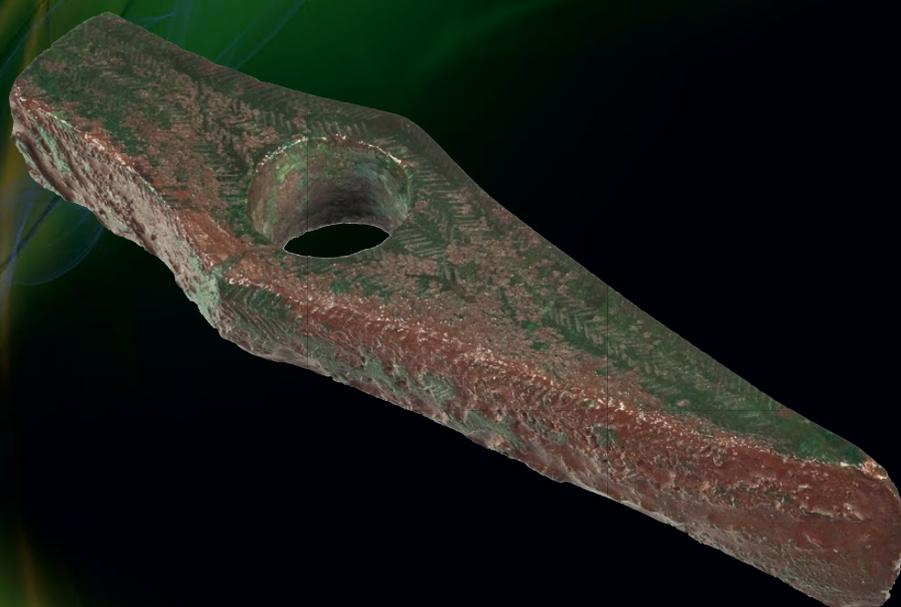


The Rise of Metallurgy in Eurasia

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



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(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

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

(1930 - 2015)

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thesis was the inference of household and settlement population size, as well as social structure, from the remains and inventories of the Late Neolithic Vinča culture houses. His main research interests include paleodemography, evolutionary archaeology (cultural transmission theory) and the social and demographic aspects of the Balkan Neolithic. Dr Porčić was also a Senior Researcher on the ERC funded BIRTH project (directed by Prof. Dr S. Stefanović) where he was in charge of the paleodemographic work package, with an aim to reconstruct the population dynamics and demographic aspects of the Neolithic transition in the Central Balkans based on the radiocarbon evidence and computer simulation. He published a book about the theory and methods of archaeological demography. He is currently working on a research which involves the implementation of models of cultural transmission through computer simulation in order to understand the patterns of material culture variation in space and time. For *The Rise of Metallurgy in Eurasia* project, Dr Porčić led a paleodemography team.

Quinn, Patrick (PhD) is a Principal Research Fellow at the UCL Institute of Archaeology, UK, and a leading expert in the field of ceramic analysis. His book on ceramic petrography is essential literature for any serious studies of ceramics. He has over 20 years of experience developing and undertaking research projects on ancient pottery and other ceramics from different archaeological periods and geographical regions. These include studies of ceramic production and distribution patterns in prehistoric Greece, as well as migration and cultural interaction in pre-contact North America. Patrick was one of the first western scholars to analyse scientifically the ceramic sculptures of the Terracotta Army in China. Patrick coordinates the Ceramic Technology Research Network at the Institute of Archaeology. He has an exceptional track record in high quality publications, including three books and over 40 peer review journal articles. He has taught specialist courses on ceramic analysis since 2005, including a highly successful intensive course on ceramic petrography, which draws participants from all continents. Patrick conducts commercial analysis of ceramics from various periods and parts of the globe. Dr Quinn was one of the ceramic specialists and PhD supervisors involved in *The Rise of Metallurgy in Eurasia* project.

Radivojević, Miljana (PhD) holds a Lectureship in Archaeomaterials at the UCL Institute of Archaeology, UK, where she acquired her PhD in Archaeometallurgy. During her previous studies and research posts at the Universities of Belgrade, Cambridge and UCL she has developed a strong research profile in both fieldwork excavations and laboratory analysis of material culture, specifically technology of early metal making. She specialised in the emergence of early copper making in

the Balkans before expanding research collaborations across the Chalcolithic and Bronze Age Europe and northern Eurasia. Dr Radivojević has published on the origins of metallurgy in the Balkans and southwest Asia, relationship of metallurgy and pottery technologies, invention, innovation and transmission of copper and tin bronze metallurgy across southeast Europe, aesthetics of ancient metal objects, as well as co-developed a novel method of re-assessing archaeological phenomena using complex networks analysis of metal supply systems in the Balkans. Dr Radivojević was one of the authors of *The Rise of Metallurgy in Eurasia* project, then Research Associate, Project Manager, and the lead editor of this volume.

Radloff, Kai (MA) is a member of the Berlin Graduate School of Ancient Studies, where he is enrolled in the programme 'Landscape Archaeology and Architecture'. He studied Archaeology and History of the Roman Provinces and Pre- and Protohistory at the Goethe-University in Frankfurt, Germany and at the University of Vienna, Austria. His main fields of interest are Archaeological prospection and the analysis of past landscapes with regard to socio-political aspects. In his studies, he is focussing on the spatial organisation of different communities and their regional networks. After graduating, he worked in the technical department of the Römisch-Germanischen Kommission (RGK) for several years, where he contributed to *The Rise of Metallurgy in Eurasia* project as a member of the team conducting geophysical surveys at the site of Belovode. Currently, he is doing research as a PhD candidate on the border landscape along the Lower Rhine in the Roman era.

Rajičić, Milica (BA) is an archaeologist who acquired her degree from the University of Belgrade. In 2020 she started the ARCHMAT-Erasmus Mundus Joint Master in Archaeological Material Science at the University of Évora. During and after her undergraduate studies she participated in many archaeological projects and excavations in Serbia, developing her interest in various archaeological materials. During the fieldwork research for the project *Rise of Metallurgy in Eurasia*, Milica was part of the team for on-site analyses of pottery on the site of Pločnik.

Rassmann, Knut (PhD) is Head of the Department of Survey and Excavation Methodology at the German Archaeological Institute, before he was Scientific Editor for the Bericht der Römisch-Germanischen Kommission (RGK). He obtained his PhD in 1991 at the Freie Universität Berlin. His main interests are Landscape Archaeology, survey and excavation methodology, Neolithic, Copper and Bronze Age in Europe. For *The Rise of Metallurgy in Eurasia* project, Dr Rassmann led the geophysics team.

Rehren, Thilo (PhD) is the A.G. Leventis Professor for Archaeological Sciences at the Cyprus Institute in Nicosia, Cyprus, and Director of its Science and Technology in Archaeology and Culture Research Center (STARC). Following a Masters in Mineralogy and a PhD in Petrology (Volcanology) he worked for nine years at the Deutsches Bergbau-Museum in Bochum, Germany, where he helped to establish the Institut für Archäometallurgie. In 1999 he was appointed Professor for Archaeological Materials and Technologies at the UCL Institute of Archaeology in London, from where he was seconded from 2011 to 2016 to establish UCL Qatar as an academic department of UCL based in Doha, Qatar, focusing on Archaeology, Museum and Gallery Practice, and Conservation Studies. His main interest lies in the study of production processes for metals and glass, and the related technical ceramics involved in this. Among other topics, he has worked on early gold and silver production in Ecuador and Bolivia, respectively, on African iron smelting and glass making, on crucible steel production in Central Asia and India, on faience, silver and copper production in China, on Egyptian LBA bronze casting and glass making, on Roman to early modern brass making in western Germany, on 19th century platinum production in Russia, and more recently on the distribution and recycling of Roman to Byzantine glass and copper and silver metallurgy in Morocco. The majority of his more than 30 PhD students have succeeded in careers in archaeology, holding positions in the Americas, Africa, the Middle East, Asia and across Europe. Professor Rehren formally held the AHRC grant underpinning *The Rise of Metallurgy in Eurasia* project (PI) and edited the monograph.

Rittner, Martin (PhD) is currently working as an Application Scientist for TOFWERK AG, developing Laser Ablation applications for the icpTOF Time-of-Flight mass spectrometer in their Demo Lab in Thun, Switzerland. Martin earned his Mag. rer. nat. (MSc) degree in Geology at the University of Innsbruck, Austria. During his PhD at Royal Holloway, University of London, he started to work more in isotope geochemistry and laser ablation (LA) analyses. He was running routine LA analyses at the London Geochronology Centre, UCL, London, a facility that is also occasionally used for research by members of other faculties and universities. This is where opportunity to analyse the samples described in this study arose. After two postdoc positions at UCL, Martin moved from academia into industry, but continues research in microanalytical methods for mainly geoscientific applications. For *The Rise of Metallurgy in Eurasia* project Martin carried out the geochemical analysis of chipped stone industry.

Roberts, Benjamin W. (PhD) an Associate Professor in the Department of Archaeology at Durham University. Prior to this, he was the Curator for the European Bronze Age collections in the British Museum. He

completed his PhD on the origins of metallurgy in western Europe at Cambridge University. He has spent over twenty years researching and publishing on early metallurgy and metal objects across Europe and beyond including the major edited volume *Archaeometallurgy in Global Perspective: Methods and Syntheses*. He is currently the leading the Leverhulme funded *Project Ancient Tin: Did British tin sources and trade make Bronze Age Europe?* He is also lead archaeologist on numerous smaller projects in Britain ranging from Bronze Age funerary sites to shipwrecks to chronologies. Dr Roberts was one of the authors of *The Rise of Metallurgy in Eurasia* project, Co-PI and the Co-Director of fieldwork research in Serbia.

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Scholz, Roman (MSc) is an employee of the Römisch-Germanischen Kommission (RGK) and responsible for field research. He has been working for the German Archaeological Institute (DAI) since 2011 and specializes in prospecting and methodology development. He studied excavation technology and then landscape archaeology at the University of Technology and Economics and the University of Potsdam. Since 2013 he has been involved in research on the Neolithic tell settlements in eastern Croatia and also accompanies the investigations on the large Copper Age settlements in the Republic of Moldova through experimental archaeological work. He is currently doing his PhD on the settlement in Bapska in Croatia at the University of Kiel. For *The Rise of Metallurgy in Eurasia* project, he was a member of the geophysics team.

Vitezović, Selena (PhD) is a Senior Research Associate at Institute of Archaeology, Belgrade. She obtained her bachelor, MPhil and PhD at Faculty of Philosophy, University of Belgrade. Her research is focused on Mesolithic, Neolithic and Eneolithic periods and on topics related to technology, economy and human-animal relations, in particular osseous technologies. She participated at numerous excavations projects as archaeologist and bone tool specialist in Serbia, Bulgaria and Croatia, including the sites of Vlakno (Croatia), Vinča-Belo Brdo, Bujanj, Pavlovac (Serbia), Nova Nadezhda, Slatina (Bulgaria) and many more. She published over 50 articles in journals and chapters in monographs and edited volumes. For *The Rise of Metallurgy in Eurasia* project she worked as a bone tool specialist for assemblages from Pločnik and Belovode.

Foreword by Evgeniy N. Chernykh

I have been waiting for this book for more than four decades! When I published 'Mining and Metallurgy in Ancient Bulgaria' (*Gornoe Delo i Metallurgiya v Drevneishei Bolgarii, in Russian*) in 1978, I was hopeful that the impetus given to Balkan archaeometallurgy with it and the excavation projects in Rudna Glava, Durankulak or Varna would have resulted in more in-depth analysis of metallurgical materials that could then reveal the much sought-after origins of Balkan metallurgy and settle the debate on independent vs diffusionist perspectives. It took another 30 years for the first secure evidence for copper smelting to show up in the now much cited publication by Radivojević *et al.* (2010a), which ultimately gave way to this monograph and set out the vision for the *Rise of Metallurgy in Eurasia* project. While reading it, I have been personally humbled to learn that my 1978 book was the main inspiration for pursuing the origins of metallurgy research by Radivojević, Roberts, Rehren and their team, and I therefore remain grateful for the honour to being amongst the first readers of this outstanding scholarly achievement.

This is a major publication both on the evolution of early metallurgy in the 'Old World' and on the Central Balkan archaeology of the 6th and 5th millennia BC. It provides a highly detailed investigation into the dating, technology and organisation of metallurgy in the Vinča culture, which covers the mentioned chronological spread. The excavation and recording of the sequences at key sites of Belovode and Pločnik, with accompanying analysis of the ore and metal analysis from the earlier projects throughout the Balkans presents a clear archaeological and archaeometallurgical framework. The radiocarbon dating programme that follows meticulous excavation and recording, as well as Bayesian modelling, yields the much welcome confirmation of c. 4900 BC as extremely secure evidence for one of the earliest known copper smelting in the world. The monograph, however, goes beyond the two key sites, and far beyond the last major Vinča site publication (e.g. Selevac in 1990 by Ruth Tringham). The scale and diversity of evidence presented and reviewed offers a holistic perspective on early metallurgy and society in the wider Balkan area.

The emphasis on incorporating the broader archaeological / societal context is clear from the beginning, and leads to the excavation reports, surveys and post-excavation analyses at Belovode and Pločnik with an exceptional level of detail, specialist reports and encyclopaedic knowledge on the variety of topics, including information that has been missing in the few publications over the previous decades of exploration at both sites. The highlights of these sections are most certainly the confirmations of the secure age of the

metal smelting activities very close to the beginning of the 5th millennium BC, as already argued in Radivojević *et al.* (2010a), together with the importance of black and green ores for metal extraction. Another highlight comes from meticulous research on the connection of pottery and metallurgical technology, successfully targeting yet another several decades old scholarly dilemma on the connectedness of these two pyrotechnologies. The richness of accompanying research on plants and animals, various stone technologies and landscape features offers an unprecedented contextualisation of the development of metallurgical knowledge that takes the readership beyond the focus on workshops, to people – their everyday lives and interaction with the environment and other communities at the time. While admittedly the geophysical surveys on both sites reveal a largely complete perspective on their spatial organisation, the excavation campaigns at both sites were naturally far smaller in scale owing to the depth and complexity of the archaeological sequences at both sites.

The heavy focus on the excavation methodology, findings and analytical procedures on materials from Belovode and Pločnik in the first three sections of the monograph stands as a kind of a final excavation report on its own; yet the following section provides an invaluable and very extensive collection of synthetic chapters on the Neolithic-Chalcolithic in the Central Balkans by emerging and leading specialists. This section almost stands as a second volume of this monograph, whose readership will likely be far wider than the previous sections focused on two key sites. As the most precious point that I take with me is the conclusion on the importance of community cooperation in performing the metallurgical activities, and the value of shared household spaces and practices across the Chalcolithic villages. It also stands in contrast to much repeated ideas on the emergence of elites and social inequality in the Balkans, which does not have much support in the evidence from across the region (see also Porčić 2019).

Finally, the global perspective section engages in a stimulating discussion on the place of early Balkan metallurgy in the interpretation of global early metallurgies and argues convincingly for the need to shift paradigms from unfruitful pursuits into the origins of social inequality to the narratives tailored to each context individually and with a strong focus on detailed technological analysis that go beyond reporting tables with compositional data. The cutting-edge approaches such as complex networks analysis reveal a completely novel world of research

opportunities to explore patterns of cooperation, as means to re-evaluate the concept of archaeological culture, as well as to probe established ideas, such as metallurgical provinces established in my previous work. I am pleasantly surprised by how much these novel approaches underline and expand the potential of defining metallurgical provinces on the basis of shared technological knowledge and I will be looking forward to future explorations on this topic.

There is certainly no shortage of material for future research and debate. If anything, the lead authors of this section set a bold challenge for prospective research by indicating points that they wish they could have done within this project (e.g. environmental analysis), and invite new generations to benefit from their fully accessible excavation and analytical database in exploring novel avenues for research. The final points that come closer to my work target the crucial role that Balkan metallurgy played in starting the wave of technological changes across the Eurasian Steppe in the Bronze Age, which authors mention as yet another

challenge to address with greater analytical detail and focus on transmission of the metal production knowledge.

Finally, what this monograph has largely shown goes beyond the Balkan archaeology and metallurgy, and that is the power of archaeomaterials research in exploring the topics of technological invention, innovation, and its transmission. From the micro detail of identifying manganese-rich copper ores as the primary source of the world's first metal to the macro detail of revealing patterns of cooperation amongst metal using communities, this project sets a very high bar for any similar research in the future and highlights the necessity for multidisciplinary research and hence cuts to the core of what archaeology is: a multi-faceted endeavour that keeps growing and benefiting from cross-disciplinary achievements. This monograph fully owns its title, as much as it will own the shelves of a global readership for many decades to come.

Moscow, 18.5.2021

Foreword by Barbara S. Ottaway

Most studies of the beginning of the earliest European/Eurasian metallurgy have centered on the Balkans. Anyone interested or working in this field had to master the complex local prehistory of Bulgaria, Romania, Hungary, Serbia and Croatia of the late Neolithic, Eneolithic or Chalcolithic period. Much of this literature was not available in English.

This has now been elegantly resolved by the publication of the 'The Rise of Metallurgy in Eurasia', edited by Miljana Radivojević, Benjamin W. Roberts, Miroslav Marić, Julka Kuzmanović Cvetković and Thilo Rehren. In this monograph the reader will find succinct summaries of the archaeology and periodisation of these cultures in the Balkans in clear and very readable English.

This forms the background to new excavations at two sites: Belovode and Pločnik, which have been executed in exemplary fashion. The digitised methodological excavation techniques, supported by numerous radiocarbon-dated events and layers, has produced a great amount of new information. This not only allows the authors to date the start of new developments and activities, but it also provides a precise absolute chronology for the occupation of both sites.

The wealth of cultural heritage of the Balkans has been enriched by the many specialists presenting their post-excavation results of Belovode and Pločnik. This provides much needed information on subsistence strategies through archaeobotanical and zooarchaeological results. A study of settlement

patterns, using geomagnetic data, has given us the estimates of overall size of the settlements, number of houses as well as estimated population size of the later Vinča period.

However, the most exciting results are that both Belovode and Pločnik have provided clear evidence of the earliest, experimental stages of metal production using green-black copper ores in the early levels. This phase was followed by more successful, sustainable smelting of the same copper ore. Furthermore, it has been shown that the smelting of copper ore at both sites was a natural progression of working with green malachite, used for the production of beads, in the earliest levels of the settlements.

This, together with the Vinča settlers experience in pyrotechnological knowledge, gained in the production of black-burnished pottery, convincingly argues for a local, independent development of metal production at Belovode and Pločnik. Furthermore, the progression of metallurgical experience gained by the settlers reflects their ability and competence in performing the entire *chaîne opératoire* of smelting, melting and working copper.

The authors are to be congratulated in successfully carrying through and publishing this ambitious project. The entire data has also been made available online, encouraging further research using their results.

Exeter, 24.5.2021

Foreword by Stephen J. Shennan

Since at least the 1960s the Balkan Copper Age has come to be seen as a salient topic in European prehistory, one that has to be covered in introductory Archaeology courses. The reason for this is the extraordinary richness of its archaeological record. Its settlement record is outstanding, its figurines striking, its painted pottery of extraordinary elaboration and its large numbers of copper axes remarkable. The initial impression of its exceptional nature that emerged from large-scale excavation programmes after WWII was only confirmed when the gold inventories of the burials in the Varna cemetery began to be published in the 1970s. However, there was also another aspect of the Balkan Copper Age that attracted attention: its date. Using his knowledge of the stratigraphic sequences from recent Balkan excavations together with the gradually increasing number of radiocarbon dates and his awareness of the need for their recalibration, Colin Renfrew, in his famous 1969 paper in *Proceedings of the Prehistoric Society*, showed that the long assumed chronological correlation between the Vinča culture and the Troy Early Bronze Age was fallacious. The developments of the Balkan Copper Age, most importantly the metallurgy itself, were at least a millennium earlier than previously believed, and much earlier than the sources from which they had been thought to derive: they were autonomous.

In *The Rise of Metallurgy in Eurasia* Radivojević and Roberts and their colleagues offer a compelling new vision of Balkan Copper Age metallurgy and its significance, while confirming Renfrew's claim of its autonomy. The work is a model of 21st century interdisciplinary research. It combines question-oriented fieldwork, deep technical knowledge of metal-making materials and processes and their archaeological residues, and of the analytical methods used to obtain information about them. These go together with a mastery of the archaeological record of the Copper Age Balkans. The volume integrates the results of the fieldwork programme and of the analyses of the material it produced with those of many specialist analytical publications that various combinations of the volume's contributors have produced in recent years, to produce a synthesis that justifies its title. I cannot begin to do justice to all its different elements and their importance in this foreword.

The six questions that provided the agenda for the project, addressing the 'how' and the 'why' of early metallurgy as well as the 'what' and the 'when' as the project leaders put it, are systematically addressed and answered. Understanding the 'how' of early Balkan copper smelting is especially difficult because

it has left so few traces in the form of slag, while the furnaces seem to have been no more than sherd-lined holes in the ground, whose remains are evanescent and therefore difficult to find. The project has overcome these difficulties and made major advances in the use of archaeological evidence for identifying the processes of metallurgical innovation. It has confirmed the independent beginning of copper smelting in the Balkans at ~5000 BCE based on the use of distinctive black-and-green coloured copper minerals, visible traits that provide a phenomenological basis for understanding the choices made by the first metal producers. The innovative smelting of these minerals, confirmed by evidence from slag analysis, resulted in the development of a process that continued in use for hundreds of years, using ore sources in eastern Serbia. The recognition of the importance of this black-and-green colour choice also neatly makes sense of the appearance of early tin bronze as a result of the exploitation of similarly-coloured copper-tin ore, as well as the non-use of less colourful copper minerals.

The consistency of the methods used is one of the many interesting features of the organisation of copper production that has emerged from the project, as is the evidence of the use of multiple ore sources, even if the famous excavated early mine at Rudna Glava remains an enigma. Another is the results of the copper smelting experiments that were carried out, showing that the process would have needed a team of people to bring it to a successful conclusion. Even if one of these team members had more expertise (including magical knowledge) than others, it is hard to see how the process could have been kept a secret, as many have argued in the past. In fact, the authors suggest, the evidence that pieces of copper ore were found very widely across the two sites excavated indicates that every household was probably producing metal. Given the small scale of any given production event in a hole-in-the-ground furnace, less than needed to produce a single axe, they must have been frequent. Knowledge would have been community wide. Together with the fact that different communities used ore from the same sources, this helps to explain the widespread uniformity in production techniques. Even if details passed on to other communities were inexact or incorrect, the possibilities would ultimately have been limited by what worked. Importantly, knowledge of the technology was sufficiently widespread that metal production did not cease with the end of the Vinča culture but continued elsewhere in the Balkans till the end of the 5th millennium: it was resilient rather than fragile in Valentine Roux's terms (2010).

In her studies of stone-bead making and of the use of rotative kinetic agenda to make wheel-turned pots Roux (e.g. Roux et al. 1995) emphasises the length of apprenticeship involved in becoming an expert – time taken that effectively excludes them to at least some degree from other activities. The widespread distribution of the evidence from Belovode and Pločnik would seem to suggest that copper smelting was not a specialist activity in the same way, perhaps because it did not require the acquisition of highly controlled embodied know-how taking years to acquire, for example the skill to produce exceptionally long flint blades. Once the key discoveries had been made and a successful recipe developed, just about anyone could do it if they had access to the relevant ores, and there were no barriers to entry in the form of expensive or difficult to build installations.

As Radivojević and Roberts argue in their final chapter, the recognition that metal smelting was not an exclusive activity goes a long way towards undermining the long-assumed association of metallurgy with the growth of

social elites and the established narratives that follow from this assumption. This is one of the major outcomes of their project. It is also in keeping with other recent arguments (Porčić 2019a) against the existence of high levels of social inequality in the Balkan Copper Age. In a similar vein, they see metallurgy as only one element in what I would call the economic growth that characterised the Vinča period and the Balkan Copper Age more generally, visible in increased population, increased production and circulation of a range of material items, and the scale of cattle-keeping. Finally, they suggest, their work demonstrates not *the* autonomous development of copper production but *an* autonomous development, characterised by the specific technology they describe.

In bringing together the massive amount of research that leads to these novel conclusions, this volume forms the baseline for all future studies not just of Balkan copper metallurgy but of any study of early metallurgical innovation.

London, 30.3.2021

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The *Rise of Metallurgy in Eurasia* team were not only scholars, but also the local workers at both Belovode and Pločnik, whose long experience in supporting the archaeological research of these sites prior to 2012 was tremendously helpful in identifying ‘the little green ones’ [malachite and copper slag] under the scorching Serbian sun during the excavation seasons of 2012 and 2013. Hence, we proudly present here our local team from Belovode: Milan Radosavljević, Milan Bogdanović, Zoran Ilić, Dragiša Panić, Radiša Panić, Dane Nikolić, Milorad Tanasković, Danijel Ljubomirović, Saša Bogdanović, Miladin Milutinović, Stefan Miloradović, Milan Popović, Milan Blagojević, Dragan Stojiljković, Filip Jovanović, Mlađo Jovanović, Milija Jovanović, Toma Mijatović, and Žika Mijatović. The local team from Pločnik were: Dejan Miladinović, Jelena Miladinović, Zoran Miladinović, Slobodan Lukić, Milivoje Lukić, Dejan Vesović, Milan Rakić, Zoran Ristić, Zoran Lukić and Jovan Vidojević. A special mention goes to Slavoljub and Snežana Radivojević, for their technical support in the field and accommodation for the team members in Prokuplje.

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Lastly, but most importantly we remain humbled by each other’s collegiality and friendship, and grateful to the good fortune that brought us together to set a milestone in the research of the origins of metallurgy. We are aware, now more than ever, of the growing complexity of the topic and of our gaps in knowledge. This monograph is far from being a final statement. We hope instead that it serves as an invitation for scholars to join us in engaging with the many questions, approaches, data sets and opportunities for discovery that early metallurgy offers for decades to come.