies. She continues to explore the evolution of metallurgy across most of prehistoric Eurasia as a means of uncovering the histories of metalsmiths, and the societies and environments they lived in.

Benjamin Roberts has spent over 20 years researching and publishing on European Copper and Bronze Age archaeology and frequently metallurgy and metal objects across Europe. He co-edited with Chris Thornton *Archaeometallurgy in Global perspective: Methods and Syntheses* (2014) and is currently leading Project Ancient Tin. Prior to joining the Department of Archaeology at Durham University, he was the Curator for the European Bronze Age collections in the British Museum.

Miroslav Marić is a specialist in the Neolithic-Bronze Age of the central Balkans at the Institute for Balkan Studies, Serbian Academy of Sciences and Arts, Serbia. He is the field director of the Gradište Iđoš project. His research interests include settlement archaeology, landscape archaeology, the Neolithic and Bronze Age of the Balkans, and radiocarbon dating.

Julka Kuzmanović-Cvetković was the Senior Custodian (now retired) at the Homeland Museum of Toplica in Prokuplje, Serbia. She spent more than four decades excavating the site of Pločnik, and developed a unique open air archaeo-park on the site that attracts tourists from the region, and across the globe.

Thilo Rehren is the A.G. Leventis Professor for Archaeological Sciences at the Cyprus Institute in Nicosia, Cyprus. In 1999 he was appointed to a Chair in Archaeological Materials at the UCL Institute of Archaeology in London, UK. Following a five-year secondment to establish UCL Qatar as a postgraduate training and research Centre of Excellence in Museology, Conservation and Archaeology he joined the Cyprus Institute in 2017. He places particular emphasis on the integration of archaeological, scientific and historical information, and on investigating the correlation and cross-fertilisation between different crafts and industries in the past.

The Rise of Metallurgy in Eurasia

Evolution, Organisation and Consumption of Early Metal in the Balkans

Edited by

Miljana Radivojević, Benjamin W. Roberts, Miroslav Marić, Julka Kuzmanović Cvetković and Thilo Rehren

Archaeopress Archaeology

Archaeopress Publishing Ltd
Summertown Pavilion
18-24 Middle Way
Summertown
Oxford OX2 7LG

www.archaeopress.com

ISBN 978-1-80327-042-5
ISBN 978-1-80327-043-2 (e-Pdf)

DOI: 10.32028/9781803270425

Cover: Ljiljana Dinić; Copper hammer-axe, type Pločnik, c. 4600 BC
(from Pločnik, Serbia) - Julka Kuzmanović Cvetković.
Inner back cover: Reconstruction of the world's earliest copper smelting. Green flames come from the extraction of metal from malachite. Experiments at Pločnik, Serbia (2013) - Marko Djurica

Copyeditor: Kate Sharpe

To the memory of Borislav Jovanović, our colleague, friend and inspiration

(1930 – 2015)

Contents

Chapter 53

Where do we take global early metallurgy studies next?

Benjamin W. Roberts, Miljana Radivojević and Thilo Rehren

The results and experiences gained from the multidisciplinary and holistic approaches underlying the *Rise of Metallurgy in Eurasia* project provide an opportunity, not only to reflect on programmes of further research in the Balkans, but also on scholarship in early metallurgy across the world. This chapter outlines what might be usefully taken forward from this project, but also seeks to highlight gaps in our understandings that could be addressed. It is by no means a comprehensive agenda for global early metallurgy studies but is instead intended to stimulate further debate and discussions that lead to new programmes of research.

Ores and Metals

The analysis and interpretation of early metallurgy across the world is invariably dominated by ongoing debates of 'origins', where competing scholars representing sites or regions seek to claim the status of publishing the 'earliest'. The scholarly prestige involved and the enhanced potential for attracting funding for future projects are undeniable. Yet the scholarship of early metallurgy is frequently singly focussed, especially in perspectives beyond that of a region. Not all metals are researched or interpreted equally. Copper and tin bronze are by far the most ubiquitous early metal discoveries across Europe, North and East Africa, Asia and the Americas and it is therefore unsurprising to see their prominence in research publications. However, rarer discoveries of gold and silver will typically be given a far greater prominence in modern scholarship and past values inevitably leading to interpretations of 'metals of power' (Meller et al. 2014). In contrast, lead which remains hugely under-researched and invariably under appreciated.

Similarly, tin bronze, perhaps due to its entrenchment in the Three (or Four) Age system in Asia, Europe and North Africa, is a far more extensively researched alloy than arsenical and antimonial copper (e.g. see Wilkinson et al. 2011). This is despite the widespread and consistent use of arsenical and antimonial copper from c. 3500 BC for over a millennium prior to tin bronze adoption across an area spanning Central Europe to Central Asia (e.g. Chernykh 1992; Roberts et al. 2009). In addition, there are geologically rich regions with extensive evidence for metallurgical innovation such as Iberia and Iran where the use of arsenical copper persisted for centuries despite the widespread potential availability in the region of both copper *and* tin ores (Cuenod et al. 2015; Helwing 2013; Perucchetti et al. 2020; Rehren et al. 2012; Thornton 2009). Yet, there is neither a pan-regional synthesis or comparative analysis of arsenical and antimonial copper metal use in Europe, North Africa or Asia nor even clarity on how the alloy was consistently produced, transmitted and traded.

The potential complexities relating to the selection of certain ores or the combination of certain metals in the creation of metal alloys can be largely resolved with archaeometallurgical analyses and ideally experimental replication. However, what has less been resolvable is the broader theoretical interpretation of the appearance and disappearance of these early metal alloys. The identification of a tin bronze artefact at Pločnik dating to c. 4650 BC, which is broadly contemporary with fourteen other 5th millennium BC tin bronze artefacts scattered across the Balkans, was a huge surprise to many archaeologists who naturally associate tin bronze with the Bronze Age chronological period several millennia later and met with misplaced and easily dispelled scepticism. The Bronze Age in the central Balkans may start at c. 3200 BC but the widespread adoption of tin bronze in the Balkans occurs only at c. 1800 BC (e.g. Boyadžiev, 1995; Pare, 2000; Pernicka et al., 1997). What had not been widely understood is that the earliest known gold artefacts as excavated at the Durankulak and Varna II cemeteries were not only contemporary to the tin bronze at Pločnik but also demonstrate a consistent and deliberate manipulation of the natural gold composition with the addition of copper (Leusch et al., 2015; Radivojević et al., 2014). There are numerous comparable examples such as the small numbers of brass artefacts, an alloy of copper and zinc, being created alongside similar coloured tin bronzes from the 3rd millennium BC onwards in Europe and Southwest Asia well before the widespread adoption of brass in region during the 1st century BC (Thornton, 2007). As Killick and Fenn (2012) note in their global review of research into pre-industrial mining and metallurgy, archaeometallurgists are 'adept at discovering inventions that failed to become innovations'. The period and the metal are clearly different entities, yet the intellectual baggage of

Childe's (1944) framework, programmatically entitled 'Archaeological Ages as Technological Stages', remains deeply embedded.

To begin to address these issues, research on global early metallurgy would benefit from analysing a larger assemblage of minerals and ornaments from pre-metallurgical contexts. It could shed more light on the mineral selecting practices of these communities and improve our understanding of how the knowledge of metallurgy evolved (cf. Rapp 2010). The identification of the minerals being selected and collected by communities in the Balkans in the millennia prior to any evidence of metal smelting and exploring their visually distinguishing characteristics and their potential sources, was fundamental to discussing the processes of invention and innovation that led to copper metallurgy (Radivojević, 2015; Radivojević and Rehren, 2016). With a detailed understanding of the ores and minerals involved and what areas were being prospected, the potential metals and alloys that might have been produced can be assessed.

The processes underpinning the smelting of the selected ores to create metals remain talismanic in global early metallurgy scholarship. However, they are frequently poorly understood beyond individual assemblages. A major obstacle to further understanding is the absence of a database containing the technological data on early smelting activities that would enable comparative analysis. Such a comparative archaeometallurgy would be dedicated to exploring the questions of how these technologies evolve, which parameters shaped them and why they exhibited similarities or differences over the course of their development. When considering the smelting processes that could have occurred in the Balkans during the 5th millennium BC, it was striking how few comparative surveys providing any detail, such as in Bourgarit (2007), had been published.

Furthermore, the experimental replication of smelting processes identified in excavation and post-excavation analyses is only infrequently conducted and even less frequently fully published (e.g. Hauptmann 2020; Heeb and Ottaway 2014; Timberlake 2007). Yet it has proved to be invaluable in understanding the expertise, raw materials, logistics and organisation of activities required to create a metal object. Finally, what is frequently missing in the early metallurgical research is freely available raw data from the excavations and post-excavation programmes which would enable subsequent scholars to re-evaluate the original conclusions. As highlighted in the recent pan-European survey of Bronze Age metal production and circulation (Radivojević et al. 2019) and put into practice in this volume (see Appendices A and B), this level of data-sharing and transparency would hugely enrich the quality and standard of scholarship.

Origins and Regions

In an important global review on the current perspectives and future of domestication studies relating to plant and animal food production arising from a dedicated seminar, Larson et al. (2014) tentatively identified sixteen regions across the world where independent domestication is thought to have occurred, and identified spatial and temporal patterns of transmission. The authors then identified three challenges: filling in gaps on maps with dates and data; exploring the environmental and ecological contexts of agricultural origins; and explaining why hunters and gatherers turned to cultivation and herding. Despite the differences in a debate that is primarily biological and geographical as opposed to one that is primarily geological and metallurgical, there is much that can be learnt for global early metallurgical research.

Scholars in early metallurgy tend to focus on a particular geographical or political region, typically one that is geologically rich in metallurgical ore sources. Extensive and detailed research in one region is then published with a far more general perspective on neighbouring regions and those further afield. The comparative analysis of early metallurgy in different regions is invariably concentrated upon neighbouring regions, and/or specific metals and then really tends only to focus on potential technological connections. This undeniably has been the case for the *Rise of Metallurgy in Eurasia* project. Its authors could legitimately cite the sheer quantity of data and debate that would need to be processed in order to achieve a more global perspective as a justification for this situation. However, what is really missing is a clear global framework for early metallurgy that provides the foundations and framework for further study and debate that goes beyond edited volumes of individual regional syntheses (e.g. Roberts and Thornton, 2014).

The definition of this global framework requires careful consideration. For instance, if it is to follow Larson et al. (2014) in defining independent regions of metallurgical invention, there are different perspectives. From geographical and geological perspectives, the Balkans, Anatolia, Levant, Caucasus and Iran are inherently interconnected, yet each has its own traditions of early metallurgical scholarship and tends to be perceived as a distinct early metallurgical region. Furthermore, the *Rise of Metallurgy in Eurasia* project highlighted the independent invention of copper, tin bronze, gold and potentially lead metallurgy in the Balkans, with no chronologically comparable evidence in neighbouring western Anatolia. Then there are areas within regions whose spectacular finds can distort the interpretations and perception of the broader region. For instance, the Varna cemetery and gold in northeast Bulgaria is unthinkingly and incorrectly extrapolated to communities across the entire Balkan region when considering the making and consuming of gold artefacts. Similarly, the arsenical/antimony copper in the Nahal Mishmar hoard is taken to typify the entire Levant. Should a metallurgical invention, even one evidenced in only small quantities before disappearing again as appears to be the case with tin-bronzes in the Balkans, be given priority over a widely adopted metallurgical innovation two millennia later? Which activities relating to early metallurgy should be encompassed? Given the traditional focus on smelting as *true* metallurgy, this would exclude regions where metal artefacts were made, circulated and used without smelting, such as the Copper Culture in North America that dates from c. 6000 BC (Bebber 2021).

The *Rise of Metallurgy in Eurasia* project highlighted that the singular and uneven focus of early metallurgy scholarship has served to obscure the presence of polymetallic horizons whereby multiple metals were being produced, circulated, used and deposited by the same communities in the same region at the same time. The mono-metallic perspective also serves to significantly underplay the deliberate manipulation of individual metal compositions, whether by the use of more complex ores or the addition of other metals, thus creating differences in colour, hardness and castability. It is argued that a polymetallic together with a geological perspective would provide a strong foundation for such a truly global approach. However, these questions and others surrounding the definition of a global framework for early metallurgy are not going to be easily resolved.

Yet, when comparing Larson et al. (2014) to the current state of knowledge in global early metallurgy, there is no clear perspective in current scholarship simply when and where different metals and metal technologies were potentially independently invented and/or innovated. When reviewing their three challenges, it is evident that there is no publication outlining where the priority areas are for adding new dates and data relating to early metallurgy. The geological and archaeological contexts of metallurgical origins around the world have not yet been subjected to any systematic comparative analysis. The explanations as to why communities across the Americas, Africa, Europe and Asia used metal alongside and in place of stone, bone, wood and other materials metal are invariably founded on assumptions rather than evaluations (see Frieman 2021).

Metallurgy and Environment

The environmental impact of global early metallurgy lies not only in the carbon contributions linked to fuel procurement and burning in order to achieve the necessary temperatures required to extract and work metal but also in the changes in land use, including deforestation, which are known to be major sources of carbon release from soils, which contain more than 70% of terrestrial carbon (Liu et al., 2020b). The first major anthropogenic carbon release has been first noticed around 6000 BC, marking the impact of the advent of agriculture, in particular through the large-scale cultivation of rice (Fuller et al., 2011; Ruddiman, 2014). Yet, the findings by Brovkin et al. (2019) demonstrate that the rise of CO_2 by 20 ppm between 6000 and 2000 BC cannot be solely ascribed to either ocean and land carbon sources. Although the impact of metallurgy has been acknowledged from the Medieval period, the impact of ancient metallurgical pursuits has been discounted through a focus on the Classical World alone (Williams, 2006), while the intensification of metal production in earlier periods around the world remains to be explored. Recently, Liu et al. (2020a) identified the importance of metallurgy and environmental studies in eastern Eurasia for observing climate change adaptation and the effects of continental scale connectedness through trade, flagging up the need for research between early global metallurgy and environmental sciences.

Currently, early global metallurgy is being increasingly identified in the form of metallurgy-related air pollution by environmental scientists studying sequences from peat bogs, glaciers and lake sediments. However, it is very regionally focussed. The recent identification of lead pollution in the peat bog sequence at Crveni Potok, Serbia from c. 3600 BC is the earliest such evidence in Europe, with comparable evidence from eastern Europe only from c. 3150 BC and western Europe only from c. 2950 BC (Longman et al., 2018). Whilst this is substantially later than the 5th millennium BC direct metal production evidence studied in the *Rise of Metallurgy in Eurasia* project, it is possible to use environmental sequences to re-evaluate the earliest known evidence for metallurgy in a region. For instance, Eichler et al. (2017) controversially argued the onset of intensive copper smelting in South America from evidence trapped in an ice core from the Illimani glacier, Bolivia from c. 700 BC, substantially earlier than the currently known evidence for significant copper smelting from c. 200 BC. There is currently no global survey of existing environmental data or programme of analysis that potentially relates to early metallurgy in terms of its initial, detectable appearance or its broader environmental impact.

Mining and Trade

The scale of early metallurgical mining activities across the world, beginning with copper ores at Rudna Glava, Ai Bunar, Jarmovac and elsewhere in the Balkans in the 6th/5th millennium BC (Chernykh, 1978; Ryndina, 2009), is now known to be far more extensive than previously understood. However, the implications of the scale, complexity and distribution networks associated with these mines are yet to be fully realised. Over 50 copper mines are now dated to the Chalcolithic-Bronze Age across Europe alone with a broader trend towards the consolidation of copper mining in major centres around mid-2nd millennium BC such as Mitterberg (Austria), Great Orme (UK) or Cyprus (e.g. Pernicka et al. 2016; Radivojević et al. 2019; Williams and Le Carlier de Veslud, 2019), amongst others. However, all of these are dwarfed by the production capacity of Kargaly (south Urals, Russian Federation), a primarily Late Bronze Age (1700-1400 BC) copper mining landscape that spread across 500 km^2 (Chernykh, 1997). With c. 100,000 tonnes of copper produced only in this mid-2nd millennium BC period, Kargaly had seven times the production capacity of the Mitterberg (Austria), the largest coeval European mine (Pernicka et al., 2016). This scale of production would have required annual felling of 150 ha of woodland, up to seven times the size of Kargaly, which stands in stark contrast to the paltry 2.6% of forest coverage of Kargaly today (Díaz del Rio et al., 2006). And yet Kargaly was one of at least six Bronze Age mining centres of a similar size in the Eurasian Steppe at the time, including Askaraly in east Kazakhstan, Dzhezkazgan in central Kazakhstan, Bozshakol in northeast Kazakhstan, Kendyktas Plateau in south Kazakhstan or Zerafshan Valley mines in Uzbekistan (Alimov et al., 1998; Berdenov, 2008; Boroffka et al. 2002; Park et al., 2020; Stöllner et al., 2011).

The *how* and *why* behind the scaling up of the metal production from c. 5000 BC to c. 1000 BC across Europe, North Africa and Asia was beyond the scope of this monograph, yet, we offer a glimpse of the complexity of operations underlining the acquisition of ores, logistics of their circulation, or multiple episodes of production required to produce a large metal implement from the very beginnings of metallurgy. Large-scale production was only enabled by the evolution of furnaces, which we see in a developed form only around the early – mid-2nd millennium BC, while the 3,000 years of metal production in between are usually ascribed to small-scale or 'household' production. These three millennia of a continual innovation in metal production are yet to be addressed in an all-encompassing synthesis that addresses specific evolutionary trajectories of metal making technology across Eurasia, and globally, and draws parallels to exhibit patterns of cooperation and knowledge transmission. These networks of cooperation were most likely responsible for connecting the East and the West through the exchange of commodities, most prominently copper alloys such as tin-bronzes, which laid out the foundations of the first global economic network at the time, later identified as the Silk Roads.

These networks of exchange in commodities, most visibly in metals, but also in textiles, animals and foods, were underpinned not only by social and political relationships, but also by agreed frameworks of measurement and value. Given the physical properties of metals such as colour, lustre, malleability and their ability to be re-shaped and recycled according to the requirements of the communities involved, it is no surprise to see metals becoming central to these networks of exchange. Research has demonstrated the emergence of standardised weight systems during the 2nd millennium BC in bronze (Kujpers et al. 2020) and gold (Rahmstorf 2019) in Europe, the widespread use of silver in trade across Southwest Asia from the 4th millennium BC (Sherratt 2016) as well as the adoption of standardised weighing equipment from the Atlantic to the Indian Ocean during the 3rd-2nd millennium BC (Rahmstorf 2011). We are only just beginning to understand the dynamics of ancient trade and markets (cf. Kristiansen et al. 2018; Rahmstorf and Stratford 2019; Rahmstorf *et al.* 2021) – and how metal was valued and used within them in the past rather than how we have projected it to be.

Societies

The relationship between early metals and societies across the world has been defined primarily by 19th and early to mid-20th century perspectives from Europe and Southwest Asia where scholarship placed metal at the core of schemes of social complexity and emerging inequalities. The period of the 5th-4th millennium BC in the Balkans and Southwest Asia is especially important in this respect as successive generations of scholars have argued that in the 5th millennium BC there are no great differences between these regions, from demographic, material and environmental perspectives, in their potential to develop urbanism and civilisation (Porčić, 2019a; Tringham, 1992, pp. 133-134). However, the 4th millennium BC in the Near East yields what Graeber and Wengrow (2021) have robustly characterised as the elusive evidence for territorial attachments that lead to private ownership, and then to a surplus of food, which in turn leads to the accumulation of wealth and power beyond the immediate kin-group, and ultimately to the production of sophisticated weapons, tools, vehicles, the rise of cities and centralised governments, with bureaucrats and priests making sure that the imbalance is maintained (and women kept in harems), while inventing writing systems to record a single 'correct' version of the past, whether it is 'correct' economically, administratively, politically or religiously. This stands in complete contrast to the dispersed farming communities of the Balkans, where a negative perception is created of a peripheral region that missed its opportunity to become 'civilised'.

The data shows that the 5th millennium BC Balkan communities did not 'run headlong for their chains' (*sensu* Rousseau, 1761), or put simply, the early advancements in polymetallurgical technologies did not materialise themselves into the emergence of cities and states. Furthermore, it seems clear that one of the major reasons why the concept of an independent origin for Balkan metallurgy was for many decades considered too bold, was due to the accepted wisdom about the development of metallurgy (as much as social evolution) based on the Southwest Asian model, or indeed, deeply intertwined with the '*Ex Oriente Lux*' concept. This proposed necessary decoupling of metal, social complexity and inequality in our perspectives on the global past is given further support when viewed from the Americas (Bebber 2021; Erhardht 2014; Hosler 2014; Lechtman 2014; Zori 2019) and more global perspectives (Chernykh 2021). Taking into account the volume, depth and analytical scrutiny of archaeological and archaeometallurgical research conducted around the world over the past 50 years and briefly reviewed here, it is clear that late 19th century narratives connecting metallurgy and a single perception of social progress have no place in 21st century archaeology.

The bibliographic reference for this chapter is:

Roberts, B. W., Radivojević, M., and Rehren, Th. 2021. Where do we take global early metallurgy studies next?, in Radivojević, M., Roberts, B. W., Marić, M., Kuzmanović Cvetković, J., and Rehren, Th. (eds) *The Rise of Metallurgy in Eurasi*a: 619–623. Oxford: Archaeopress.