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COPPER MINERALS AND ARCHAOMETALLURGICAL MATERIALS FROM THE VINČA CULTURE SITES OF BELOVODE AND PLOČNIK: OVERVIEW OF THE EVIDENCE AND NEW DATA

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Abstract. – The Vinča culture sites of Belovode and Pločnik have been attracting scholarly attention for decades now, due to numerous discoveries indicative of copper mineral and metal use in these settlements, which are confirmed as, currently, the earliest worldwide and very likely developed independently in Eurasia.¹ The authors attempt to give an overview of already published data along with new results stemming from the recently completed doctoral research of the primary author.² All materials related to copper mineral use and pyrometallurgical activities are presented through the concept of metallurgical *chaîne opératoire*, following the established sequence of operations,³ which is adjusted for this specific case study and divided into three categories: copper mineral processing, (s)melting debris, and the making and working of finished metal objects. The qualitative overview of available data is therefore focused mainly around the material side of the studied samples and provides an insight into the technological choices for making copper mineral ornaments and copper metal artefacts in the sites of Belovode and Pločnik. Accordingly, it provides a model for the understanding of similar material assemblages that occur in other Vinča culture sites, or beyond.

Key words. – Belovode, Pločnik, Vinča culture, malachite, copper metal, tin bronze, malachite beads, *chaîne opératoire*, slag, Serbia.

Vinča culture metallurgy has gained renewed interest through international scholarship in the past few years, owing to the productive publication activity of Serbian researchers.⁴ This activity recently led to one of the largest international collaborative archaeology research projects ever conducted in Serbia. Funded by the UK government, the partners come from three countries, the United Kingdom, Germany and Serbia.⁵ Its main goal is to investigate the rise of the earliest known metallurgy in Eurasia with specific focus on the earliest occurrence of this technology at three Vinča culture sites of Belovode, Pločnik and Jarmovac.

All three sites have thus far yielded evidence that covers the entire *chaîne opératoire* of metallurgical activities: mining, production and consumption. The archaeometallurgical assemblage originating from Belovode and Pločnik is reviewed here in light of the

¹ Radivojević et al. 2010.

² Radivojević 2012.

³ cf. Ottaway 2001.

⁴ e.g. Antonović 2002, 2006; Šljivar, Kuzmanović-Cvetković 2009; Šljivar et al. 2012; Radivojević et al. 2010, 2013.

⁵ <http://www.ucl.ac.uk/rise-metallurgy-eurasia>

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recently completed analytical work.⁶ The Jarmovac materials will be studied in detail in the future. The focus of this paper is on a qualitative overview of the available evidence for activities related to copper mineral use and archaeometallurgical activities at Belovode and Pločnik. A detailed quantitative study is beyond the scope of this paper, and will be attempted separately elsewhere.

All materials considered here were discovered before 2009 at the sites of Belovode and Pločnik. The majority of them originate from detailed investigations carried out by the National Museum in Belgrade (D. Šljivar) and the Museum in Toplica (J. Kuzmanović-Cvetković) from 1993 and 1996 respectively. The careful consideration of archaeometallurgical evidence from these two sites has already been communicated through national and international scholarship.⁷ To this, we now add a set of 48 newly analysed materials, which provides a more nuanced picture of the *chaîne opératoire* of early copper making at the sites of Belovode and Pločnik, and the Vinča culture in general.

The majority of the studied collection consists of copper minerals and malachite beads, while the rest of the assemblage includes individual slag samples, slagged ceramic sherds and copper metal artefacts. In comparison with the amount of technological debris (and slags in particular) in later prehistoric periods, the sample size in this study appears small by any standard. However, it targets the crucial period in the evolution of metallurgy in Europe and, as a coherent assemblage, is unprecedented in size, quality and resolution. In terms of chronology, all metallurgical activities at the sites of Belovode and Pločnik are placed within the first half of the 5th millennium BC. The suggested start of the occupation of Belovode is c. 150 years earlier than in Pločnik, which is set at c. 5350 BC and c. 5200 BC respectively. Both sites were abandoned at about c. 4650 BC.⁸

The *chaîne opératoire* of metallurgical activities consists of complex operations that altogether provide information on solutions shaped by three different spheres: the physical, social and environmental worlds.⁹ In order to assess how and why some particular technological choices in the metal production process were made over others, this process needs to be deconstructed into distinctive components.¹⁰ Furthermore, these components require additional division due to differences in the temperature treatment they underwent, which helps us distinguish “cold” from “hot” (extractive) metallurgy, and accordingly differentiate between copper mineral use and pyrometallurgy.¹¹ All components of the metal

production process represent variables prone to mutation, replication and innovation within the transmission process, and significantly influence the final outcome of the metal making activity. In order to address metal production in the Vinča culture, activities related to copper mineral use and pyrometallurgical activities are described here in three distinctive stages of the process: *copper mineral processing*, *(s)melting debris*, and *the making and working of finished metal objects*. All technological analyses were carried out at the Wolfson Archaeological Science Laboratories at the UCL Institute of Archaeology, by the primary author of this paper, and under the supervision of Professor Thilo Rehren.

THE PROCESSING OF (ARCHAEOLOGICAL) COPPER MINERALS

All copper minerals studied here are recognised as archaeological since they are originating from archaeological sites (in contrast to geological minerals that come from the mines). Although bead minerals and ores in this study are typically malachite, the rationale for a distinction between these has been developed in the previous study of material from Belovode,¹² and refers to their differentiation in the technological treatment that was applied in their processing. Thus, minerals most likely used for bead making at the sites of Belovode and Pločnik (i.e. “cold” processing) (Fig. 1a) will be referred to as copper minerals only, while those most likely used for copper smelting (or “hot” processed) will be termed copper ores.

In this study, copper ores are assumed to contain significant manganese content, as first indicated by the analyses of copper production evidence from Belovode.¹³ Macroscopically, these ores appear green and black, where green comes from the colour of a secon-

⁶ Radivojević et al. 2010; Radivojević 2012; Radivojević et al. 2013.

⁷ Šljivar 1996; Šljivar, Jacanović 1996b; Šljivar, Kuzmanović-Cvetković 1998a; Šljivar 2006; Šljivar et al. 2006 (to cite just a few).

⁸ Borić 2009.

⁹ Roux 2003.

¹⁰ Ottaway 2001; Ottaway, Roberts 2008.

¹¹ Radivojević et al. 2010, 2779–2780.

¹² Radivojević et al. 2010.

¹³ Radivojević et al. 2010.

dary copper mineral (malachite) and black from the manganese content (Fig. 1b).

(S)MELTING DEBRIS

The smelting of copper ores refers to the primary extraction process, where the produced metal was usually further purified by refining, or melting. The common smelting debris are installations, slagged ceramics and slags. Technical ceramics (crucibles, furnace remains, or tuyères) are particularly interesting for studying past metallurgical processes as they reflect technological choices in this craft. The understanding of their shape, fabric and size is crucial for distinguishing whether the typically fragmented ceramic pieces belong to a crucible container or to the lining of the smelting installation.¹⁴ However, the most informative part of a crucible or an installation fragment is the slag attached to its walls, as is the case with slagged sherds from the site of Belovode in this research (Fig. 2a). One of the most valuable materials for studying metal production at the site of Belovode are small slag pieces (8 in total), discovered together with slagged sherds in a single trench (No. 3) in this site (for typical example see Fig. 2b).

MAKING AND WORKING: COPPER MINERALS AND METAL ARTEFACTS

This group of artefacts consists of malachite beads and copper metal artefacts, both of which include sub-groups of semi-finished and finished artefacts. Malachite beads, as one of the earliest artefacts made of copper minerals, were used for ornamental purposes in both the Balkans and the Near East, due to their distinctive green colour.¹⁵ These objects were commonly processed in a series of “cold” shaping techniques, applied in different technological steps. The ornament (bead) making process starts with a raw *nodule* of mineral, which, once roughly shaped (but not perforated), is recognised as a *roughout*; following sessions of fine chipping it reaches the stage of a preform or *blank*, commonly followed by drilling before it reaches the final, bead shape.¹⁶ Notably, the order of sequences varies culturally but also in relation to materials used for ornament making.

The metal artefacts group is particularly informative for the metallurgical *chaîne opératoire* in the Vinča culture, as the variety allows the investigation of different sequences of production and interpretation within

their wider cultural, environmental and physical surroundings (Fig. 3).

ARCHAEOLOGICAL SITES AND RELATED MATERIALS

Belovode

The site of Belovode (Fig. 4) lies on a windy plateau with the eponymous spring running through the settlement, located near the village of Veliko Laole, c. 140 km southeast of Belgrade. The location of Belovode is typical of Vinča culture settlements: it rests on a large plateau of ellipsoidal shape at an altitude of c. 200 m, in surroundings suitable for agricultural activities, cattle breeding and pastures.¹⁷ The nearby Mlava River runs deep into the volcanic mountain range called Homolje, which belongs to the zone of primary copper mining and metallurgy.¹⁸

It has been excavated since 1993 by the National Museum of Belgrade and the Museum in Požarevac.¹⁹ Within an estimated 100 hectares covered by up to 3 m of cultural layers, four building horizons have been documented (Belovode A–D), correlating with the entire Vinča culture sequence.²⁰

The Vinča culture sequence of Belovode is established on the basis of its distinctive ceramic typology,²¹ as well as locally recognised pottery variations.²² In its earliest stages, Belovode was most likely inhabited by Starčevo groups, as indicated by the, so-far occasional, finds of late Starčevo pottery. This potential brief occupation by the Starčevo groups was followed by the Vinča culture occupation, which ended around the mid 5th millennium BC. By the end of the 4th millennium BC a section of this site was briefly re-occupied by the Late Chalcolithic Kostolac culture but this is limited to a single intrusion in Trench No. 6;²³ we have only

¹⁴ Rehren 2003.

¹⁵ Bar-Yosef Mayer, Porat 2008.

¹⁶ Lankton et al. 2003, 16.

¹⁷ Šljivar et al. 2006, 251–252.

¹⁸ Krajnović, Janković 1995.

¹⁹ Šljivar, Jacanović 1996a; Šljivar, Jacanović 1996b; Šljivar, Jacanović 1997; Jacanović, Šljivar 2003; Šljivar et al. 2006.

²⁰ Šljivar et al. 2006, 251.

²¹ Garašanin 1951; Garašanin 1973.

²² Šljivar, Jacanović 1996b; Arsenijević, Živković 1998.

²³ Borić 2009, 208.

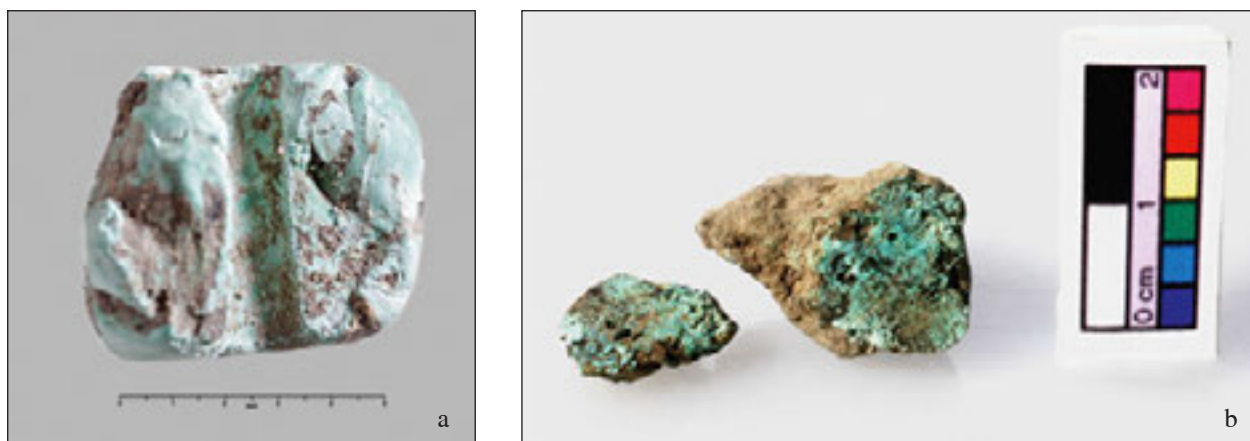


Fig. 1. a) Malachite bead from Belovode (23). Note the pure green colour of this sample in comparison with the Mn-rich one on the right; b) Typically green-and-black Mn-rich copper mineral from Belovode

Сл. 1. а) Малахијина перла са Беловода (23). Приметити чисту зелену боју овој узорка у поређењу са минералом (десно) који је обојан манјаном; б) Типичан зелено-црни бакарни минерал са Беловода обојан манјаном



Fig. 2. a) A slagged ceramic sherd from Belovode (31b); b) An individual slag sample from Belovode (134)

Сл. 2. а) Керамички фрагмент са згуром са Беловода (31b); б) Индивидуални узорак згуре са Беловода (134)



Fig. 3. a) Folded copper metal sheet (Плочник 75); b) massive copper implement (Плочник 143)

Сл. 3. а) Пресавијени бакарни лим (Плочник 75); б) Масивна бакарна алатка (Плочник 143)

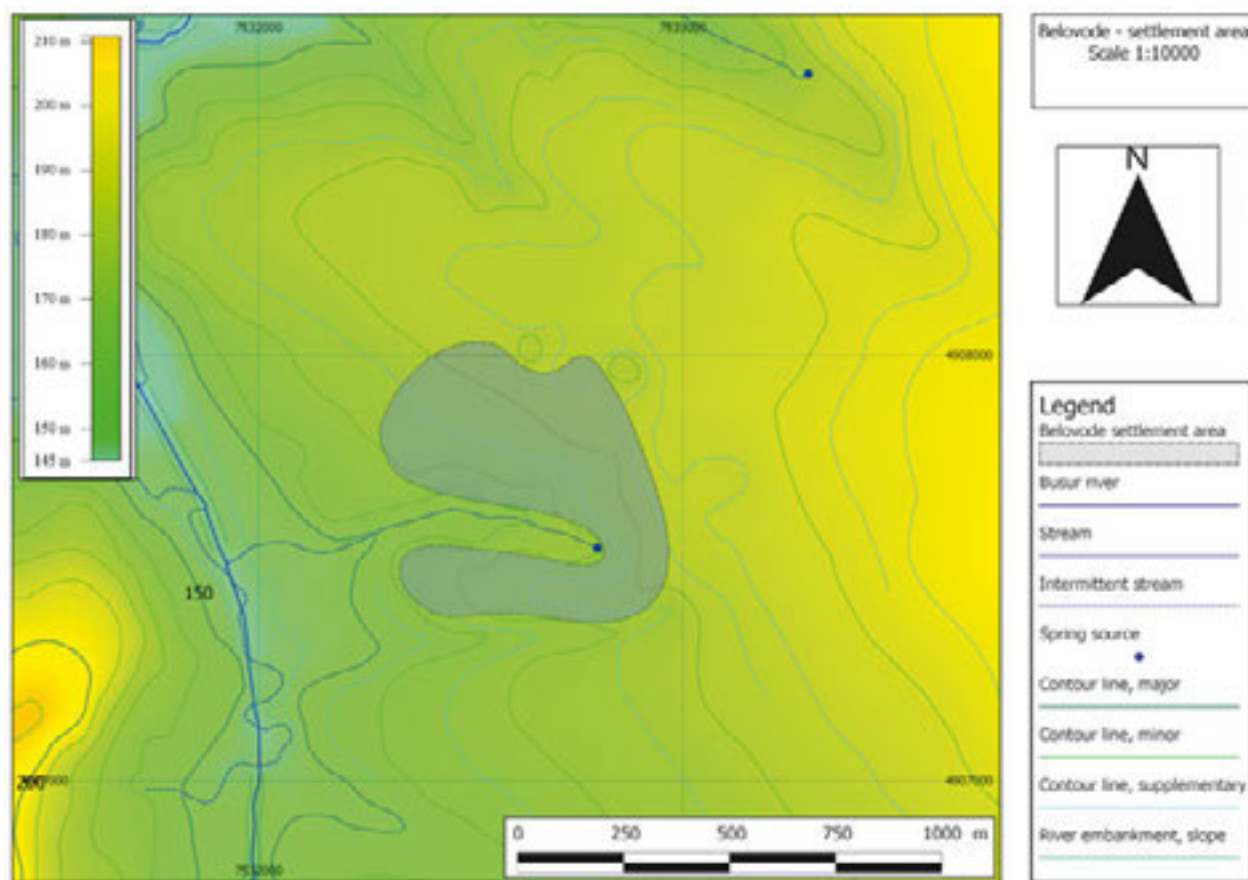


Fig. 4. Plan of the site of Belovode (by J. Pendić)

Сл. 4. План локалитета Беловоде (припремио Ј. Пендић)

included here sample M12 (Table 1) after careful examination of its firm contextualisation within the Vinča culture occupation. By 2009, c. 400 m² had been excavated through 14 trenches, usually 25 m² in size, all of which are concentrated in the southern part of this settlement.

The site of Belovode has recently received nine accelerator mass spectrometry (AMS) radiocarbon dates, obtained from animal bones from Belovode, which confirmed the expected Vinča culture chronological span.²⁴ The probability distribution for the beginning of the Vinča occupation in Belovode indicates a date of c. 5350 BC, while the boundary for the end of the Vinča culture use of the site is set at c. 4650 BC. Of particular significance here is the dating of the earliest stratigraphic evidence for extractive metallurgy in Belovode, which starts at around 5000 BC; this is currently the earliest secure date for copper metal production anywhere.²⁵ Importantly, it coincides with the intensive

mining activities in Rudna Glava, also from around c. 5000 BC.²⁶

However, Rudna Glava does not appear to have been exploited by the inhabitants of Belovode as another copper source, discovered in Ždrelo (Fig. 5), c. 10 km from Belovode, makes the most likely candidate according to lead isotope analysis.²⁷ Nine Vinča culture settlements in total have been found in this area, prompting scholars to propose their association with the mining and metallurgical activities in the area,²⁸ although this remains to be explored in future research.

²⁴ Gläser 1996; Borić 2009.

²⁵ Radivojević et al. 2010.

²⁶ Borić 2009, 206.

²⁷ Radivojević et al. 2010, 2781, Fig. 10.

²⁸ Šljivar, Jacanović 1996b.

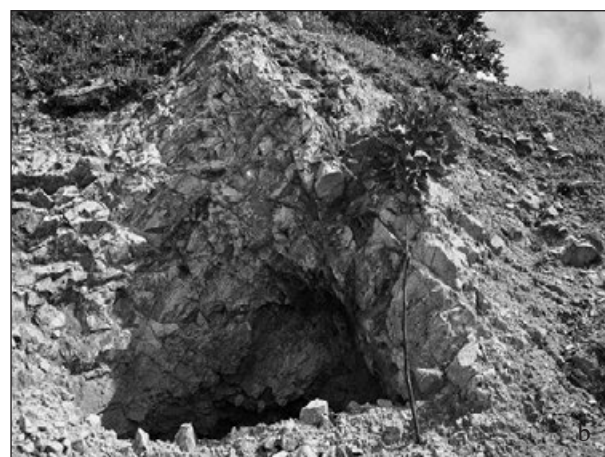


Fig. 5. a) Open-cast mine (?) at Ždrelo; b) Entrance to the shaft in Ždrelo (photos by M. Radivojević)

Сл. 5. а) Површински рудник (?) у Ждрелу; б) Улаз у окно на Ждрелу (фотографије: М. Радивојевић)

COPPER MINERAL USE

Malachite beads, pendants and “green” copper minerals appeared from the earliest occupation in Belovode, and continued throughout all building horizons. These most numerous finds in Belovode are usually uncovered mixed with ash and pieces of charcoal. Other contexts include house floors, storage jars, ceramic sherds (with malachite adhered to them), or workshops within a household. Two such areas in Trenches 12 and 13 yielded together c. 2.5 kg of copper minerals throughout all building horizons, which is almost one third of the total weight of malachite finds discovered at this site.²⁹

Ten samples belonging to the copper minerals group have been selected for this study, three of which come from the so-called metallurgical Trench No. 3,³⁰ while the rest originates from various household contexts (see Table 1). All samples, barring M3, M13, M17, 33b and 3) are confirmed to be malachite with significant levels of manganese in their composition. The remaining set of copper minerals was sourced from a vein containing paragenesis of cuprite with copper sulphides.³¹ The small size of these minerals (c. 1–3 cm) may imply that they were beneficiated, or in other words crushed to facilitate smelting. Two stone mallets with a groove in the middle, discovered in the context of workshops in Trenches 1 and 7,³² could offer clues about tools used for this process. Such tools may have been used for mining as well, according to the analogy with similar finds from Rudna Glava.³³

Installations/slugged sherds

Charred surfaces with malachite, copper mineral powder adhering to fragmented ceramic sherds and grooved stone mallets are common situations in household contexts in Belovode. There are also a few small-sized pottery vessels of conical shape and coarse fabric from Trenches Nos. 7 and 8, Vinča B1 horizon, which had green minerals attached to the outer surface, however, analyses have shown that these were not crucibles (samples Belovode M26, M29 and M30).³⁴ In addition, a fragment of ceramic mould discovered on the site surface is thought to originate from the latest layer of occupation.³⁵

Two shallow pits rimmed with ceramic sherds and a burnt layer of clay from Trenches 10 and 13, a Vinča

²⁹ The primary author weighed all malachite from Belovode for the purpose of her PhD research.

³⁰ Radivojević et al. 2010.

³¹ Radivojević 2012.

³² Šljivar et al. 2006, 259, Pl. I/4

³³ cf. Jovanović 1982.

³⁴ Radivojević 2007.

³⁵ Šljivar et al. 2006, 259, Pl. I/3.

³⁶ Šljivar et al. 2006, 253, 260, Pl. II/4.

³⁷ Šljivar 2006; Šljivar et al. 2006, 253.

³⁸ The investigation with portable XRF carried out by Prof. Thilo Rehren (UCL Qatar) and the primary author of this paper did not show remains of potentially adhering slag, copper contamination or excessive vitrification of these cylindrical objects and is, thus, considered as not related to the archaeometallurgical process.

B1 building horizon, are identified as early *furnaces* by the excavator.³⁶ Elongated cylindrical ceramic forms (so-called *chimneys*) with a diameter of about 20 cm and a reconstructed height of up to 80 cm and open at both ends (Figure 6), have been tentatively linked to the rimmed pits in the ground and, thus, the smelting operation.³⁷ Nevertheless, “true” smelting installations

with traces of convincing remains are yet to be discovered at the site of Belovode.³⁸

Pyrometallurgical activities at the site of Belovode are only represented by eight individual copper slag samples in total and four slagged ceramic sherds from Trench No. 3, all of which demonstrate sustained smelting activities on the outskirts of this site. Another

Table 1: The newly studied collection from Belovode, arranged by analytical numbers. Samples No. 23–29 have already been studied and presented in Radivojević (2007)

Табла 1: Нова анализирана колекција материјала са Беловода, уређена према аналитичким бројевима. Узорци 23–29 су претходно анализирани и презентовани у Радивојевић (2007)

No.	Analytical No.	Excavation year	Field label	Field context	Results: type of material
1	Belovode 3	2007	Trench 13, spit 14	Household	Copper mineral
2	Belovode 9	1995	Trench 3, spit 12	Household	Malachite bead
3	Belovode 10	2001	Trench 8, spit 22	Household	Malachite bead
4	Belovode 12	2007	Trench 13, spit 10	Household- workshop?	Malachite bead
5	Belovode 13	2003	Trench 10, spit 27	Household	Malachite bead
6	Belovode 18	2007	Trench 13, spit 10	Household	Copper mineral
7	Belovode 23	2001	Trench 8, spit 23	Household	Malachite bead
8	Belovode 30a, 30c	1995	Trench 3, spit 5	(Building) waste pit	Slagged ceramic sherd
9	Belovode 31a, 31b	1995	Trench 3, spit 6	(Building) waste pit	Slagged ceramic sherd
10	Belovode 33b	2008	Trench 14, spit 15, surface 4	Household	Copper mineral
11	Belovode 34a (1,2,3)	2008	Trench 14, spit 3	Household	Copper minerals from an amphora
12	Belovode 40	2002	Trench 9, spit 18	Household-pits	Lead-based slag cake
13	Belovode 131	1995	Trench 3, spit 6	(Building) waste pit	Copper slag
14	Belovode 134	1995	Trench 3, spit 7	(Building) waste pit	Copper slag
15	Belovode 136	1995	Trench 3, spit 5	(Building) waste pit	Copper slag
16	Belovode 154	1999	Trench 7, spit 6	Household-workshop?	Malachite bead
17	Belovode M3	1995	Trench 3, spit 8	(Building) waste pit	Copper mineral
18	Belovode M6	1995	Trench 3, spit 10	(Building) waste pit	Copper metal droplet
19	Belovode M10	1995	Trench 3, spit 19	Household	Copper mineral
20	Belovode M14	2002	Trench 9, spit 11	Household	Copper metal droplet
21	Belovode M32	1995	Trench 3, spit not known	Household	Malachite bead
22	Belovode M35	1995	Trench 3, spit 17	Household	Copper mineral
23	Belovode M12	1998	Trench 6, spit 10	Household	Copper mineral
24	Belovode M13	2000	Trench 7, spit 18	Household	Copper mineral
25	Belovode M17	2004	Trench 10, spit 8	Household	Copper mineral
26	Belovode M20	1995	Trench 3, spit 2	(Building) waste pit	Copper slag
27	Belovode M21	1995	Trench 3, spit 4	(Building) waste pit	Copper slag
28	Belovode M22 (a,b)	1995	Trench 3, spit 5	(Building) waste pit	Copper slag
29	Belovode M23	1995	Trench 3, spit 7	(Building) waste pit	Copper slag



Fig. 6. a) Reconstructed ceramic “chimneys” from Belovode (after Šljivar et al. 2006, Plate II/3);
b) Tentative reconstruction of the smelting installation at Belovode (after Šljivar et al., 2006, Plate II/5)

Сл. б. а) Реконструисани керамички „димњак“ са Беловода (према: Šljivar et al. 2006, Tabla II/3);
б) Претпостављена реконструкција инсталације за шпољење са Беловода (према: Šljivar et al. 2006, Tabla II/5)

pyrometallurgical situation has been recovered in Trench No. 9; both will be presented in more detail below. These materials were usually discovered in areas filled with ash, charcoal, charred wood or stone constructions and mainly represent an outdoor activity.

Trench No. 3

Trench No. 3 (dimensions 8 x 2 m) yielded evidence for copper smelting activities throughout the final, D horizon of occupation of the site of Belovode, which coincides with the entire Gradac Phase sequence starting in c. 5000 BC.³⁹ This phase of the Vinča culture is known to have lasted longer in the Morava Valley settlements than in those situated nearer to the Danube,⁴⁰ and, at this site, most likely covers the late Vinča culture sequence, dated to c. 5000–4650 BC.⁴¹

The Belovode D horizon, represented in this Trench by materials from a waste pit,⁴² includes all finds coming from spits 1–11, and amongst others various archaeometallurgical debris. Thousands of ceramic finds were unearthed in this horizon alone, many of which are diagnostic of the Gradac Phase in general, like the conical bowls with a thickened rim channelled on the inte-

rior, or tri- and four-partite vessels with a cone-shaped neck and protruding shoulder, usually accompanied by typically incised ribbon decorative ornaments.⁴³

The slag pieces collected from this trench are vitrified, strongly magnetic and green-stained droplets, not exceeding 1 cm in length (example in Fig. 2b). They appear to have been highly viscous and very rich in copper metal, however with no signs of crushing in pursuit of copper metal prills. This may well have been due to their small size and weight, since all samples in total weigh less than 4 g. Given that, in appearance, these slag pieces resemble (green) malachite, as a result of the corrosion of the copper metal prills entrapped in them, it is possible that the green colour facilitated their recognition in the field excavations, leading to a

³⁹ Borić 2009, 206; Radivojević et al. 2010.

⁴⁰ Jovanović 1994.

⁴¹ Jacanović, Šljivar 1995.

⁴² Šljivar, Jacanović 1996a.

⁴³ Arsenijević, Živković 1998; see also Schier 1996; Schier 2000.



Сл. 7. Велики комад згуре са Беловода, датиран у последње векове 6. миленијума пре н. е. (фото: М. Радивојевић)
 Fig. 7. Large slag cake from Belovode, dated to the last centuries of the 6th millennium BC (photo by M. Radivojević)

biased recovery in favour of more copper-rich pieces and overlooking those without green staining.⁴⁴

The green staining on fragmented slagged sherds comes from the contact of these samples with the metallurgical process. The slagged mass is followed by heavily vitrified areas, which appear along the edges of the studied samples (Fig. 2a), but also extend across their cross-sections. The latter implies that these sherds were most likely used fragmented during the metallurgical process. All metallurgy-related materials were discovered sealed with building waste, such as the remains of house daub, domestic pottery and animal bones. Notably, in spit 10, which belongs to this building horizon, two shallow rock-lined constructions, indicated as fireplaces, were identified as potentially linked with metallurgical debris in excavation records. The stratigraphic evidence related to the earliest slag piece is dated to c. 5000 BC; the smelting evidence, according to the excavation reports, continued until the abandonment of the site, in c. 4650 BC.

Trench No. 9

Pyrometallurgical activities are recorded in Trench No. 9 as well (dimensions 5x5 m).⁴⁵ In this trench, spits 21–7 yielded typical Vinča culture material that corresponds with all four building horizons in Belovode (A–D). Archaeological materials found in spits 6–1 belonged, most probably, to the latest manifestation of the Vinča D phase.⁴⁶

The use of copper minerals occurred regularly throughout building horizons Belovode A–C, excluding Belovode D and the successive, not yet well-defined, horizon. Of particular interest here is spit 11, which yielded a copper metal droplet. The copper metal droplet (M14) was discovered in the context of the regular appearance of ceramic pedestal bowls, typical of the Vinča A to Gradac Phase. Chronologically, and in relative stratigraphic terms, it can be seen as correlated with the early Gradac Phase and, effectively, with the start of metallurgical activities in Trench No. 3, dated to c. 5000 BC.⁴⁷ Interestingly, early Belovode horizons in this trench yielded Vinča culture figurines with modelled appliques: necklaces with perforated disc-pendants,⁴⁸ resembling gold applications from the late 5th millennium BC burials and settlements in Bulgaria and Ukraine. Similar examples have been discovered at the site of Vinča–Belo Brdo as well.⁴⁹

An unusually large round slag cake was unearthed in spit 18 (Belovode 40, Fig. 7), and argued as being

⁴⁴ Radivojević et al. 2010, 2779.

⁴⁵ Jacanović, Šljivar 2003.

⁴⁶ cf. Jovanović 1994.

⁴⁷ cf. Radivojević et al. 2010.

⁴⁸ Šljivar et al. 2012, 31, Pl. III/1–4.

⁴⁹ Tasić 2008, 151, Fig. 58.

firmly contextualised within the Vinča B1 phase.⁵⁰ Preliminary analyses conducted by the primary author of this paper revealed that this artefact has significant concentrations of lead, which may suggest the production of this metal. However, future analysis is expected to shed more light on this unusual archaeometallurgical evidence. In terms of absolute dating, a metal droplet (M14) could be dated to c. 5000 BC, while the slag cake (Belovode 40) may be ascribed the date of c. 5200 BC, since it is argued to come from an undisturbed context of spit 18.⁵¹

COPPER MINERAL AND COPPER METAL ARTEFACTS

Malachite beads occur throughout all horizons in Belovode and vary in size, from 4 mm to 1.5 cm in diameter, with the exception in size and form (deltoid pendant with perforation) being the one found in Trench No.1, Vinča A1 horizon.⁵² Beads selected for this study were recovered as related to various copper minerals, slag pieces, workshop activities or dwelling structures (here Belovode 9, 10, 12, 13, 23, 154, M32). All beads are present as finished artefacts only, either as fragmented or whole pieces (see example in Fig. 1a). Some Belovode beads have undergone mineralogical study, which confirmed the presence of malachite, with traces of tenorite and kolwezite.⁵³

The only copper metal artefacts in Belovode were found in the vicinity of the site: a copper metal chisel and a bun-shaped metal ingot.⁵⁴ Their cultural provenance is only assumed to be of the Vinča culture due to the vicinity of the site. However, one needs to bear in mind the Late Chalcolithic occupation by the bearers of the Kostolac culture, also detected in Belovode.⁵⁵

Pločnik

The site of Pločnik (Fig. 8) is situated underneath the eponymous modern village, 19 km west of the town of Prokuplje in south Serbia and 300 km south of the capital, at c. 300 m asl. It is set on the left bank of the Toplica river, whose shifted bed is presently eroding the c. 3.60 m thick cultural layer of this site.⁵⁶ Pločnik is surrounded by good quality agricultural land and thermal springs, but also with good communication routes along the Toplica, the major river stream in this part of Serbia. It springs from Kopaonik, a mountain c. 50 km from the site, whose rich iron veins were exploited in Roman and medieval times.⁵⁷ More than 50

sites with archaeometallurgical installations have been identified around toponymic places like Suvo Rudište (in Serbian: Dry Mine) or Bakarnjača (in Serbian: Copper-rich), indicating intensive metallurgical activities in the past.

The archaeological settlement of Pločnik was first identified in 1926, when the first group of metal artefacts was discovered during the building of the Yugoslav railway. Excavation campaigns commenced in 1927, and then continued 1960–1978, under the jurisdiction of M. Grbić and B. Stalio respectively, both of the National Museum Belgrade.⁵⁸ Most recently, field excavation resumed in 1996 under the joint supervision of D. Šljivar (National Museum Belgrade) and J. Kuzmanović-Cvetković (Homeland Museum in Toplica, Prokuplje),⁵⁹ and are still ongoing.

Grbić's and Stalio's campaigns uncovered an area of c. 1800 m² which, when added to another c. 550 m² from an ongoing campaign, adds up to a total of c. 0.2 ha explored thus far. The estimated size of the Vinča village in Pločnik is c. 100 ha, which refers to the size of the top cultural horizon.⁶⁰ The unique and abundant ceramic finds in the site inspired Garašanin to name the late Vinča culture after Pločnik (I, IIa and IIb),⁶¹ which corresponds to Vinča C, D1 and D2.⁶²

Twenty massive copper implements, discovered by chance in two groups during the 1927 campaign, prompted Grbić⁶³ to title the first site publication: *Pločnik, eine Prähistorische Ansiedlung aus der Kupferzeit* (Pločnik,

⁵⁰ Šljivar et al. 2012, 33–34, Pl. VIII/1.

⁵¹ Borić 2009, 207–209; Šljivar et al. 2012, 33–34.

⁵² Šljivar et al. 2006, Pl. II/1.

⁵³ Jović 1996.

⁵⁴ Šljivar et al. 2006, 252, 269, Pl. I/1–2.

⁵⁵ Borić 2009, 208.

⁵⁶ Stalio 1960, 34; Stalio 1962, 21.

⁵⁷ Bogosavljević et al. 1988; Bogosavljević 1989; Bogosavljević-Petrović, Tomović 1993; Bogosavljević-Petrović 1995; Mrkobrad 1989; Mrkobrad et al. 1989.

⁵⁸ Grbić 1929; Stalio 1960; Stalio 1962; Stalio 1964; Stalio 1973.

⁵⁹ Šljivar 1996; Šljivar 1999; Šljivar 2006; Šljivar, Kuzmanović-Cvetković 1997; Šljivar, Kuzmanović-Cvetković 1998a; Šljivar, Kuzmanović-Cvetković 1998b; Šljivar et al. 2006; Kuzmanović-Cvetković 1998.

⁶⁰ Šljivar, Kuzmanović-Cvetković 1998b, 80.

⁶¹ Garašanin 1951, 12.

⁶² cf. Milojević 1949.

⁶³ Grbić 1929.

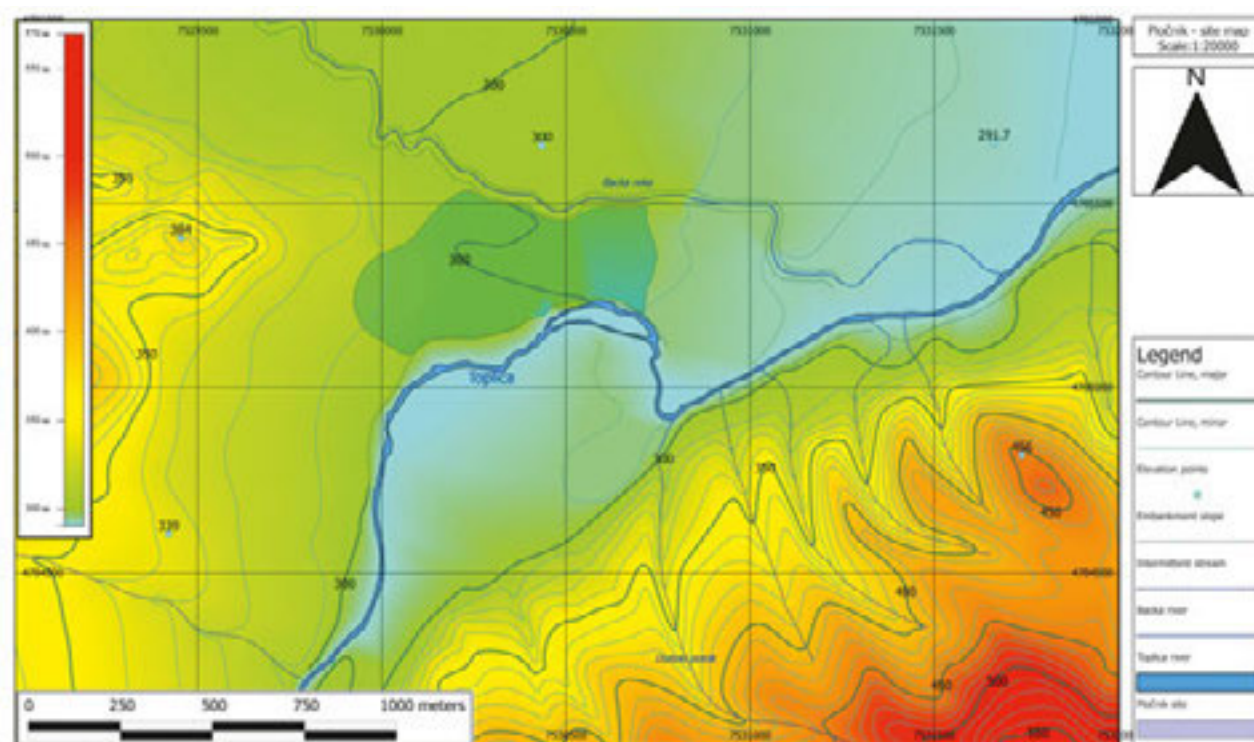


Fig. 8. Plan of the site of Pločnik (by J. Pendić)

Сл. 8. План локалитетна Плочник (припремио Ј. Пендић)

a prehistoric settlement of the Copper Age, in German). He assumed that Pločnik was an important metallurgical centre which existed at the dawn of the Copper Age and maintained rich exchange networks with other contemporary settlements in the region, such as Vinča–Belo Brdo, Gradac or Butmir.⁶⁴ Nevertheless, these copper implements, having been unique and isolated finds from a location remote from the Near East, did not appeal to Garašanin as being of genuinely Vinča culture origin.⁶⁵ He referred to them as intrusive *hoards* belonging to the Middle Eneolithic/Chalcolithic Bubanj–Hum culture which, in his opinion, succeeded the Vinča culture sequence at the site of Pločnik. Stalio, coming across two more groups of massive metal artefacts in Pločnik, also agreed that they belonged to the Bubanj–Hum culture.⁶⁶

In 1978, a single well-contextualised copper implement was discovered associated with the Gradac Phase feature (house?), but was published almost two decades later.⁶⁷ The resumed excavation campaign (from 1996) brought more evidence for dating metallurgical activities at Pločnik firmly within the Vinča culture sequence, which was uninterrupted at this site. A total

of three building horizons were identified, all of which belonged solely to the Vinča culture.⁶⁸ Horizon III (the Gradac Phase) yielded a well-contextualised copper chisel typologically resembling some of the previous chance metal finds from Pločnik.⁶⁹ This, and the chisel from year 1978⁷⁰ demonstrated the Vinča culture origins for metallurgical activities in Pločnik.

The site of Pločnik has recently received its first AMS dates.⁷¹ The probability distribution for the start of the Vinča culture occupation in Pločnik was 5290–5140 cal BC, with the highest probability around 5200 BC. As for the boundary end, the highest probability is at c. 4650 BC, suggesting the use of the settlement for c. 600

⁶⁴ Grbić 1929, 7, 18.

⁶⁵ Garašanin 1951; Garašanin 1973.

⁶⁶ Stalio 1960, 35; Stalio 1964, 39–40.

⁶⁷ Šljivar 1996; Šljivar, Kuzmanović-Cvetković 1997.

⁶⁸ Šljivar 1996, 94.

⁶⁹ Šljivar et al. 2006, 255, Pl. VIII/3.

⁷⁰ Šljivar 1996.

⁷¹ Borić 2009, 211–215.

years.⁷² Significantly, one of the AMS dates is closely related to the copper chisel (here Pločnik 216);⁷³ the preceding context is dated between 5040–4860 BC (95% probability) thus marking the *terminus ante quem* for this and other metal artefacts in Pločnik, along with the start of the Gradac Phase at this site. This is consistent with the beginning of the Gradac Phase at other sites as well (Belovode, Rudna Glava).⁷⁴

Three building horizons in Pločnik correspond with Vinča A, B1 and B2 respectively.⁷⁵ Horizons I and II (c. 2.5 m thick altogether) bore massive remains of dwelling structures (up to 6.5 m in length) and related postholes, including wide pits filled with ash, charcoal and bone fragments in the top layers, and ceramic fragments characteristic for Vinča A and B1 phases.⁷⁶ The Gradac Phase is represented with a c. 1 m thick cultural layer at the site of Pločnik which, at c. 0.4 m.⁷⁷ Here, dwelling structures are intersected with wide pits filled with charcoal and ash in several successive layers, some with bone and ceramic fragments in the upper layers (Figs. 9, 10).⁷⁸

The materials selected for this study originate from campaigns in 1998–2009, and come from 7 trenches in total (see Table 2). The most extensively sampled is Trench No. 20, which in the Gradac Phase occupation unveiled exceptional evidence for the Vinča culture metallurgy.⁷⁹

COPPER MINERAL USE

The use of copper minerals is evident from the early formation of this site: green lumps are found scattered across the settlement in the same manner as in Belovode, usually outside potential dwelling features in so-called *workshop* areas. These *workshops* usually consisted of stone structures and amorphous remains of floors for which insufficient evidence is present to ascribe them to either economic or dwelling structures. Šljivar and collaborators reported finds of lumps of copper minerals of varying sizes, with an altered structure which was porous and mixed with

Table 2: Newly studied collection of materials from the site of Pločnik

Табла 2: Нова анализирана колекција материјала са локалитета Плочник

No.	Analytical No.	Excavation year	Field label	Field context	Result: type of Material
1	Pločnik 43	2007	Trench 20, spit 10	Workshop	Malachite bead
2	Pločnik 51	2006	Trench 19, spit 23	Household	Copper mineral
3	Pločnik 52	2000	Trench 14, spit 10	Household	Copper metal droplet
4	Pločnik 54 (b, m)	2002	Trench 16, spit 19	Household	Copper mineral and a malachite bead (blank)
5	Pločnik 57	2006	Trench 19, spit 13	Household	Copper mineral
6	Pločnik 63	2008	Trench 21, spit 5	Dwelling structure	Tin bronze foil
7	Pločnik 65	2008	Trench 21, spit 6	Dwelling structure	Malachite bead
8	Pločnik 66	2004	Trench 18, spit 7	Stone structure	Malachite bead
9	Pločnik 67	2007	Trench 20, spit 7	Workshop	Copper metal artefact
10	Pločnik 69	2007	Trench 20, spit 4	Workshop	Copper metal droplet
11	Pločnik 71	2007	Trench 20, spit 7	Workshop	Copper mineral
12	Pločnik 72 (b, m)	2007	Trench 20, spit 3	Workshop	Copper mineral and malachite bead
13	Pločnik 73	2007	Trench 20, spit 7	Workshop	Copper metal artefact
14	Pločnik 75	2007	Trench 20, spit 7	Workshop	Copper metal artefact
15	Pločnik 143	2004	Trench 18, spit 7	Stone structure	Copper metal artefact
16	Pločnik 145	2007	Trench 20, spit 7	Workshop	Copper metal artefact
17	Pločnik 207	2009	Trench 22, spit 17	Household	Malachite bead
18	Pločnik 209	2009	Trench 22, spit 15	Household	Copper mineral
19	Pločnik 216	2000	Trench 14, spit 7	Stone structure	Copper metal chisel

charcoal, hence assuming its association with metallurgical activities.⁸⁰

Six copper minerals in total have been selected for this study (Pločnik 51, 54 m, 57, 71, 72, 209, see Table 2), two of which come from Trench No. 20 (71 and 72), which covers the entire Gradac Phase section. Other copper mineral finds were sampled in order to provide information on their use in earlier phases of Pločnik occupation. All minerals (barring 72) are black and green Mn- rich copper minerals.

METALLURGICAL ACTIVITIES

Stalio⁸¹ discusses the appearance of “bronze” and various metallurgical debris from the latest building horizon as being related to the production of Pločnik metal. Regrettably, no such archaeometallurgical debris was found in the archives of the National Museum in Belgrade. Nevertheless, the most recently uncovered situation in Trench 20 yielded evidence of a potential metallurgical workshop in Pločnik, which is described in more detail below.

Trench No. 20

A structure whose contours were followed over a 6 x 6 m area appeared at a relative depth of 0.8 m, with a surface filled with rubble, stones, numerous pottery fragments and several metal artefacts and metal casting debris⁸² (Fig. 11). A rectangular fireplace (possibly a furnace), measuring 1.4 x 1.4 m dominated this structure, with massive walls preserved up to 0.5 m in height, visibly repaired several times (several clay layers), and traces of intense firing.⁸³

This, along with the discovery of a massive copper chisel (Pločnik 145), a fragment of a tool or ornament (Pločnik 67), a fragmented bracelet (?) (Pločnik 73), a folded metal sheet (Pločnik 75) and copper minerals (Pločnik 71 and 72) (Table 2), led excavators to assume that the structure represented a metallurgical workshop (see Fig. 12).⁸⁴

Other finds in this structure included stone tools and large ceramic vessels, such as amphorae, jugs and similar liquid containers. Particularly interesting were ceramic “tubes”, which did not contain indications of use in metallurgical processes, but resembled the shape of the “chimneys” from Belovode (Figs. 6, 13). The potential furnace remains, although impressive, did not offer sufficient data to assume its metallurgical function; however, the conjunction with fragmented

metal objects in the same structure could indirectly imply its use for casting or melting, for example.

COPPER MINERAL AND METAL ARTEFACTS

The most significant discoveries in Pločnik were four groups of exceptionally massive copper metal implements, 34 in total.⁸⁵ To this, four more implements are added, all well-contextualised within the Gradac Phase occupation of this settlement.⁸⁶ The term *hoard* was introduced by Grbić⁸⁷; however, to avoid confusion they will be referred to here as *groups*.⁸⁸

Group I was a donation of the Directorate of Yugoslav Railways in 1926, discovered during the building works for the railway station in Pločnik, at a depth of c. 0.8–1 m.⁸⁹ He also noticed that the find originated from the close proximity of an oven; however, he did not elaborate further on this. The find consisted of nine objects, seven of which were made of copper metal: two hammer axes (Pločnik type), two chisels, two complete and one fragmented bracelet and two stone axes made of magnesite (Fig. 14).

Group II consisted of 18 objects, 13 of which were copper metal tools: one hammer-axe (Pločnik type), 12 chisels and five stone axes made of magnesite (Fig. 14). Grbić⁹⁰ reported that they were found in the vicinity of a destroyed furnace, scattered over an area 5 m wide, at a depth of c. 1 m.⁹¹

⁷² Borić 2009, 212.

⁷³ Šljivar et al. 2006, 255, Pl. VIII/3.

⁷⁴ Borić 2009, 214.

⁷⁵ Šljivar 1996.

⁷⁶ Šljivar, Kuzmanović-Cvetković 1997, 106.

⁷⁷ Šljivar, Kuzmanović-Cvetković 1997, 104.

⁷⁸ Šljivar, Kuzmanović-Cvetković 1998a, 5–6.

⁷⁹ Šljivar, Kuzmanović-Cvetković 2009.

⁸⁰ Šljivar et al. 2006, 256 ff.

⁸¹ Stalio 1960, 34.

⁸² Šljivar, Kuzmanović-Cvetković 2009, 59.

⁸³ See figures in: Šljivar, Kuzmanović-Cvetković 2009, 58.

⁸⁴ Šljivar, Kuzmanović-Cvetković 2009, 61.

⁸⁵ Grbić 1929; Stalio 1964; Šljivar 1999; Šljivar et al. 2006.

⁸⁶ Šljivar 1996.

⁸⁷ Grbić 1929.

⁸⁸ Radivojević 2006.

⁸⁹ Grbić 1929.

⁹⁰ Grbić 1929, 8–9.

⁹¹ Šljivar et al. 2006, 255.



Fig. 9. The profile of the site of Pločnik facing the river (November 2012).
Note the massive cultural layer bearing remains of pits (photo by J. Pendić)

Сл. 9. Профил локалитета Плочник према реци (новембар 2012).
Приметити масивни културни слој са остацима јама (фото: Ј. Пендић)

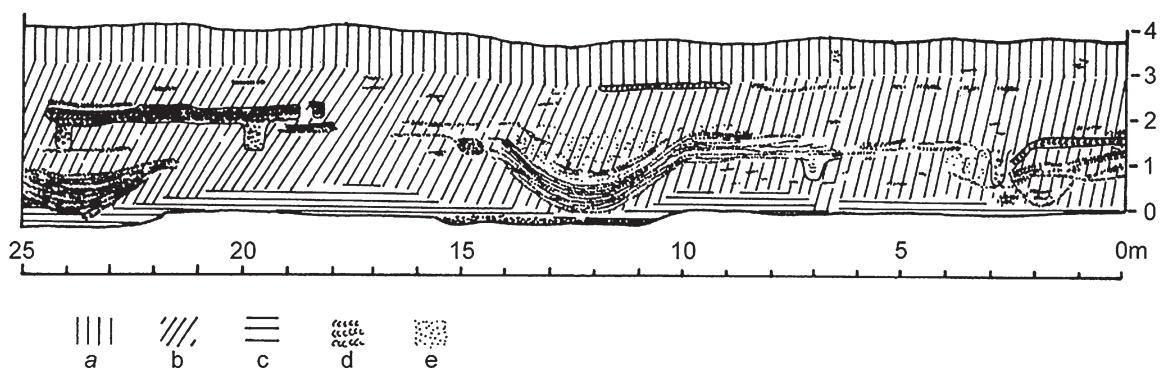


Fig. 10. Southeast profile of Pločnik: a) dark brown soil; b) light brown soil;
c) sterile soil; d) daub; e) ash (after Šljivar, Kuzmanović-Cvetković 1998a, 4)

Сл. 10. Југоисточни профил Плочника: а) тамнобраон земља; б) светлобраон земља;
с) здравица; д) леј; е) ђепо (према: Šljivar, Kuzmanović-Cvetković 1998a, 4)

Similar conditions were recorded for *Group III*, where copper and stone tools were uncovered, scattered in an area 5 x 0.5 m, at a depth of 0.7 m.⁹² The find consisted of 11 objects, 9 of which were made of copper

metal: one hammer-axe (Pločnik type), five chisels, a bracelet, a pin with a forked end, a copper ingot bar and two stone axes made of magnesite (Fig. 14). The resumed excavation in 1996 took place in the area of the



Fig. 11. Dwelling structure in Trench No. 20, Pločnik (excavations in 2007)

Сл. 11. Насеобинска структура у сонди 20, Плочник (истраживања из 2007. године)



Fig. 12. A copper chisel (Pločnik 145) in Trench No. 20 in situ (photo by J. Kuzmanović-Cvetković)

Fig. 13. A ceramic "tube" (far left) from Trench 20 (photo by J. Kuzmanović-Cvetković)

Сл. 12. Бакарно длећо (Плочник 145) из сонде 20 in situ (фото: Ј. Кузмановић-Цвејковић)

Сл. 13. Керамичка „туба“ (лево) из сонде 20 (фото: Ј. Кузмановић-Цвејковић)

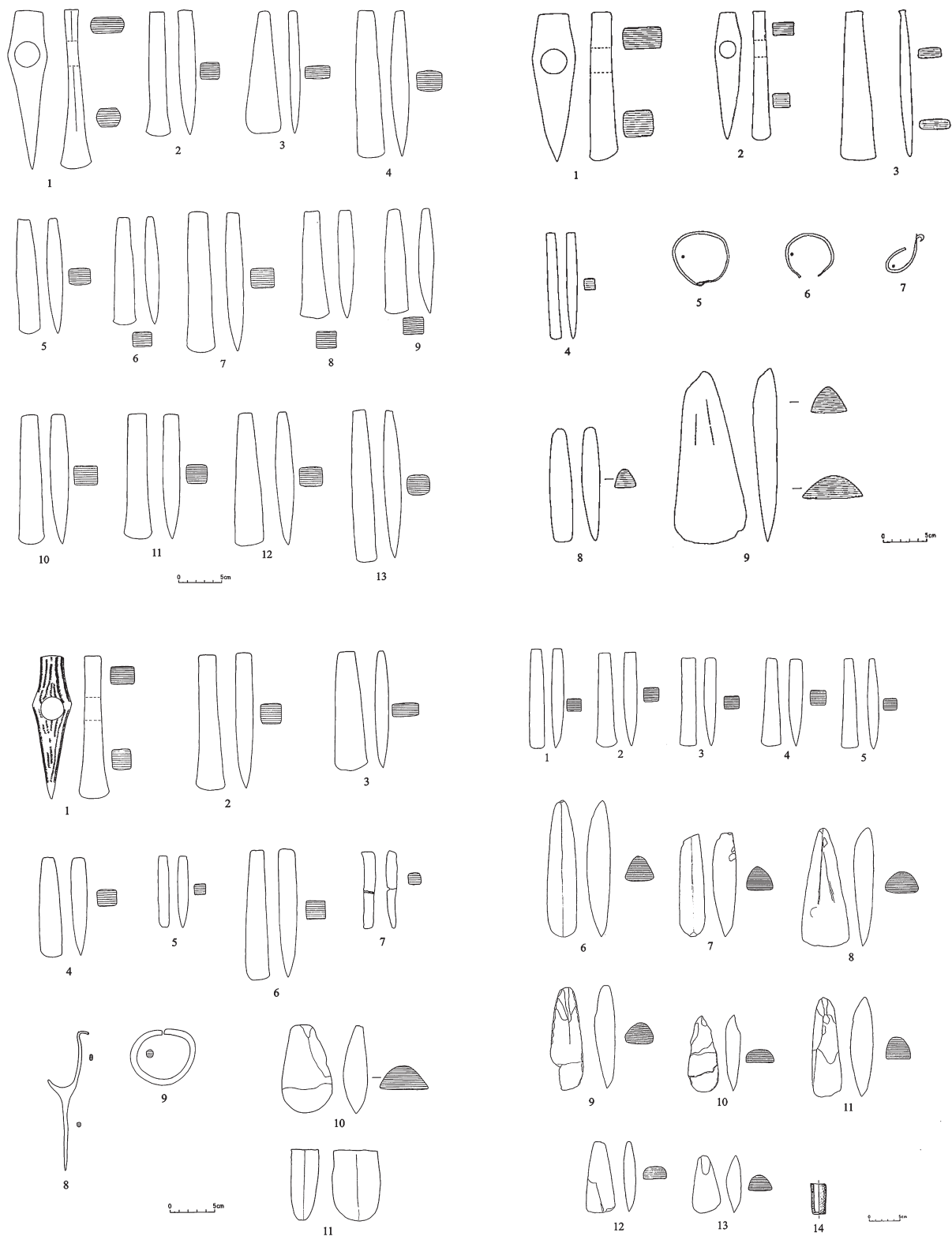


Fig. 14. Four Pločnik groups (clockwise): Group I (complete), Group II (only 13 metal implements), Group IV (complete) and Group III (complete) (after Šljivar et al. 2006, 261–265)

Сл. 14. Четири групе налаза са Плочника (у смеру казаљке на саату): Група I (цела), Група II (само 13 металних алатки), Група IV (цела) и Група III (цела) (према: Šljivar et al. 2006, 261–265)

Group III discovery and unearthed dozens of ceramic materials belonging to the early Gradac Phase, a small rectangular stone structure and one stone axe made of magnesite, identical to the one accompanying metal objects in Group III.⁹³ The owner of the excavated land on this occasion donated a copper chisel to the National Museum in Belgrade which he found, during the building of his family house, in the vicinity of the Group III location.

Group IV was found in 1968 during the building of the Nis–Pristina railway, at a depth of c. 0.3 m. It includes 14 objects, 5 of which are copper chisels, eight stone axes made of magnesite and one miniature pottery vessel (a casting pot?) (Fig. 14).⁹⁴ The casting (?) pot, however, did not show assumed traces of metalworking upon inspection by the primary author at the National Museum in Belgrade.

Four Pločnik groups of metal finds in total amount to: 4 Pločnik type hammer-axes, 25 chisels, four bracelets, a copper ingot bar and a pin, all together weighing c. 16 kg.⁹⁵ As such, they are a unique and exceptional find of copper artefacts and, according to the most recent AMS dating, one of the earliest in this part of Eurasia.⁹⁶ Seventeen copper metal tools from Pločnik were studied earlier for their chemical composition and lead isotopes, which revealed an unexpected complexity of ore/metal exchange networks: at least three different copper deposits from east Serbia, Macedonia and across Bulgaria provided metal for their production.⁹⁷ Significantly, all finds originated from a single area in Pločnik, which excavators also call the “industrial” zone due to the thick ash-and-charcoal deposit frequently encountered in Horizon III. An excellently preserved figurine head from the “industry zone” was discovered with half of the face painted lengthwise with a light grey slip (Fig. 15). The excavators believe that the colour effect on its face symbolised the light (surface) and dark (underground) environments of early miners’ lives in Pločnik.⁹⁸

For this study two out of the four most recently discovered and well-contextualised copper artefacts were sampled, labelled as Pločnik 143 and 145 (see Table 2). Pločnik 143 was discovered within a stone structure, together with a stone axe made of magnesite and a small pottery vessel, all of which again correspond with the beginning of the Gradac Phase in Pločnik.⁹⁹ A massive copper chisel (Pločnik 145) was unearthed in a similar workshop setting in Trench 20 (Fig. 10), along with two fragmented pieces of a tool and a bracelet respectively (Pločnik 67, 73), a folded metal sheet (Pločnik 75), a copper mineral (Pločnik 71) and several stone

tools. All these were discovered scattered across the same surface, in spit 7 and in the vicinity of a potential rectangular furnace (see Figs. 9, 10).¹⁰⁰ Pločnik 216 is a small fragmented chisel discovered within a stone structure outside the potential dwelling feature, and chronologically falls close to the date obtained from the preceding context of a collapsed burnt structure in spits 10–11 at c. 5040–4840 BC.¹⁰¹ These metal artefacts were made of pure copper, with only traces of other impurities.¹⁰²

Malachite beads of different sizes and shapes were recovered throughout all horizons of occupation in Pločnik, six of which have been selected for this study (Table 2, Fig. 16). A bead roughout (72) and a whole bead (43) were discovered in Trench 20, and together with two other whole beads (65, 66) can be dated within the Gradac Phase occupation in Pločnik. Bead blank (54) and two whole beads (43, 207) can also be dated to the Gradac Phase occupation at this site.

A tin bronze foil (Pločnik 63) was excavated from an undisturbed context, on the floor of a dwelling structure next to the copper metal workshop at the site, about 1 m from a fireplace and was enclosed in several late Vinča culture pottery vessels.¹⁰³ Compositional analysis demonstrated that this metal foil was made of a complex alloy of copper and tin, along with significant concentrations of elements like As, Sb, Co, Ni, Pb and Fe. This securely contextualised find comes from a single and undisturbed occupation horizon at the site of Pločnik, dated to c. 4650 BC. This date is, according to the field evidence, *terminus ante quem* for the Pločnik foil. The tin bronze foil from the site of Pločnik is, therefore, the earliest known tin bronze artefact anywhere in the world.¹⁰⁴

⁹² Stalio 1964, 35.

⁹³ Šljivar, Kuzmanović-Cvetković 1998b, 82.

⁹⁴ Stalio 1964.

⁹⁵ Šljivar et al. 2006, 255.

⁹⁶ Borić 2009, 214.

⁹⁷ Pernicka et al. 1997, 93–94, T. 3.

⁹⁸ Šljivar, Kuzmanović-Cvetković 1998a; Šljivar, Kuzmanović-Cvetković 1998b.

⁹⁹ Šljivar et al. 2006, 255–256.

¹⁰⁰ Šljivar, Kuzmanović-Cvetković 2009, 58–59.

¹⁰¹ Borić 2009, 213–214, Fig. 24.

¹⁰² Radivojević 2012.

¹⁰³ Radivojević et al. 2013, 1033, Fig. 2.

¹⁰⁴ Radivojević et al. 2013, 1032.

CONCLUSIONS

The overview of activities related to copper mineral use and extractive metallurgy at the Vinča culture sites of Belovode and Pločnik suggests that metal smiths at these settlements were covering different stages of metallurgical *chaîne opératoire*. Both sites, however, exhibit overlapping activities, such as the collection and potential beneficiation of distinctively coloured copper (black and green Mn-rich) minerals as well as pure green ones. This differentiation shows that Vinča culture metal smiths understood the material properties of these two types of copper minerals, and very likely used them for different purposes. The pure green mineral (malachite) seems to have been used for malachite bead making, as seen in Fig. 1a, while Mn-rich copper ores at these sites were used for copper smelting, as already suggested by Radivojević and collaborators.¹⁰⁵

Although these distinctively coloured minerals occur at both settlements, evidence for copper smelting has only been recovered from Belovode. Besides the five copper slag samples published in Radivojević et al.,¹⁰⁶ more slag pieces and slagged sherds from the same trench (No. 3) have advanced our understanding of the early smelting process. The slagged sherds were probably used fragmented, given that the slagged mass spilled over the cross sections (Fig. 2b). These were very likely used to line a hole in the ground, where the metal could have been smelted. It is not yet clear if production evidence from Belovode represents an *in situ* workshop, or a pit where metal production waste was discarded; future publications on the settlement formation will reveal more information on the character of the context of these finds. However, it is important to emphasise that this context has not been disturbed and, as such, is firmly placed at the beginning of the 5th millennium BC.¹⁰⁷

The presence of the black and green (Mn-rich) minerals at the site of Pločnik may lead one to assume that these were also prepared for copper smelting at this site. The smelting evidence, however, has not yet been discovered, but the presence of macroscopically and compositionally analogous minerals to those smelted in Belovode indirectly suggests that evidence for copper production in Pločnik remains to be recovered in future investigations.

The presence of an *in situ* metallurgical workshop has only been archaeologically confirmed at the site of Pločnik (Trench 20).¹⁰⁸ Remains of a fragmented tool/ornament (67), a fragmented bracelet (73), and a folded



Fig. 15. A figurine head from Pločnik, divided lengthwise with one half painted dark and the other whitish, dimensions (in cm): height 20, face 10.7, face width 16.3 and neck width 11.6 (photo by J. Kuzmanović-Cvetković)

Сл. 15. Глава фигурина осликана по дужини, димензија (у см): висина 20, лице 17, ширина лица 16,3 и ширина вратца 11,6 (фото: Ј. Кузмановић-Цветковић)

metal sheet (75), together with a well preserved massive copper implement (145) in a single dwelling structure indeed implies that this object could have been occupied by a metal smith. This workshop was, nevertheless, not used for primary metal production but, according to the present evidence, only for the casting and/or repair of metal tools.

This copper workshop from Trench 20 was also used for malachite bead making, judging by the presence of a bead roughout (Pločnik 72, Fig. 16a). The bead blank

¹⁰⁵ Radivojević et al. 2010, 2784.

¹⁰⁶ Radivojević et al. 2010.

¹⁰⁷ Radivojević et al. 2010, 2779.

¹⁰⁸ Šljivar, Kuzmanović-Cvetković 2009.

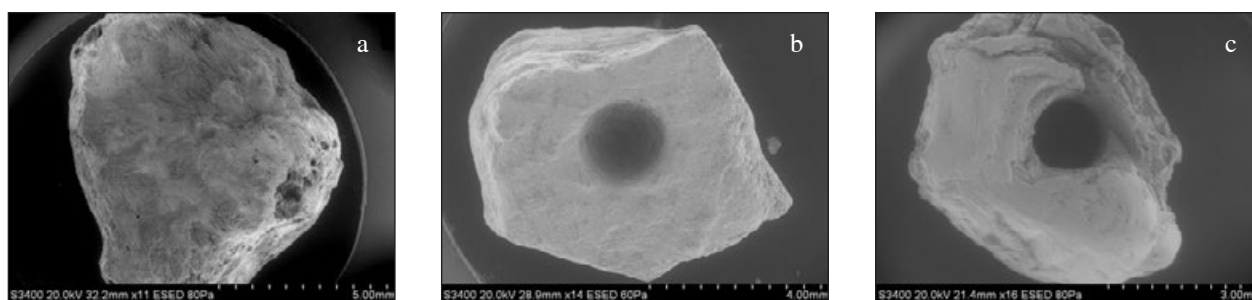


Fig. 16. All stages of malachite bead processing at the site of Pločnik:
a) Bead roughout (72); b) bead blank (54); c) whole bead (66)

Сл. 16. Све фазе процесуирања малахијних перлица на локалитету Плочник:
a) roughout – језгро (72); b) blank – недовршено (54); c) цела перлица (66)

(Pločnik 54, Fig. 16b) from another trench (No. 16) a few meters from the metal workshop in Trench 20, may suggest the presence of yet another bead making workshop. Significantly, the assumption on the presence of several workshop areas at the site of Pločnik does not exclude the possibility of their part-time use by Pločnik craftsmen. The concept of a specialised metallurgical workshop appears later in prehistory (e.g. Bronze Age), and earlier suggestions of specialised workshops need to be treated with caution until they are supported by a more detailed publication on site formation, which is currently beyond the scope of this paper.

The *chaîne opératoire* of copper mineral use and metallurgical activities at the sites of Belovode and Pločnik, despite the overlap in copper mineral selection, differs when it comes to production (which is identified in Belovode only) and consumption activities (detected in Pločnik only). Nonetheless, the suggestion of the potential existence of smelting activities in the site of Pločnik based on the presence of black and green minerals, as well as a few (insufficiently contextualised) metal artefacts from the catchment area of Belovode may prove this division on the production and consumption site as unsubstantiated in future investigations. Thus far, it appears that present materials from these two sites complement each other: the first step of the process, primary metal production, was conducted in Belovode, while the second, casting and finishing of metal artefacts, took place at the site of Pločnik. We still lack evidence of the (re)melting of primary produced copper, and a crucible that was most likely used during this particular process.

Evidence from the two different sites, however, can still help to reconstruct the Vinča culture metallurgy

chaîne opératoire. Although more nuanced discussions on this process remain to be published, this qualitative and macroscopic overview of the present evidence provides a good foundation for understanding the metal production process in the 5th millennium BC Vinča culture.

Despite the fact that both Belovode and Pločnik were carefully excavated, information on their formation processes is not always clear, as already pointed out above. Since the majority of field documentation remains unpublished, relevant contexts for this study are limited to relative spits within individual trenches. This has provided only restricted information on the spatial distribution of metallurgical debris and its relation to the spatially closest settlement features. Importantly, most of these features originated from arbitrary units, where the relationships are obscured and not always straightforward. Thus, this paper focused on the material properties of a variety of excavated artefacts, attempting to point to important connections among them from this particular perspective, rather than to rely on a plan of distribution of small-sized trenches scattered across both Belovode and Pločnik.

Another problem in relation to the sites of Belovode and Pločnik arises with the lack of AMS data on specific contexts related to diverse metallurgical activities. Borić¹⁰⁹ made a detailed study on the relation of metallurgical activities and the newly available AMS data. Nevertheless, these dates are not sufficient for the fine separation of copper mineral use and pyrometallurgical processes in the Vinča culture settlements, nor

¹⁰⁹ Borić 2009.

do they provide direct dating evidence for the majority of metallurgy-related finds. Therefore, the temporal analysis of metallurgical activities here has been mainly dependant on the relative chronology, based on specific pottery forms and the conventional periodisation of the Vinča culture across the entire region. Such an approach, although not without errors, currently provides the only feasible resolution for the context of the majority of metallurgy-related samples presented here.

The relation of the Gradac Phase to the rise of metallurgy is undoubtedly crucial for our understanding of this process in the Vinča culture: the earliest stratigraphic evidence for copper smelting is discovered at the beginning of this phase. It is also contemporary with the intensified activities in Rudna Glava, as well as the earliest dated copper implement from Pločnik. The changes in material culture that follow this phase are a phenomenon common for the Balkans in general,¹¹⁰ and require particular attention in interpreting the origins of metallurgy in this part of Eurasia in future discussions.

The introduction of metallurgy evidently influenced other aspects of material culture at the time. The most important association is, beyond doubt, pottery production, such as the appearance of black burnished ware, whose conjunction with the emergence of metallurgy has been discussed at length;¹¹¹ nevertheless, not yet sufficiently studied. A valuable observation comes from Belovode, where modelled applications on figurines resemble contemporaneous metal jewellery from sites situated along the lower Danube, and further towards the northern Black Sea coast.¹¹² This analogy highlights the importance of the Danubian communication route for the spread of metallurgy across the Balkans.

However, the main point of the contextual and qualitative survey of available artefacts in this overview is the diversity of metallurgical debris identified across the sites of Belovode and Pločnik. Various technological sequences, indicated by crushed minerals, fragments of installations, smelting slags, casting debris or final

products, cover nearly a complete *chaîne opératoire* of metallurgy. This production chain comes across as sufficiently elaborate in the earliest known stage of pyrometallurgical activity in this part of the world, implying that it had probably developed a few generations earlier from the moment we spotted it in archaeological records. Also, the cultural transmission of this once precious skill seems to take place across two relatively distant settlements, implying close economic and potentially social connections among their inhabitants. The craftsmen from Belovode and Pločnik were, based on current evidence, covering different ends of the same metal making process, which strengthens the likelihood of their potential collaboration. The lead isotope match of Belovode slag samples with the Pločnik copper chisel (216) strengthens this assumption;¹¹³ this will be explored in detail in future publications. Finally, the quantity and quality of collected and sampled materials is currently unprecedented in academic work, and provides an excellent case for studying the emergence, evolution and transmission of metallurgical skills within the Vinča culture, and across the Balkans.

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¹¹⁰ cf. Garašanin 1995.

¹¹¹ e.g. Renfrew 1969; Gimbutas 1976.

¹¹² See examples in: Dumitrescu 1961; Sergeev 1963.

¹¹³ Radivojević 2012.

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Резиме:

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МИНЕРАЛИ БАКРА И АРХЕОМЕТАЛУРШКИ МАТЕРИЈАЛИ СА ВИНЧАНСКИХ ЛОКАЛИТЕТА БЕЛОВОДЕ И ПЛОЧНИК: ПРЕГЛЕД МАТЕРИЈАЛА И НОВИ ПОДАЦИ

Кључне речи. – металургија, винчанска култура, Беловоде, Плочник, бакар, згура.

Беловоде и Плочник, локалитети винчанске културе који се налазе у источној и јужној Србији, већ деценијама привлаче пажњу широке академске јавности због открића јединствених налаза који потврђују постојање металуршке активности у овој култури. Ови налази датирају са почетка 5. миленијума пре н.е., што их чини тренутно најстаријим познатим доказима прераде метала у свету, који уједно и оживљавају теорију о независном настанку металургије на Балкану. Са новим подацима се наметнула потреба да се сачини преглед доступних информација о начину производње метала и о технолошким изборима винчанских ковача током тог процеса. Аутори су саставили квалитативан преглед ископаног материјала који је у вези са употребом бакарних минерала и са археометалуршким активностима на ова два локалитета. За ову прилику је направљен преглед материјала који је већ публикован, али и оног чије су анализе скоро завршене у склопу докторске тезе примарног аутора (укупно 48 анализираних узорака). Сав материјал је подељен у три главне категорије: *археолошки минерали, остаци (примарне) производње метала и израда и обрада јошвих металних артефаката*, који заједно чине ланац металуршке производње.

Резултати студије указују на присуство разноврсних налаза који се заједноклапају у један скоро комплетан металуршки ланац операција. Овај ланац почиње одабиром бакарних минерала и њиховом припремом (уситњавање) за процес топљења. Приметили смо да су винчански металурзи знали да разликују материјалне квалитете двеју врста бакарних минерала: једне којој припадају чисто зелени минерали,

који су се користили за прављење малахитних перлица, и друге, којој припадају црно-зелени, тј. богати манганом, и за који је претходна студија већ показала да су топљени како би се добио метал. Ова друга врста минерала је названа рудама, за разлику од прве, коју и даље називамо минералима, а разликујемо их по температурном третману. Обе врсте минерала нађене су на оба локалитета. Остаци производње метала су нађени само на Беловодама и то највише у једној сонди, бр. 3 која је изнедрила укупно 8 налаза бакарних згура и 4 налаза керамике са залепљеном згуром (такође од топљења бакра). За ове анализе је већ потврђено да припадају примарној продукцији метала. Исти закључак важи и за велики комад згуре из сонде бр. 9 на Беловодама, за који су анализе показале да има значајну концентрацију олова. Иако на локалитету Плочник нису пронађени остаци производње метала, присуство зелено-црних руда бакра богатих манганом, које су се на Беловодама топиле, указују на могућност да ће можда сличан доказ бити пронађен и на Плочнику у будућим истраживањима. Оно чега на Беловодама нема јесу готови производи од бакра, који су пронађени у значајном броју на локалитету Плочник. Радионица из сонде 20 садржала је узорке савијеног лима, фрагментованих алатки или накита, као и готове металне алатке, што указује да се у њој највероватније обрађивао метал. Овај метал је примарно произведен негде другде, пошто су изотопске анализе показале да се згуре са Беловода и бакарно длето са Плочника слажу по месту порекла руде бакра од које су направљени. Радионица у сонди 20 на Плочнику такође је изнедрила незавршене

комаде бакарних перли, што је дефинише као радионицу за „хладну“ обраду бакарних минерала, наспрам високотемпературног третмана који је примењиван за израду металних алатки. На локалитету Плочник је пронађен и лим начињен од природне бронзе, тј. топљењем комплексне руде бакра и калаја, а не легуром та два метала. Овај изванредан налаз је тренутно најстарији налаз овакве врсте на свету.

Ланац металуршких операција са локалитета Беловоде и Плочник се стога међусобно допуњавао – док се на Беловодама екстраховао метал, на Плочнику се он ковао и обрађивао. Иако овај ланац операција није комплетан, ова студија је демонстрирала да он постоји у развијеној форми, са технолошким изборима који одражавају одлично познавање хемијских и физичких карактеристика различитих минерала, контроле процеса топљења метала и техничких могућно-

сти обраде метала бакра. Ова врста технолошког приступа у изучавању процеса производње метала показала се као једина која у датом тренутку може да изведе закључке о овој активности на локалитетима Беловоде и Плочник. Теренска документација, која је само парцијално публикована и која се ослања на специфичне контексте у оквиру малих сонди, још не пружа задовољавајућу слику о просторном односу анализираног материјала, па је стога аналитички приступ једини који тренутно може међусобно да повеже бакарне минерале, руде, згуре и металне предмете у генералну слику развоја металургије на овим винчанским насељима.

Колекција налаза, иако мала по уобичајеним стандардима представља највреднију колекцију те врсте у свету, јер је по квалитету уникатна у хронолошким оквирима у којима се појавила.