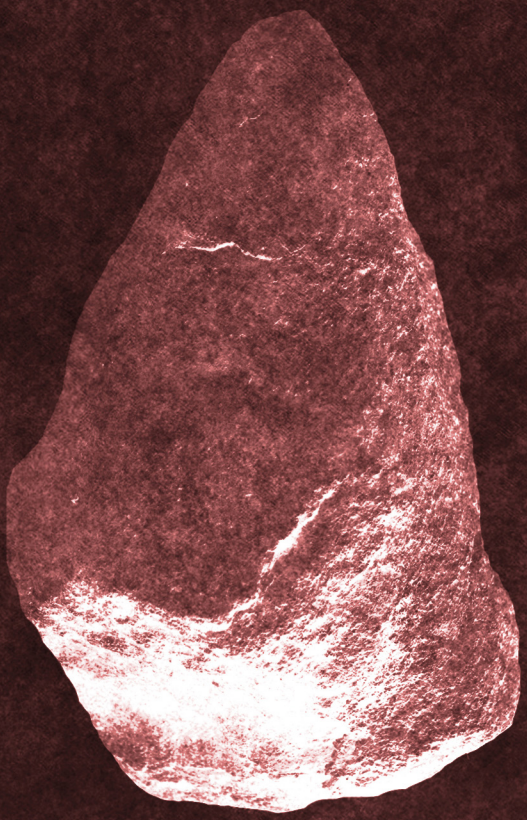
# ARCHAEOTECHNOLOGY STUDIES

*raw material exploitation from prehistory to the Middle Ages*



**Editors**

*Selena Vitezović*

*Dragana Antonović*

**ARCHAEOTECHNOLOGY STUDIES** *raw material exploitation from prehistory to the Middle Ages*

# STUDIJE ARHEOTEHNOLOGIJE:

## Eksploatacija sirovina od praistorije do srednjeg veka

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**Selena Vitezović**
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## Raw material exploitation from prehistory to the Middle Ages

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**SADRŽAJ**

## RAW MATERIAL MANAGING AND EXPLOITATION IN THE PAST

Archaeology studies material remains of the past, and the question of raw material from which they were made is often the very first, initial research question.

Raw materials include food and water for humans and animals, as well as materials for making tools, shelter, clothes, other daily objects such as vessels, storage containers, etc., and also for objects of art, ritual and cult. Their origin and method of acquiring are often interlinked and are connected into a complex network of mutual relation. For example, food remains, such as animal bones, skin, tendons, are used for artefact production, non-edible parts of plants may serve for other purposes, such as stems for roofs or for covering the floor, fresh running water is important for human and animal consumption but also for numerous production processes, gathering in the woodlands may encompass diverse resources, such as wood for basketry, plant and animal food, and so on. The system and the organization of acquiring and exploiting of different raw materials represent the most important part of every economy and economical system. The questions such as availability of some of the raw materials, the degree of their exploitation versus their availability, the mode of exploitation as well as the method of their extracting, connected with the technological choices, are particularly important for studying not only economic, but also other social aspects.

Analyses of raw material may provide information on the exploitation of the environment and human-environment relations; the relative distance of the sources from the settlement may point to the territory used or controlled by certain group, routes of trade and exchange, or, in a case of hunter-gatherers, routes of migration and/ or territory covered. Technology of extracting some raw materials, such as stones or ores, may indicate the level of technological knowledge

and the organization and the overall economic system within a community that explored them.

Furthermore, some materials can be considered as luxurious and prestigious among some human groups; this is often, but not exclusively related to the rarity of the given raw material or to the difficulties in its extracting and/or working. Some materials may be used for both daily and ritual objects, some not, thus revealing some aspects of the perception of the environment, both landscape and animal world.

The analysis of raw material acquiring and managing has a special place within the technological analysis. Technology (from Greek word τέχνη, meaning skill) is a conceptual approach to the material culture studies, that encompasses all the human actions upon a matter, from individual level (body gesture, embodied knowledge in crafting) to the social and cultural setting of production (cf. Inizan *et al*. 1999, also Miller 2007 and references therein). Technology or technological systems can be roughly described as processes and practices associated with production and consumption, from design to discard (Miller 2007: 5). The view of technology as a cultural-driven phenomenon implies that there is usually more than one technique that satisfies the minimum requirements for any given task. Therefore, the technological choices may be strongly influenced by beliefs, social structure and tradition within the given society – it is important to analyse why specific manufacturing techniques were employed and not another ones, why some objects are quickly discarded and other repaired several times, etc. (cf. Lemonnier 1992, 1993, see also Killick 2004).

As for raw materials, the question is why a specific material was chosen and not some other. Some raw material may be readily available or exist in the environment and yet remain unused. Raw material choices are influenced by factors that can be roughly described as external – namely, the availability (including available quantities and possibilities for extractions with available technology), physical and mechanical properties, and internal – social, cultural preferences, traditions, etc.

Careful choices of raw materials, and not random usage of first that come at hand, may be noted since very early stages of human past. Careful selection of particular raw materials, even targeted

search for adequate materials, their collecting, transporting, hoarding for later use, etc., can be traced back very deep into our past. Studies on lithic raw material demonstrated that already in the Middle Palaeolithic period tool provisioning and management strategies show clear organization and planning depth (Meignen et al. 2009).

The studies of raw material acquiring and managing are not important only for studies of economy; they can have great influence on other fields of research as well. As L. Meignen and co-authors noted, „Analyses of Middle Paleolithic technological behaviors – and by extension of Neandertal cognitive capacities and mobility organization – have been revolutionized by theoretical perspectives devised from lithic technological and raw material investigations" (Meignen *et al.* 2009: 15)

Today, studies of raw materials must also include diverse multi- and interdisciplinary approaches. Throughout the 20th century, most of the studies were focused on the discovery of the sources of a certain raw material, especially lithic and metal. Lithics are probably the most studied raw material (e. g., Antonović 1997, 2003, Biró 1998, Gatsov 2006, Gurova 2011, Šarić 2014, to mention just a few examples from Balkan archaeology), although they are far from being exhausted. In past few decades, however, may be noted both the improvements in methodology as well as an increased interest and increased variety in raw material studies. For example, we may quote the studies on amber (e.g., du Gardin 2002, Murillo-Barroso and Martinón-Torres 2012), or salt (Cavruc and Harding 2012, Saile 2012, Weller 2012).

Interest in osseous raw materials especially increased in past three decades or so, both in Europe and other continents (e. g., Guthrie 1983, Scheinsohn and Ferretti 1995, Margaris 2012, Allentuck 2013; see also Schibler and Choyke 2007, Choyke 2013). One of the classical studies on symbolic value of raw materials is the one on the osseous raw materials, by Robert McGhee (1977), on raw material choices within the Thule culture in arctic Canada. McGhee clearly demonstrated that the use of antler, ivory and bone for specific artefacts is by no means accidental, and is in fact strictly linked to the worldview. From the relations between the raw material and their products, McGhee reconstructed oppositions land/sea, summer/winter, man/woman, antler/ivory.

* * *

This volume is the result of several thematic session that took place at Annual meetings of the Serbian archaeological society, especially sessions *Exploitation of raw materials, exchange and trade in prehistory,* and *Technology of raw material exploitation from prehistory to the Middle Ages.*

The first paper by M. Mitrović presents a study on knapped raw materials from a new, interesting point of view – it discusses the aesthetic qualities of flint materials. The next two papers are focused on osseous raw materials; V. Krištofić analyses the osseous raw material choices in the Neolithic period, on the case study of the site of Jakovo-Kormadin, while S. Vitezović looked into the usage of osseous materials for ornaments in times when metals entered into wider use, on the case study of the Mokrin necropolis.

The next three papers are dealing with metals from different perspectives. R. Balaban discusses early copper artefacts and their symbolic value. D. Antonović and V. Dimić offered new results from very interesting, but at the same time challenging research on early mining activities and they present the results from the investigations of the site of Prljuša on the Rudnik mountain. Paper by T. Sekelj Ivančan and T. Marković is a leap forward in time, into the Middle Ages, and they are focused on the iron processing along the Drava river. Finally, the book is closed by analysis of clay raw materials in the Middle Ages using the area of medieval Ras as model for raw material procurement strategy and organization of pottery production, by V. Bikić and U. Vojvodić.

Editors would like to thank to everyone who helped in creating this book, authors and all participants at Annual meetings of the Serbian Archaeological Society, members of the editorial board and reviewers, as well as to the Serbian Archaeological Society, and, last but not least, to translators, Jelena Vitezović and Miloš Krnetić.

**Selena Vitezović**
**Dragana Antonović**

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# COPPER ORE EXPLOITATION AT THE SITE OF PRLJUŠA ON MALI ŠTURAC

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***Abstract**: Prljuša on Mali Šturac is the only evidence so far of prehistoric ore exploitation at Rudnik. Very hard rocks at this site, which contained mineralized malachite, affected the manner in which the ore was exploited. It is probable that the rock hardness was the reason why miners on this mining site exploited mineralization from the surface and from horizontal ore veins which were located near the surface of the soil. So far no vertical mining canals were discovered at Prljuša. Surface ore exploitation was discovered in the zone of Shaft 4 and 6, and underground exploitation in the Object 1. In all parts of the site the extremely large number of mining stone mallets was discovered. The manner of exploitation of ore and numerous stone mallets are the reason why the mine of Mali Šturac, regardless of the lack of certainty in the dating of pottery, can be determined to the very beginning of primitive metallurgy, i.e. the Early Eneolithic.*

***Keywords**: prehistoric mining, copper, raw materials, archaeometallurgy, Eneolithic, Serbia*

***Apstrakt**: Prljuša na Malom Šturcu je za sada jedini dokaz praistorijske eksploatacije rude na Rudniku. Veoma tvrde stene, u kojima se nalazila mineralizacija malahita, uticale su na način eksploatacije rude na ovom lokalitetu. Verovatno da je upravo tvrdoća stene bila razlog zašto su rudari na ovom rudniku eksploatisali rudu sa površine i iz horizontalnih rudnih žica koje su se nalazile plitko ispod površine terena. Do sada na Prljuši nisu otkriveni vertikalni rudni kanali. Površinska eksploatacija*

*rude je otkrivena u zoni Okna 4 i 6, a podzemna u Objektu 1. U svim delovima nalazišta pronađen je izuzetno veliki broj rudarskih kamenih batova. Način eksploatacije rude i brojni kameni batovi su razlog zašto se rudnik na Malom Šturcu, bez obzira na nedostatak sigurnog hronološkog opredeljenja keramičkih nalaza, može da opredeli u sam početak primitivne metalurgije, u doba ranog eneolita.*

***Ključne reči**: praistorijsko rudarstvo, bakar, sirovine, arheometalurgija, eneolit, Srbija*

## Introduction

The great wealth in ores of the mountain Rudnik has been exploited, incessantly, since prehistory up to today. Prljuša on Mali Šturac is the only evidence so far of prehistoric ore exploitation at Rudnik. The existence of mining activities during the Roman period, and especially in medieval Serbia, was confirmed not only by archaeological findings, but also by written historical sources. The mountain Rudnik was one of the main sources of argentiferous lead in medieval times. During the Ottoman occupation, mining was reduced to the minimum in this area, and its' renaissance occurred only after Serbia gained independence in the 19th century, continuing up to today (Јовановић 2007: 150–152, 255–261, 400–403, 427–431).

The area of Rudnik is characterized by a complex geological structure (Ђајић 2014: 43). It consists of sedimentary, igneous and contact metamorphic rocks. Sedimentary rocks from the Cretaceous period are most widely distributed, and the most common ones are principally sandstones. The creation of igneous rocks is linked to the beginning of volcanic activity in the area of Rudnik in the period before the Upper Cretaceous series, when dacite-andesites intruded, while most of the quartz latite volcanic rocks, in the form of irregular masses of large dimensions or thin dykes and sills, intruded in the ore deposit of "Rudnik" in Miocene. Aside from

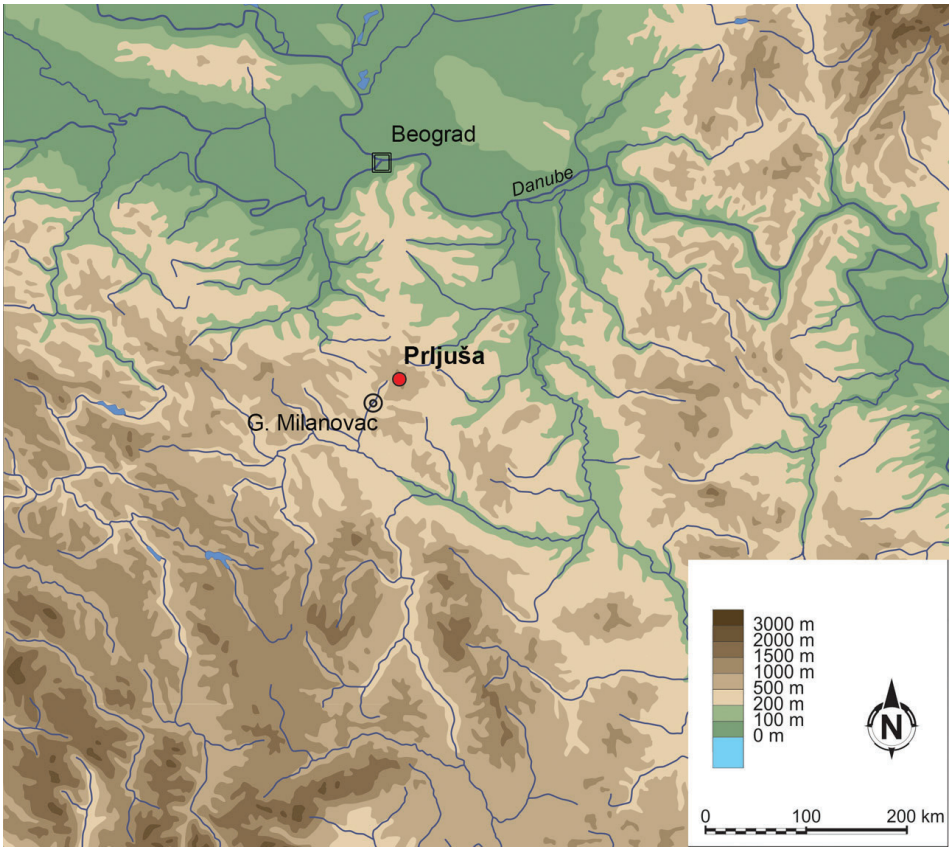


**Fig. 1.** Position of the site Prljuša at Mali Šturac (Rudnik mountain)
**Sl. 1.** Položaj nalazišta Prljuša na Malom Šturcu (planina Rudnik).

sedimentary and igneous rock, there are also contact metamorphic rocks present, namely, weakly metamorphosed marly-clay sediments, sandstones and conglomerates, and also products of higher degree of metamorphism – hornfels and skarns. On a larger area around the peak of Mali Šturac, explosive breccias were discovered, mostly composed of quartz latite, latite, metamorphosed sediments etc. The creation of these rocks is linked to diatreme, canal through which explosive volcanism occurred as the final phase of magmatic activity on Rudnik (Ђајић 2014: 59).

The barren and very steep surface, the size of 2,5 ha on the South-Western slope of Mali Šturac, the lowest peak of the

mountain Rudnik in Central Serbia (Fig. 1), was named Prljuša precisely because of that unusual barrenness in the midst of a forest surroundings. This Serbian word denotes a piece of land which was burnt down, without any vegetation, giving a clear illustration of the look of the site. The site is ellipsoid in shape, its' length along the Southwestern–Northeastern axis is 234 m, its' width along the Northeastern–Southwestern axis is 138 m and it spreads from 882 m at the bottom to 994,41 m above sea level at the top of the slope. It is a very steep slope with the average inclination from $28^0$ to $31^0$, and in the lower part it reaches an inclination of even $37^0$. In 1980 a prehistoric copper mine was discovered on this site, which has been, intermittently, researched up to today. From 1981 till 1989 the research was performed as part of the "Project for researching old mining and metallurgy on Rudnik" by the Institute of Archaeology from Belgrade in cooperation with the National museum of Čačak, Institute for the Protection of Cultural Monuments in Kraljevo and the National museum of Kraljevo, headed by Borislav Jovanović (Јовановић 1988: 11). The research was renewed in 2011 as part of a new project "Prospection of Mali Šturac: research of prehistoric mining" of the Institute of Archaeology, performed in cooperation with the Museum of Rudnik-Takovo region from Gornji Milanovac.[1]

It was precisely the aforementioned geological process, the forming of diatreme, that lead to the appearance of ore on the surface of the ground at the site of Prljuša. Shafts discovered so far showed that ore spread mostly across the surface, but also that it could be found in veins, many of which were spreading below the surface of the soil, on small depth. This type of ore deposits in this area affected the manner of exploiting copper carbonate ore, mostly malachite, in prehistoric times.

[1] The project is headed by Dragana Antonović, in collaboration with Selena Vitezović from the Institute of Archaeology in Belgrade, Ana Cicović from the Museum of Rudnik-Takovo region from Gornji Milanovac, Momir Vukadinović, geophysicist from Belgrade, and Vidan Dimić, PhD student at the Faculty of Philosophy in Belgrade.

**Fig. 2.** Shafts 1 and 2 discovered in 1981.
**Sl. 2.** Okna 1 i 2 otkrivena 1981. godine.

## Researched shafts

From 1981 up to today numerous finds of prehistoric mining activities were discovered on the entire slope of Prljuša. Firstly, in the central part of the site (940 m above sea level), in the first year of research three shafts were identified, marked as Shafts 1 and 2 (Јовановић 1988: 6). Those were, in fact, traces of surface exploitation of ore, which can be seen in all parts of this mine.

Shaft 1 and Shaft 2 are small recesses in the rock, with diameters up to 3 m, from which copper ore was extracted (malachite). Traces of surface exploitation are visible on the surface of the rock around and inside those recesses (Fig. 2). The research of those shafts was not pursued, so we do not know if the spreading of the ore continued further into depth and whether an underground mining

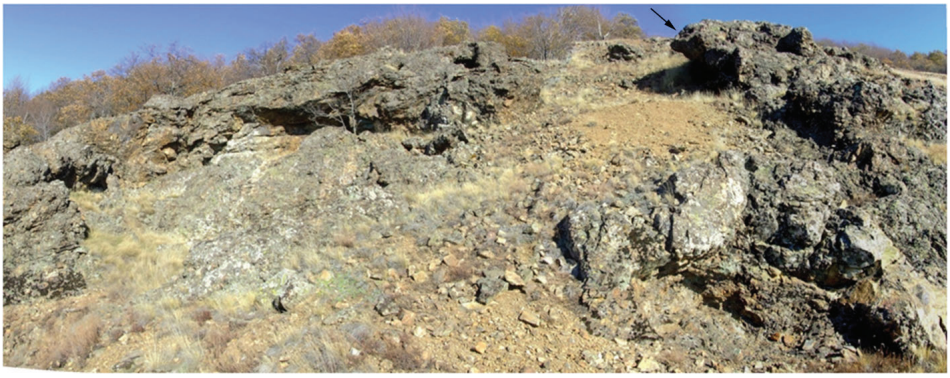

**Fig. 3.** Objects 10–15 discovered during prospection in 2011, with Shaft 3 discovered in 1987.
**Sl. 3.** Objekti 10–15 otkriveni tokom rekognosciranja 2011. godine, sa Oknom 3 otkrivenim 1987.

canal remains under the surface pit, filled with debris today, thus remaining hidden from archaeologists.

Shafts 3, 4, 5 and 6 were discovered in 1987, also in the central part of the site. From the line connecting shafts 4–6 begins a vast scree layer in the lower part of the site, with thickness from 2,5 to 6 metres,[2] which conceals the entrances into mining shafts, probably identical to those which are still located on the surface in the upper part of the slope of Prljuša.

Shaft 3 is located above Shafts 1 and 2 (943 m above sea level) and it is somewhat larger than the previous two. Considering the fact that the site of Prljuša is specific precisely due to its' stony structure, upon which it is very difficult to identify archaeological traces, previous researchers of this site did not perceive that Shaft 3 was, in fact, a part of a considerately larger complex of shafts, detected in 2011, and marked in the field documentation as Objects 10, 11, 12, 13, 14 and 15 (Fig. 3). Shafts 1 and 2 also belong to this complex, and they are located on its' lower edge. In the vicinity of Shafts 1–3 stone mallets with grooves were found (Богосављевић

[2] In 2016 a geophysical research was performed in the lower part of the site, with which the thickness of scree was determined on 31 position and on those places on which, during the geophysical research of 2012, the existence of ore deposits or old mining work was identified. Publication dealing with results of the said researches is being prepared.

**Fig. 4.** Shaft 5, discovered and excavated in 1987.
**Sl. 4.** Okno 5, otkriveno i istraživano 1987. godine

1988: 14), which allow us to date them into the early prehistoric mining.

Shaft 5 was researched the most, though not completely, in excavation seasons 1987–1989. It is at this shaft that two mining canals spread from the approach platform, one towards the East and the other towards the West (Fig. 4). The Western one is very short, ca 2 metres, and the Eastern one, longer and wider, plunges into depth and it was not researched. The excavations did not discover any traces of ore exploitation, hence, we do not know whether it was underground or surface, as with Shafts 4 and 6.

Shaft 4 and Shaft 6 were discovered in 1987, and researched in 1988–1989, and afterwards again in 2013–2014, when the manner in which ore was extracted in this part of the mine was completely defined.

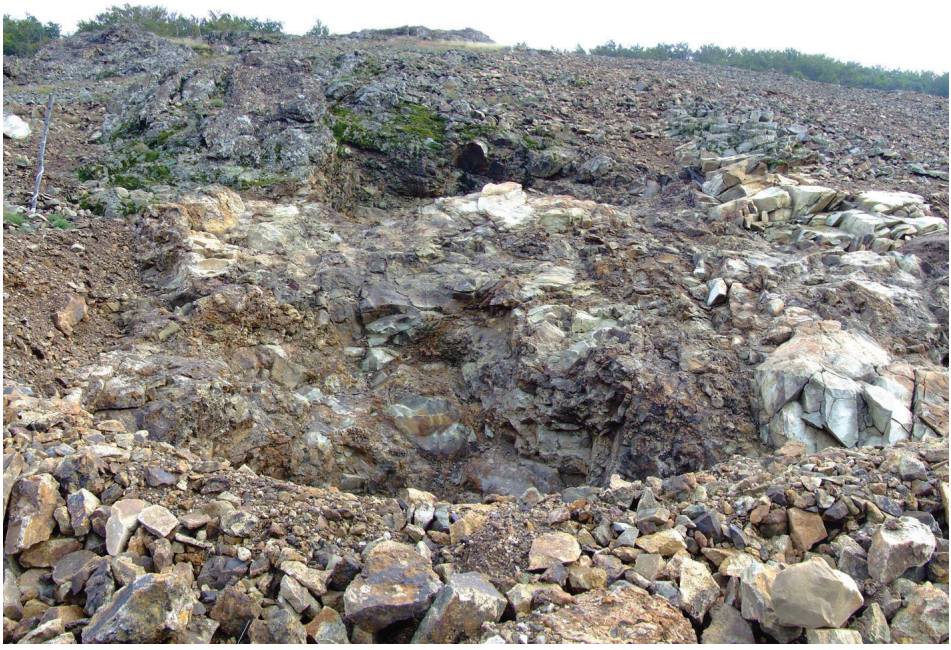

**Fig. 5. S**haft 4 with surface ore exploitation, excavated in 2013.
**Sl. 5.** Okno 4 sa površinskom eksploatacijom rude, iskopavano 2013. godine.

After the geophysical research conducted in 2011, it was established that in the zone of Shaft 4, at the depth of ca 3 m below the soil surface, there was a spacious ore body or a mining gallery (Antonović & Vukadinović 2012). The link between this body or underground gallery and the surface of the soil is a thin vein of ore, which reached the surface and from which the ore spread down the slope. In 2013 a part of this zone was researched and traces of surface exploitation of ore were discovered on an area the size of 90 $m^2$ (Antonović *et al.* 2014)(Fig. 5).

Shaft 6 was discovered in 1987 and it was researched on smaller scale up to 1989. It was then that an approach platform was identified, with an opening for a narrow mining canal in its' Eastern part. In lower layers of the platform several smaller atypical pottery fragments were found, dated loosely into the Late Eneolithic and Early Bronze Age (Јовановић 1988: 8; Богосављевић 1988: 21, 31). The

**Fig. 6.** Shaft 6: inner gallery and surface ore exploitation in front of it, between them is the entrance with vertical walls cut through rock
**Sl. 6.** Okno 6: unutrašnja galerija i površinska eksploatacija rude ispred nje, između njih je ulaz sa vertikalnim zidovima prosečenim kroz stenu.

research was continued in 2013–2014 (Antonović *et al.* 2014; Antonović 2017). At that time it was discovered that the approach platform was, in fact, a filled-in wide and relatively shallow mining pit, with dimensions of 4 x 3 m, from which a short and narrow canal, 2 m long, was spreading towards the East, and two more canals towards the West, with shape and dimensions similar to the Eastern one. In the South-Eastern part there is a recess in the rock with traces of massive burning. In front of the mining pit, towards the South, there was a zone of ca 25 m$^2$ with traces of surface exploitation of ore (Fig. 6). During the excavations 56 stone mining mallets were found – 25 in the outer and 31 in the inner part of the Shaft.

The Shaft named Object 1 is located at the top of the site of Prljuša, at 980 m above sea level. It was discovered in 2011, and excavated since 2014. This shaft represents the most extensively explored case of underground exploitation of copper ore on this site (Fig. 7). Up to today, 7 metres of mining canal, one gallery with dimensions of 4,2 x 5,3 m, an entrance into the shaft of regular rectangular shape, from which a mining canal forks towards the East and West, as well as numerous stone mallets were researched. Mining

**Fig. 7.** Shaft Object 1
**Sl. 7.** Okno Objekat 1

canals, which are, in fact, canals made by following and exploiting the ore, were spreading horizontally some 2–3 m beneath the surface of the soil. Centuries later, after the exploitation was over, the relatively thin ceiling collapsed into the emptied shafts. During the archaeological researches, large pieces of rock were encountered in those mining canals and galleries. The overview of the manner in which the shaft Object 1 was functioning helped us understand how ore was extracted in other shafts, whose remains, in the upper part of the slope of Prljuša, are numerous, and in large part visible on the surface (Fig. 3; 8).

During the field surveys of the slope of Prljuša 15 objects were discovered so far –remains of shafts which are visible even today on the surface of the site. The most impressive is certainly the complex of several shafts on the Western end of the site (Objects 10–15) – a large rock, rising several metres above the surface of the rest of the surrounding terrain. There are numerous mining canals and galleries in it, which are open towards the sky today, since a thinned ceiling, which remained without support after the exploitation of the shaft,

**Fig. 8.** Shaft Object 13 with collapsed ceiling; the original entrance into the shaft is still visible at the bottom of the rock.
**Sl. 8.** Okno Objekat 13 sa obrušenom tavanicom; pri dnu stene još uvek je vidljiv originalni ulaz u okno.

collapsed. On several places there are still visible regularly shaped entrances into shafts (Fig. 8). Numerous stone mining mallets found around this complex, especially on the slope beneath it, bear testimony of the intense prehistoric exploitation of copper ore.

All visible remains of prehistoric ore extraction are located in the upper part of the site, higher than the point of 936 m above sea level. At this altitude, Shaft 4 and Shaft 6 were discovered. Shaft 5 is located at a somewhat lower point – 930 m, which represents the border for visible remains of prehistoric mining in the Western part of the site. Below this border, the surface of the soil is covered by a thick layer of scree. The geophysical research from 2012 detected anomalies indicating ore exploitation conducted long-time ago. New geophysical research from 2016 confirmed that those anomalies represent remains of old mining activities, covered by scree, which can be as thick as 10 m in several places.


**Fig. 9.** Pottery found in Object 1.
**Sl. 9.** Keramika otrkivena u Objektu 1.

Object 1 is the only shaft in which pottery was found that can be dated more reliably. Several beakers with two handles were discovered, whose shape is typical for the Bubanj-Hum culture (Fig. 9). However, the small amount of samples, as well as the lack of absolute dating, does not allow for a more precise cultural-chronological determination into one of the phases – Bubanj-Hum I or Bubanj-Hum III – which are separated by 2000 years. Shapes of this kind can be found in horizons of Early Eneolithic settlements in Bodnjik near Družetić (North-Western Serbia), which is determined

as belonging to the cultural complex of Bubanj-Salkuca-Krivodol (Живановић 2013: 27–28, 55), Kalenić at the colliery of Kolubara (Благојевић 2005: 58–61) and Bubanj near Niš in the horizon of the Bubanj-Hum I culture (Милановић & Трајковић-Филиповић 2015: 127). At Krivodol and Zaminec in Bulgaria, vessels were discovered which were completely identical to those found on Rudnik (Георгиева 2012: 125, T. 13/1, 19/3, 7, 35/7). Beakers with two handles, very similar to the Early Eneolithic ones, but still visibly different, were present in the Early Bronze Age culture of Bubanj-Hum III and Vatin, and they were found at the necropolis of Vranjane, the site of Velika Humka (Zotović 1985: 32, T. V/3), Prijevor, Ade (Stojić & Nikitović 1996) and at the site of Sokolica in the village of Ostra near Čačak (Дмитровић & Љуштина: 2007: 12, T. III/2). The manner in which the ore was exploited, i.e. the following and emptying of malachite veins, leaving behind irregular mining canals, was decisive for dating the shaft Object 1 into the Early Eneolithic, and hence the entire mine at Prljuša as well. More precise dating will be possible only once we have obtained the absolute dates and found a larger sample of pottery material. It is possible that the lower part of the slope was exploited even before that, during the period of the Vinča culture. That was also the supposition of the first researchers of the site, primarily due to the abundance of rock crystal, which can be found on the entire surface on the site, and for which it may be presumed that it was exploited during the Vinča culture (Јовановић 1988: 9; Bogosavljević-Petrović *et al.* 2017: 27–28).

**Ore exploitation**

Very hard rocks at Prljuša, which contained mineralized malachite, affected the manner in which the ore was exploited. In the diatreme zone at Mali Šturac, explosive breccias are spread, mostly composed of quartz latite, latite and metamorphosed sediment. Mineralized malachite was going through those hard rocks, and reached the surface at certain spots. The geophysical research of 2011 detected, in the zone of Shaft 4, a massive anomaly, which was interpreted as an ore body or a larger underground mining gallery,

to which a narrow canal lead, with an opening on the surface (Antonović & Vukadinović 2012). During the excavation of Shaft 4 the entrance to this gallery wasn't discovered, and the narrow canal, for which it was believed that it would lead to the gallery, was, in fact, the location where the ore came up to the surface and spread from there, radially, across the terrain beneath it. So far no vertical mining canals were discovered at Prljuša, perhaps because in those times the miners had technical difficulties in extracting ore from the depth precisely because of the hardness of the rocks which contained the ore. It is probable that that was the reason that ore was exploited on this mining site from the surface and from horizontal ore veins which were located near the surface of the soil.

**Fig. 10.** Shaft 6: burning traces on walls of the gallery and the short canal probably used for setting beams for hanging large stone mining mallets.
**Sl. 10.** Okno 6: tragovi paljevine na steni i kratak kanal verovatno korišćen za uglavljivanje greda za kačenje velikih rudarskih batova.

Surface ore exploitation in the zone of Shaft 4 was researched on a larger surface, with dimensions 9 x 10 m (Fig. 5). The hard rock containing the ore was first being split with the use of fire. Burning traces can be seen on several places on the researched surface, and precisely on those parts where the ore once was. The use of fire for splitting rocks containing ores was noted in other

**Fig. 11.** Object 1: large stones in the upper layers, probably parts of collapsed shaft ceiling.
**Sl. 11.** Objekat 1: veliko kamenje u gornjim slojevima, verovatno delovi obrušene tavanice okna.

prehistoric mines as well (O'Brien 2015: 204). The rock was heated by fire, the suddenly cooled with water. The ore was separated from the matrix of the rock with mallets. Traces of hitting are visible in mineralization zones (Fig. 10; 14). Mining stone mallets were found in all layers of excavation. They differ in size, shape and use-wear level. It is assumed that massive mallets, weighing over 2,5 kg, were used for the initial splitting of the rock, in order to set the ore free. Smaller mallets were probably used to separate malachite from the rock. During ore exploitation, large pieces of debris were laid aside on the Western edge of the surface mining pit, where there was no mineralization. The Eastern part of the mining pit, the one towards the near-by Shaft 6, wasn't used for debris, because the ore exploitation was spreading that way. Used and damaged mallets of larger dimensions were also thrown on the rubbish pile to the West from the exploited surface, while smaller mallets were left in the mineralization zone.

Shaft 6 bears traces of surface and pit exploitation of ore (Fig. 6). The Northern part of the shaft represents a wider, though not very deep pit. Today it is an open pit, but traces on surrounding rocks, as well as large stones which were encountered during the excavation would indicate that it was an underground gallery, spreading on a small depth under the surface of the soil. A passage with vertical walls lead to it, cut through the rock. The dimensions of the pit are 4 x 3 m and it is at the depth of 1,5 m from the entrance level. There are several short canals along its' edges, 1–2 m long (Fig. 10). It is possible that these canals were used for setting beams, upon which large stone mining mallets were hung (Fig. 12). The rock was being split with fire in this shaft as well. Traces of burning on the rock, and on certain places even deposits of soot, are visible in the lower layers of the pit (Fig. 10). A considerate number of mallets was found, damaged by use. In front of the entrance to the pit there is a 25 $m^2$ zone with traces of surface ore exploitation, spreading towards Shaft 4. It is beyond doubt that these two shafts, not far from one another, were exploited at the same time.

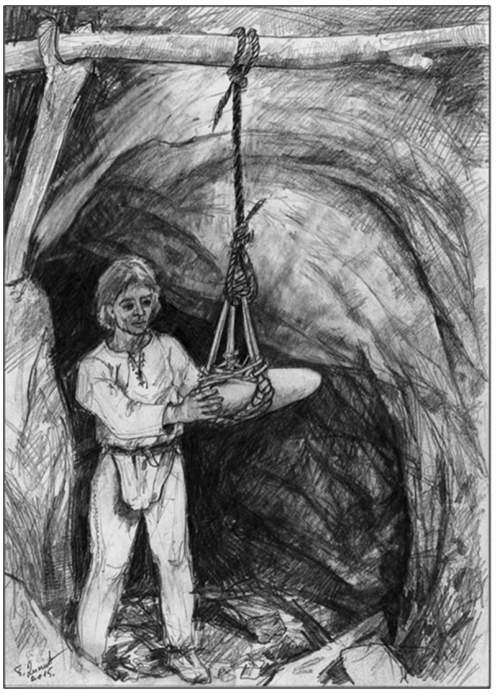

**Fig. 12.** Reconstruction of construction for hanging large stone mining mallets (drawing Blagoje Dimić).
**Sl. 12.** Rekonstrukcija konstrukcije za vešanje velikih kamenih rudarskih batova (crtež Blagoje Dimić).

In the shaft Object 1, underground ore exploitation was noted. The vein of ore was located on small depth below the surface of the soil, along the line East–West (Fig. 7). The ore was removed starting from the rectangular opening, by which two Early Eneolithic beakers

**Fig. 13.** Objects 1: stone mallet weighing 19,8 kg found at the entrance to the gallery at the west end of the mining canal.
**Sl. 13.** Objekat 1: kameni bat od 19,8 kg težine nađen na ulazu u galeriju na zapadnom kraju rudnog kanala.

with two handles were left, one at each side. From the entrance, a mining passage of irregular shape was going towards the East and towards the West. On the Eastern end, some 5 metres from the entrance, the passage ended with a small gallery with dimensions of 5 x 3,2 m. Large pieces of rocks in the upper layers were discovered, both in the passages and in that gallery, which would indicate that there was underground ore exploitation conducted and that the ceiling collapsed after the shaft was abandoned (Fig. 11). Several recesses were discovered in the walls of the gallery; it is possible that they had the function of fixating some sort of wooden construction, upon which massive stone mallets were hung. The discovery of one such mallet, weighing 19,8 kg, at the very entrance to the gallery from the passage leading to it, gave us the basis for such an assumption (Fig. 13). In the gallery itself, in its' central part, 178 stone mallets were discovered. Traces of fire can be seen on the walls of the gallery, on places where there was mineralization. On such places, there are also traces of ore being removed from parent rock with the use of stone mallets. In the central part of the gallery, in which 178 mallets of different sizes were found, a large layer of burning was discovered, with up to one metre of thickness (Fig. 14).

**Fig. 14.** Object 1: the central part of the gallery with traces of fire.
**Sl. 14.** Objekat 1: centralni deo galerije sa tragovima paljevine.

It would appear that it was not a fire that got out of control, judging by the stone mallets, which do not bear any damage caused by high temperatures, but only soot traces on their surface.

The extremely large number of mining stone mallets was discovered in all parts of the site. It is estimated that there are ca 2000 of them in the surface layer alone. This estimation was made after the micro-field survey of the site during the geophysical research in 2012. At that time geophysical measurements were performed in the lower half of the site, by applying the Self Potential method, on 597 points distributed in a rectangular 5 x 5 m grid. In average, there was one stone mallet identified on every point. If we assume that for every mallet found on the surface there is at least one other in the underground layer, and that the same number of mallets can be found in the upper part of the site as well, we come to the number of over 2000 stone tools. To this we should add a considerate number of mallets discovered in researched shafts. During the excavations, it

was determined that a considerably larger number of these mining tools was located beneath the surface of the soil. In Shaft 4 there were 77 of them found, in Shaft 6 – 56 of them, and in shaft Object 1 an astonishing number of 197 mallets. In the mines of Rudna Glava and Jarmovac near Priboj, stone mallets were present in considerably smaller percentage.[3] Such a ratio in the presence of mallets should be brought into connection with the hardness of the rock containing the ore. At Prljuša, the ore is found in considerably hard and compact rocks, which is not the case at Rudna Glava and Jarmenovac, where the rocks are somewhat softer and less coherent. Therefore, the splitting of rocks in the mine of Prljuša demanded a large amount of mallets because they were often getting damaged during the work, as witnessed by a large number of fragmented tools of this type. We may see another difference between Prljuša on one hand and Rudna Glava and Jarmovac on the other, namely, in the use of fire, which was only occasionaly used in the process of ore exploitation on the other two mines (Jovanović 1982: 64).

## Conclusion

Every mine from the period of earliest metallurgy has its' own specific characteristics which make it different from other mines. At the time when metallurgy appeared on the Balkans, the inhabitants of this region had almost no experience in mining (the exception is the flint mine at the site Kriva Reka near Shumen in Northeastern Bulgaria; Georgiev 1978: 70). Unlike other parts of Europe, for example, Central and Western, where metallurgy and ore extraction were preceded by a long period of underground exploitation of flint, such mines have not been discovered on the Balkans as yet. It is most probable that flint mines did not exist in this part of Europe due to a copious amount of quality stone that could be found on the surface. The surface exploitation of raw materials has a long "tradition" in this area ever since the Palaeolithic (Šarić 2013; Богосављевић-Петровић 2005: 92–102; Михаиловић *et al.* 2015; Mihailović *et al.* 2015). This

[3] Percentual values are taken into consideration due to the fact that these are mines with smaller exploitation surface.

manner of obtaining raw materials continued also in the Neolithic. Raw materials were mostly gathered along watercourses, but also in places known since the Palaeolithic (Šarić 2013: 23; Богосављевић-Петровић 2005: 92–102). Undoubtedly, the prehistoric inhabitants of the Central Balkans would come to learn in this manner, ever since the Mesolithic, about the rich ore deposits of the territory they inhabited, as witnessed by ore fragments (malachite, galenite) in the Mesolithic and Neolithic collections of stone artefacts (Antonović 2003: 34; Antonović 2014: 17–20), so it is beyond doubt that the inhabitants of the Central Balkans had knowledge on mining sites since the Mesolithic.

The earliest mines on the Balkans testify of the autochthonously developed method of ore exploitation. Local miners would extract the ore in the manner they deemed best for the type of ore deposit they encountered. At Ai Bunar in Bulgaria, they would reach the deposit by digging in long open canals, which could be even several metres long and which would follow the ore streak (Черных 1978: 59). At Rudna Glava, vertical shafts, i.e. canals which represent emptied veins of ore, were exploited up to the depth of 10–12 m, as far as the primitive technology known to the representatives of the Late Vinča culture would enable them to (Jovanović 1982: 4–13). At Jarmovac, there are vertical shafts present, which could be even from the Vinča period, but there are no mobile finds that would confirm that possibility. Surface ore exploitation, judging by the pottery findings, was exclusively linked to the Vinča culture in this mining site (Derikonjić *et al*. 2011). The mine of Mali Šturac, which is from the post-Vinča period, differs from the previous two because of the very hard rocks containing the ore, which forced the miners to limit their activity to surface exploitation, and demanded a considerable number of stone mallets. There are no crucial differences between early mines at the Balkans. There are no shafts in the sense of those existing since the Late Bronze Age and in many parts of Europe was not in use until Roman times (Stöllner *et al*. 2011: fig. 3; O'Brien 2015: 8, 169), which would enable the passage to the ore through underground canals; the ore veins were followed from the surface, and the extraction of ore from them would create shafts of irregular

shape and size. That is why the mine of Mali Šturac, regardless of the lack of certainty in the dating of pottery, can be determined as belonging to the very beginning of primitive metallurgy, i.e. the Early Eneolithic.

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## EKSPLOATACIJA RUDE BAKRA NA LOKALITETU PRLJUŠA NA MALOM ŠTURCU

Veliko rudno bogatstvo Rudnika eksploatiše se, bez prestanka, od praistorije do danas. Prljuša na Malom Šturcu je za sada jedini dokaz praistorijske eksploatacije rude na Rudniku. Od 1981. godine do danas na celoj padini Prljuša otkriveni su brojni ostaci praistorijske rudarske aktivnosti. Veoma tvrde stene u kojima se nalazi mineralizacija malahita na Prljuši uticali su na način eksploatacije rude. Do sada su otkriveni tragovi površinske eksploatacije, horizontalni hodnici plitko ispod površine terena, a vertikalni hodnici, kakvi su postojali na Rudnoj Glavi i Jarmovcu, nisu otkriveni na ovom rudištu, možda upravo zbog velike tvrdoće stena u kojoj se nalazi ruda i tehničke ograničenosti praistorijskih rudara da u takvoj geološkoj sredini prave vertikalne kanale.

Površinska eksploatacija rude otkrivena je u zoni Okana 4 i 6. Tvrda stena u kojoj se ruda nalazila prvo je razbijana vatrom. Sama ruda odvajana je od osnovne stene pomoću batova. Kameni rudarski batovi nalaženi su u svim slojevima iskopa. Različitih su veličina, oblika i stepena istrošenosti. Pretpostavlja se da su masivni batovi težine preko 2,5 kg korišćeni za početno razbijanje stene kako bi se oslobodila ruda. Manji batovi su verovatno služili za odvajanje malahita od stene.

Jamska eksploatacija otkrivena je u Oknu 6 i Objektu 1. Severni deo okna 6 predstavlja širu i ne mnogo duboku jamu u koju se dolazilo preko zone sa površinskom eksploatacijom. Danas je to otvorena jama, ali tragovi na okolnim stenama, kao i veliko kamenje na koje se nailazilo tokom njenog iskopavanja upućuju na to da je reč o podzemnoj galeriji koja se prostirala plitko ispod površine tla. U nju je vodio prolaz vertikalnih zidova, prosečen kroz stenu. Po obodu

ima više kratkih kanala dužine 1–2 m. Moguće da su ovi kanali korišćeni za uglavljivanje greda o koje su se vešali veliki kameni rudarski batovi. I u ovom oknu stena se razbijala vatrom. Tragovi gorenja na steni, a na pojedinim mestima i naslage gareži, vidljivi su u donjim slojevima jame.

U oknu Objekat 1 zabeležena je samo podzemna ekploatacija rude. Rudna žila se nalazila plitko ispod površine tla i pružala se pravcem istok–zapad. Njeno pražnjenje je počinjalo od četvorougaonog otvora kod koga su bila ostavljena dva ranoeneolitska pehara sa dve drške, po jedan sa svake strane. Od ulaza rudni hodnik nepravilnog oblika je išao na istok i na zapad. Na istočnom kraju, 5 metara od ulaza završavao se jednom nevelikom galerijom dimenzija 5 x 3,2 m . Veliki komadi stena u gornjim slojevima otkriveni su kako u hodnicima tako i u toj galeriji, što ukazuje da je reč o podzemnoj eksploataciji rude i da se tavanica obrušila nakon napuštanja okna. Na zidovima galerije otkriveno je više udubljenja koja su moguće imala funkciju u fiksiranju neke drvene konstrukcije o koju su se vešali masivni kameni batovi. Otkriće jednog takvog bata, težine 19,8 kg, na samom ulazu u galeriju iz hodnika koji je vodio do nje, daje osnovu za takvu pretpostavku. Tragovi vatre primećuju se na zidovima galerije, na mestima gde je bila mineralizacija. Na tim mestima postoje i tragovi izbijanja rude iz matične stene nastali upotrebom kamenih batova.

Izuzetno veliki broj kamenih rudarskih batova otkriven je na celom lokalitetu. Procenjuje se da ih samo u površinskom sloju ima oko 2000. Ova procena izvedena je nakon mikrorekognosciranja lokaliteta tokom geofizičkih istraživanja 2012. godine. Tokom iskopavanja je ustanovljeno da se znatno veći broj ovog rudarskog oruđa nalazi ispod površine terena. U Oknu 4 prikupljeno ih je 77, u Oknu 6 njih 56, a u oknu Objekat 1 čak 197 batova.

Svaki rudnik iz vremena najranije metalurgije ima svoje specifičnosti koje ga čine različitim u odnosu na druge rudnike. U vreme pojave metalurgije na Balkanu stanovnici ove regije nisu imali nikakvog iskustva u rudarenju. Za razliku od drugih delova Evrope, na primer centralnog i zapadnog, gde je metalurgiji i iskopavanju ruda prethodio dug period podzemne eksploatacije kremena, na Balkanu takvi rudnici do sada nisu otkriveni. Najverovatnije da rudnici kre-

mena nisu ni postojali u ovom delu Evrope zbog obilja kvalitetnog kamena na površini. Površinska eksploatacija sirovina na ovim prostorima ima dugu "tradiciju" još od paleolita. Ovakav način pribavljanja sirovina nastavlja se i tokom neolita. Sirovine se skupljaju najčešće po vodotocima, ali i na mestima poznatim još od paleolita. Nema sumnje da su se praistorijski stanovnici centralnog Balkana, još od mezolita, na taj način upoznavali sa rudnim bogatstvom teritorije koju su naseljavali, o čemu svedoče komadi rude, uglavnom malahita, ređe i galenita, u mezolitskim i neolitskim kolekcijama kamenih artefakata, pa nema sumnje da su stanovnici centralnog Balkana još od mezolita znali za rudišta.

Najraniji rudnici na Balkanu svedoče o autohtono razvijenom metodu eksploatacije rude. Lokalni rudari su iskopavali na način za koji su mislili da je najbolji za orudnjenje na koje su naišli. U Ai Bunaru u Bugarskoj do rude se dolazilo ukopavnjem dugih otvorenih kanala dubokih i do nekoliko metara, kojima se pratila rudna žica. Na Rudnoj Glavi vertikalna okna eksploatisana su do dubinen 10–12 m, dokle je dozvoljavala primitivna tehnologija kasne vinčanske kulture. Na Jarmovcu postoje vertikalna okna koja bi mogla biti čak i vinčanska, ali nema pokretnih nalaza koji bi to potvrdili. Površinska eksploatacija rude, sudeći na osnovu keramičkih nalaza, na ovom rudištu je isključivo vezana za vinčansku kulturu. Rudnik na Malom Šturcu, koji je post-vinčanski, razlikuje se od prethodna dva po veoma tvrdoj steni u kojoj se nalazi orudnjenje što je rudare ograničavalo na površinsku eksploataciju i zahtevalo priličan broj kamenih batova. Ne postoje suštinske razlike među ranim rudnicima na Balkanu. Nema okana u onom smislu reči kakva postoje od kasnog bronzanog doba kojima se orudnjenju prilazilo podzemnim hodnicima, nego se rudna žica pratila od mesta na kome je izbijala na površinu, a iskopavanjem rude iz nje nastajala su okna nepravilnog oblika i veličine. Zato se i rudnik na Malom Šturcu, bez obzira na nedoumice u datovanju do sada pronađene keramike, može opredeliti u sam početak primitivne metalurgije, a to je rani eneolit i vreme Bubanj Hum I kulture.

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