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OLD COLLECTION AND NEW INSIGHTS: TECHNOLOGICAL ANALYSIS OF OBSIDIAN FINDS FROM THE LATE NEOLITHIC LAYERS OF VINČA-BELO BRDO

ABSTRACT

A large collection of obsidian finds from the Late Neolithic layers of the Vinča-Belo Brdo site, recovered during the excavations led by M. Vasić from 1929 to 1934, is curated in the Archaeological Collection of the University of Belgrade. Despite the long history of research of this collection, a detailed technological analysis of this material has not been conducted thus far. In this study, the results of technological analysis of 1,261 obsidian finds from the Late Neolithic levels of Belo Brdo are presented and discussed in the light of new data about the site. The results show that, although caution is needed when generating insights about the past based on this old collection, it can be a valuable source for making new inferences about the past.

KEYWORDS: OBSIDIAN, VINČA-BELO BRDO, LATE NEOLITHIC, TECHNOLOGY, BLADES, KNAPPING TECHNIQUE, SPECIALISATION.

INTRODUCTION

Numerous obsidian finds from the Late Neolithic layers site of Vinča-Belo Brdo (Serbia) have attracted the attention of researchers since the first excavations of M. Vasić (see reference 4 in Srejović, Jovanović 1957). Although Vasić generally considered the stone tools as anachronisms (Васић 1932: 52), due to his misinterpretation of the site chronology (see Borić 2016; Palavestra 2012; 2013; 2020; Palavestra, Babić 2016), he was quite interested in obsidian finds, rewarding laborers that found obsidian during the excavations (Garašanin, Garašanin 1953, 26, cited in Palavestra 2020: 79, footnote 70). Obsidian is mentioned in multiple parts of his monographs (Васић 1932; 1936a; 1936b; 1936c), as a raw material for knives and sidescrapers that were possibly used for shaving, tattooing, or as parts of tribulum (tool for threshing). Obsidian might have been particularly significant for Vasić as an indication of trade – he suggested that it possibly originates from the area of the Bükk Mountains (Васић 1932: 52; i.e., the area of Bükk culture, Carpathians, see Tripković 2004, footnote 17).

A large collection of obsidian finds that were collected during Vasić's excavations of Belo Brdo from 1929-1934 is curated in the Archaeological Collection of the University of Belgrade. In 1957, Srejović and Jovanović reported the results of the first systematic analysis of 1,398 obsidian finds from this collection (as well as flint finds, but they will not be discussed here). They noted that obsidian sporadically appears quite early in the sequence of the site (pit M, 10.13 – 9.35 m of relative depth[1]), while it disappears at 3.8 m of relative depth. Between the appearance and disappearance of obsidian on Belo Brdo, there are significant os-

1 Vasić excavated the site of Vinča-Belo Brdo in roughly 10 cm thick mechanical layers. For every find, the relative depth was recorded in relation to the "absolute zero" (Васић 1932; 1936a; 1936b; 1936c).

cillations in the frequency of finds from this raw material at different levels (see Figure 1 of their article). The *percentage of all obsidian finds* is 2.9% between 10.0 and 9.0 m, much higher between 8.6 and 8.0 m (54.6%), and then gradually decreases before its disappearance at 3.8 m. According to Srejović and Jovanović, the amount of obsidian indicated the intensity of connections between Belo Brdo and the neighbouring areas in the north (see also Kaczanowska, Kozlowski 1990).

Srejović and Jovanović (1957) have also conducted a typological analysis of obsidian finds. They indicated the presence of cores, knives (blades), fan-shaped and trapezoidal endscrapers, and pointed scrapers. Based on the presence of cores throughout the sequence, Srejović and Jovanović concluded that the knapping was done within the settlement. Two types of blades were distinguished: 1) straight with triangular or trapezoidal cross-section, from 0.7 to 5 cm long, with or without retouch, appearing in all levels from pits to 4 m; 2) curved blades with a triangular cross-section, without retouch, with a length between 3.5 and 6 cm, distributed between 9.0 to 5.0 m, but most frequently between 8.3 and 6.0 m. According to Srejović and Jovanović, the shape of obsidian blades is "determined by the very nature of the material ... thin blades, usually small in size with very sharp edges and without a large variety of shapes" (Srejović, Jovanović 1957: 258). They also noted two types of scrapers: 1) fan-shaped scrapers, in the "form of a circular segment or an irregular ellipse" (Srejović, Jovanović 1957), common in all levels; 2) trapezoidal scrapers that appear between 9.0 and 8.0 m and disappear around 4.5 m of relative depth.

Following the pioneer study of Srejović and Jovanović, many researchers were interested in the questions of the origin and distribution of obsidian from Vinča-Belo Brdo and other sites in the Central Balkans and Southern Pannonia (Chapman 1981: 80-81; Marić 2015; Milić 2014; 2016; 2021; Tripković 2004; Tripković, Milić 2008; William-Thorpe et al. 1984; Глишић 1968). The provenance of obsidian from Belo Brdo in the Carpathians (Slovakia, Carpathian 1 source) was confirmed by a chemical characterisation (Tripković, Milić 2008 and references therein), while the distribution of obsidian served for inferring possible cultural connections, trade and exchange models, site hierarchies, etc.

Despite this general interest in obsidian finds, the technological aspects of Belo Brdo obsidian were not extensively studied following the pioneer study by Srejović and Jovanović (1957). Srejović made only some sporadic insights about the obsidian, observing "fine, small blades" (Srejović 1981) from this material and suggesting obsidian was a "precious raw material for the production of sickles and precise tools" (Срејовић 2001). Although Radovanović et al. (1984) conducted a detailed, systematic analysis of different aspects of lithics from Belo Brdo, the obsidian collection was not thoroughly studied, as their focus was primarily on chert finds. These authors calculated the percentages of obsidian (in relation to chert) in different levels of the site, inferring that it was the highest between 9.0 and 7.0 m (10.0-9.1 – 20.3%; 9.0-7.0 – 69.5%; 8.0-7.1 – 69.9%; 7.0-6.6 – 5.8%; 6.0-5.0 – not calculated due to a small sample; 5.0-4.1 – 4.1%). Based on the predominance of blades (79.5%[2]) compared to flakes (19.8%) and cores (0.3%), they suggested that either the blades were produced outside the settlement and then brought to the site, or the obsidian was processed in other areas of the site from the ones that Vasić excavated. Radovanović et al. (1984) also noted that all 22 obsidian cores they analysed are microcores (10-20 mm in length) with pyramidal or chisel-edged morphology.

M. Milić (2016: 211) has also made certain insights based on the obsidian collection from Belo Brdo – the entire reduction sequence is present on Belo Brdo, indicating the on-site exploitation of obsidian cores, "although the cores were occasionally prepared before they were brought to the site" (pp. 211); obsidian cores have small dimensions (mean length is 1.7 cm) and a pyramidal shape; blades are predominant among the debitage types (80%); obsidian blades and bladelets were produced using pressure flaking (i.e. debitage), indicating a specialised production (Milić 2016: 223); blades rarely have use-traces and retouch. Milić also noted that there are "bullet cores and pressure-flaked blades" on Belo Brdo and other sites that she referred to as "important centres for obsidian distribution" (Milić 2016: 239).

Thus, despite a long history of research on the obsidian from Vinča-Belo Brdo, a detailed techno-

2 Percentages were calculated from the unnamed table in the upper part of page 19 of their work.

logical analysis has not been done on this collection. During the work on lithic finds from Vasić's excavations between 1929 and 1934, I analysed a total of 1,520 obsidian finds curated at the Archaeological Collection of the University of Belgrade. Based on the collected data, this study aims to explore the technological aspects of obsidian production on Belo Brdo during the Late Neolithic and contextualise these insights in light of new data about the site. A large number of finds in this collection provide a suitable sample for assessing the production technology and related questions, such as those regarding the changes in the applied knapping techniques (e.g., Bogosavljević Petrović 2015; 2018; Milić 2016; 2021), standardisation and specialisation (e.g., Bogosavljević Petrović 2015; 2018; Kaczanowska, Kozlowski 1990; Perlès 2001; Vuković 2011), certain aspects of trade (e.g., cores vs. nodules vs. blades; e.g., Milić 2016), etc. Another goal of this study is to determine the value of this collection, with all of its shortcomings (e.g., Palavestra 2020), for gaining knowledge about the past.

VINČA-BELO BRDO

The site is located on the right bank of the Danube river, approximately 14 km to the east of Belgrade (Serbia) and the confluence of the Danube and Sava rivers. Vinča-Belo Brdo was excavated in three large campaigns – from 1908 to 1934; between 1978 and 1986; 1998-ongoing (see Tasić 2005; 2011b). The rich stratigraphy of the site contains archaeological remains from the Neolithic to medieval period, but the majority of deposits are from the Late Neolithic, and they had a huge impact on the study of this period at both a local and regional scale. The site was continuously inhabited during the whole Late Neolithic of the Central Balkans, for around 800 years (~5300~4500 BC) (Tasić et al. 2015a; 2015b; 2016). For more information about the site, the reader is referred to other sources (e.g., Tasić 2005; 2011).

1929-1934 excavations (M. Vasić)

As previously mentioned, the obsidian collection in the Archaeological Collection of the University of Belgrade consists of finds collected during the excavations conducted between 1929 and 1934. In these campaigns, Vasić excavated new trenches P and G (Palavestra 2020). Despite the existence of the "main axis" during the 1929-1934 excavations, i.e., a linear reference point in relation to which Vasić (occasionally) positioned the excavated material, he did not take many notes about the spatial (horizontal) distribution of objects and artifacts (Palavestra 2020), and some very general and selective information can be drawn from his journals, publications, and excavation plans (see Palavestra 2020 for an overview). Thus, the context of finds is largely missing for the obsidian collection from these excavations. However, the most recent excavations (1998-ongoing) have shown that the (small sample of) 14 obsidian finds were found in different areas of the site (mainly the cultural layer), and there are no indications of obsidian workshops and other specific contexts for obsidian finds on Belo Brdo and other Late Neolithic sites in the region, as on some other Late Neolithic sites (e.g., Robb 2007: 202-203).

Vasić excavated the site in 10 cm mechanical levels (strip digging, Palavestra 2020: 98) and meticulously noted the vertical distribution of finds. The relative depth of objects and features was noted in journals, excavation plans, and on the artifacts themselves (see Palavestra 2020). A relative depth was measured as a vertical distance from the "zero", "an absolute reference point" (an elm on the top of the hill, Palavestra 2020). Although this arbitrary reference point was a basis for all measurements of relative depth, it was possibly excavated and removed in later campaigns (Марић 2011). Another issue is that Vasić's "10 cm" mechanical levels were sometimes larger, reaching up to 30 cm (Palavestra 2020). Finally, in attempting to relate the relative depths of 1929-1934 material with those from previous campaigns, Vasić added certain values to the relative depths of the finds excavated from the P and G trenches (0.5 m, 1.8 m) (Palavestra 2020).

Based on the evidence provided by Palavestra (2020), the validity of Vasić's system of measuring vertical disposition seems questionable. However, two strands of evidence show that the relative depths of Vasić are fairly robust and give a valid chronological sequence:

1) W. Schier (1996; 2020) was able to reconstruct the correct chronological ordering of Vasić's (1929-1934) 10 cm units (levels), by conducting a frequency seriation (a method of relative dating)

based on the frequency of ceramic types in different levels of the site. The correct chronological ordering is expected if the layers are not mixed, disturbed, or inappropriately excavated. As Schier (1996: 144) concluded: "the chronological resolution of Vasić's 10 cm levels is far better than generally assumed".

2) In 2015, Tasić and colleagues published the results of a comprehensive analysis of the absolute chronology of Vinča-Belo Brdo, based on the radiocarbon dating of samples from Vasić's excavations (Tasić et al. 2015b). In total, 85 radiocarbon determinations were made on 82 samples, while a Bayesian framework was applied to establish a formal chronological model of the site, where prior knowledge about the stratigraphic position of samples (age-depth model) and possible reservoir effect were incorporated. Despite noting the presence of a certain number of outliers, Tasić et al. (2015b: 38) concluded that the "chronological resolution of Vasic's 10-cm spits is far clearer than previously thought".

Thus, although Vasić's evidence should be critically re-evaluated when possible, it seems the relative depths of the material from the Archaeological Collection are robust indicators of the chronological ordering of artifacts. Nevertheless, "it should be pointed out that the mentioned demarcations by meters must not be taken too sharply" (Garašanin 1979: 152).

SAMPLE

A total of 1,520[3] obsidian finds from the Archaeological Collection of the University of Belgrade were analysed. After excluding 16 finds from the Early/Middle Neolithic (Starčevo culture) and 243 finds without a relative depth, 1,261 obsidian finds from the Late Neolithic levels of Belo Brdo are discussed here. Interestingly, the number of finds reported here differs from the numbers reported in other publications: Srejović, Jovanović 1957 – 1398 with relative depth; Radovanović et al. 1984 – 1488 in total; Tripković 2004 – 1488 in total. The reason for these differences in the number of finds in the collection is unknown to the author of this work. Concerning the number of finds with an identifiable relative depth, some relative depths possibly became unreadable several decades after the analysis of Srejović and Jovanović or Radovanović and colleagues.

To explore the temporal variability in obsidian production, the material was classified according to the commonly used Milojčić's periodisation: Vinča A (9.3 – 8.0 m), Vinča B (8.0 – 6.0 m), Vinča C (6.0 – 4.0 m), Vinča D (4.0 – 1.3 m). Although Milojčić's Vinča D phase ends at 2.5 m (Tasić et al. 2015b, Table 8), the material from the younger Late Neolithic levels (up to 1.3 m) is also included here for chert/obsidian comparisons (see below) to assess the entire sample of Late Neolithic finds (see Tasić et al. 2015b).

METHODS

For reconstructing different aspects of production technology, a technological analysis (e.g., Andrefsky 2005; Inizian et al. 1999; Kooyman 2000; Pelegrin 2006; 2012; Shea 2013; Tostevin 2012) was applied to obsidian finds. To better illustrate certain aspects of obsidian production, a comparison was made with chert production on Belo Brdo, which will be published elsewhere (Radinović, in preparation). General information was collected about all obsidian finds – ID, box number, bag/case number, relative depth, raw material properties (colour and texture), type of product, (blank type or flake type), and presence/absence of fragmentation. A more detailed attribute analysis was conducted on obsidian cores and prismatic blades, as the laminar technology was the main goal of the knapping process (Bogosavljević Petrović 2015; 2018; Milić 2016; Radovanović et al. 1984; see below). In the case of cores, the following attributes were recorded – core type (flake/blade core), pattern of removals, core morphology, dimensions (length of the debitage surface, length and width of the striking surface) and mass, while for the blade cores the shape of the debitage surface and the regularity of removals were also noted.

The assessment of diachronic changes in technological aspects of obsidian production was mainly based on the variability of blades, as they provided sufficient samples for statistical analyses. For blades, data was collected about taphonomy (fragmentation, presence of post-depositional sur-

3 It should be noted that the number of 1,520 obsidian finds discussed here is slightly higher than the number of obsidian finds that will be published in my doctoral thesis (1465; https://doi.org/10.17605/OSF.IO/JRC9D), as I subsequently analysed an additional 55 obsidian finds from this collection that were absent during my work on the thesis.

face modifications and pseudo-retouch), metrics (mass, maximal length, width, and thickness in the different parts of blades), morphology (presence of cortex and back, directionality of removals, number of dorsal negatives, debitage profile and distal end type, blade regularity), detachment features (properties of the striking platform, presence/absence of lip, bulb, bulbar scar, ripples, and mesial belly), and the characteristics of retouch (retouch distribution, Clarkson's index of invasiveness; Clarkson 2002). Based on the collected data, different aspects of production, such as the knapping method and technique (e.g. Damlien 2015; Inizian et al. 1999; Pelegrin 1990; Sollberger, Patterson 1976), and maintenance of blades were assessed.

Additionally, a geometric morphometrics (GMM) analysis in the form of Elliptic Fourier analysis (EFA) was utilised on whole unretouched blades for assessing certain aspects of obsidian production that are related to the choice of knapping technique (Radinović, Kajtez 2021). Geometric morphometrics is a set of tools for quantitatively analysing the shape of objects (e.g., Slice 2007), while the EFA is the most commonly used GMM approach for analysing closed contours of objects that vary primarily in two dimensions (e.g., Caple et al. 2017; Kuhl, Giardina 1982). For gaining insights into the possibly utilised knapping techniques, the outlines of obsidian blades from Belo Brdo were compared with outlines of experimentally produced chert blades (Lengyel, Chu 2016; Muller et al. 2017; Pelegrin 2006; 2012; Sørensen 2006; see Radinović, Kajtez 2021), as there is still no reference collection of obsidian blades produced by different knapping techniques.

A detailed description of the EFA and the analytical protocol for the analysis of blade outlines are published elsewhere (Caple et al. 2017; Hoggard et al. 2019; Kuhl, Giardina 1982; Radinović, Kajtez 2021) and will be only briefly summarised here. Images of the dorsal sides of blades were edited and used for digitising the blade outlines. A .tps file for storing the outline coordinates was created using the tpsUtil 1.78 software (Rohlf, 2019), while the tpsDig 2.31 software (Rohlf 2017) was used for digitising blade outlines with 200 equidistant points. Before proceeding with visualisations and statistical analyses, the outlines were normalised using the R programming software (R Core Team 2020) and the *Momocs* v. 1.3.2. package (Bonhomme et al. 2014), to remove the effect of size, rotation, and location. The first 20 harmonics, which describe 99.9% of blade outlines, were retained for assessing and comparing the variability of blade outlines. Principal Component Analysis (PCA; e.g., Shennan 1997: 265-303) was used for exploring the variability of blade outlines.

All visualisations and statistical analyses presented in this paper were performed in the R programming language (R Core Team 2020), using the following packages: *dplyr* v. 1.0.3 (Wickham et al., 2021), *ggplot2* v. 3.3.3, (Wickham 2016), *ggpubr* v. 0.4.0 (Kassambara 2020), and *lsr* v. 0.5.2 (Navarro 2015). Following the principles of open science (e.g., Marwick 2017), the analytical protocol for data collection, data, and code for reproducing the majority of statistical analyses and visualisations (except chert-obsidian comparisons) are available at the Open Science Framework (OSF) platform (https://doi.org/10.17605/OSF.IO/FNVPK).

RESULTS AND DISCUSSION

The distribution of obsidian finds according to relative depths and Milojčić's phases is shown in Fig. 1. The number of obsidian finds is low in the earliest Late Neolithic levels, notably increases at around 9.0 m of relative depth, then sharply decreases after 7.7 m and remains low before the disappearance of obsidian at 3.8 m (although there is one find with a relative depth between 3.9 and 3.0 m). The percentage of obsidian in relation to chert decreases from 47% in Vinča A to 1.6% in Vinča D (Fig. 2). The percentages of obsidian are smaller than those reported by Radovanović et al. (1984), most probably because these authors did not analyse the entire chert assemblage from the Archaeological Collection (Radinović, in preparation). However, data from the "third glance" of Belo Brdo (Tasić 2011; Tasić 2015a) is notably different regarding the counts and percentages of obsidian: 1) the percentage of obsidian in relation to chert is much smaller than 69.9% (Radovanović et al. 1984: 14) or 47% (Fig. 2) in any of the phases – it is between 1 and 5% (personal insight into the collection from deep sounding, Tasić et al. 2016), as on most of the other sites from the period (see Milić 2016; Tripković 2004 for an overview); 2) the obsidian does not disappear from Belo Brdo in the

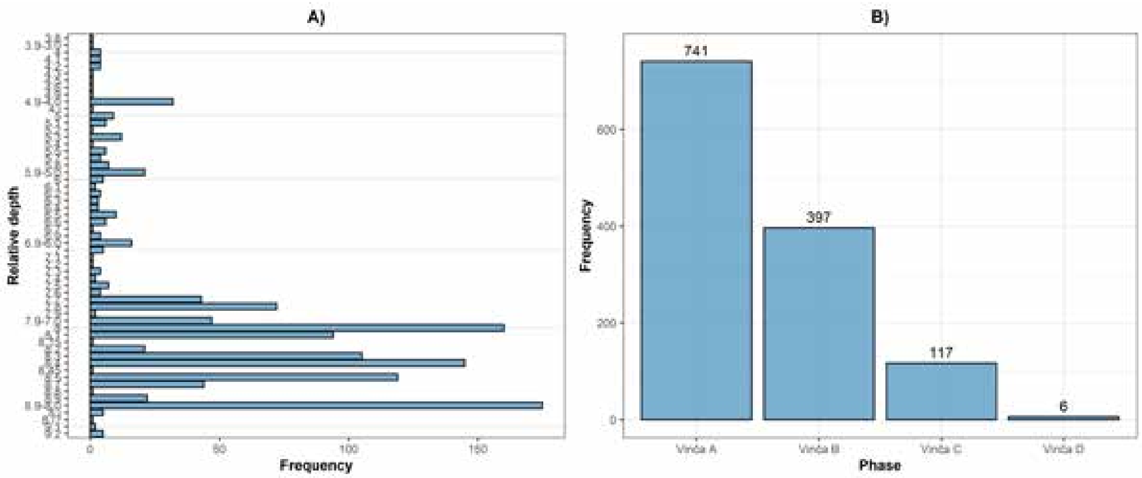

Fig. 1. The distribution of obsidian finds from Belo brdo according to a) relative depths and b) Milojčić's phases.

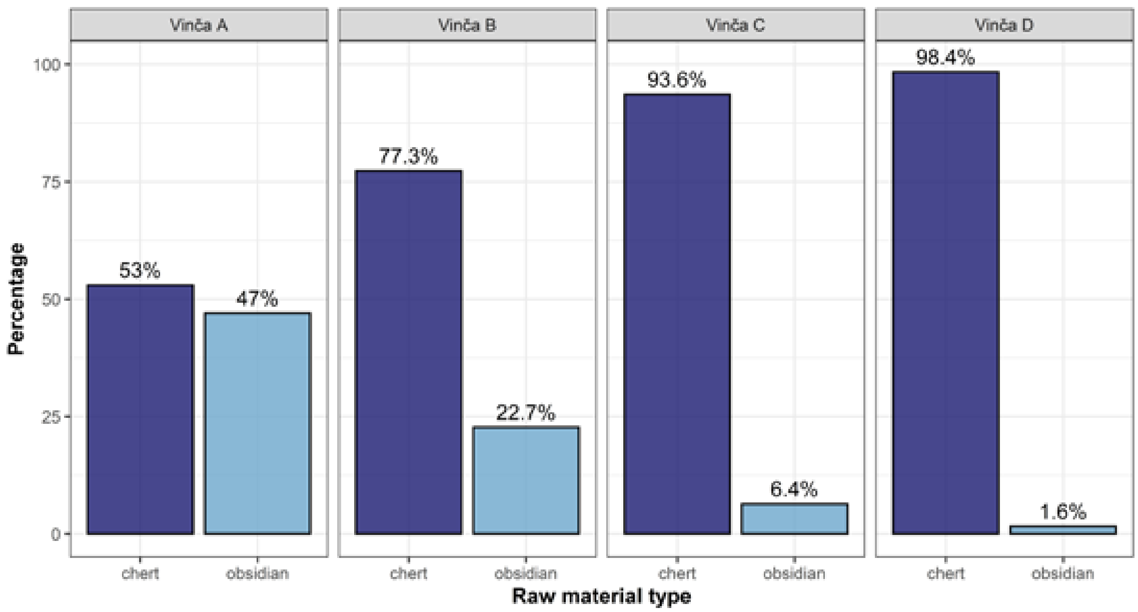

Fig. 2. The percentages of chert and obsidian in Milojčić's phases.

latest Late Neolithic phase (i.e. after 3.8 m) (Milić 2016: 208-209; Tripković, Milić 2008). These discrepancies are possibly caused by a recovery or storage bias in the case of Vasić's collection, and they might have important implications:

1) Lower percentages of obsidian possibly question the role of Belo Brdo as a trading (Bogosavljevic Petrovic 2015; Chapman 1981: 83) or redistribution centre (Milić 2016: 66; see also Milić 2021), "social core" (Milić 2016: 208), suggested settlement hierarchies (e.g., Chapman 1981: 137), and the models of trade and exchange (e.g., Chapman 1981: 80-81; William Thorpe et al. 1984). Very high percentages of obsidian on Belo Brdo (and possibly other sites that were excavated by early researchers; e.g., Mileker 1938, cited in Tripković 2004) are possibly a consequence of some kind of bias (e.g., storage) – lower percentages make more sense given the fact that the obsidian trade was generally a small-scale endeavour (Milić 2016).

2) Based on the presence of obsidian in Vinča D, it can be concluded that the cultural connections with the northern neighbours did not cease during this period, which is in line with other research on the distribution of obsidian in the region – for instance, Selevac (Voytek 1990: 441-442) and the sites in the Vršac area (e.g., Chapman 1981: 80-81) have obsidian in the final Late Neolithic phase.

From a total of 1,261 finds with a relative depth, there are 14 cores (1.1%), 1,231 flakes (97.6%), and 16 pieces (1.3%) characterised as waste/undeterminable. The percentage of flakes decreases in later phases, while the percentage of cores increases through time (Fig. 3). These temporal differences in the structure of collections are statistically significant, as indicated by the Fisher's exact test (n = 1261, X-squared = 48.922, df = 6, $p < 0.01$), but slight as indicated by a small effect size (Cramer's V = 0.14). Based on the high number of flakes sensu lato (flakes and blades), it has been suggested that the obsidian blades were not produced on the site (Radovanović et al. 1984). However, a high degree of core exploitation (e.g., Sullivan, Rozen 1985) – for example, Sheets and Muto (1972), produced 83 blades from a single core – and a high fragmentation rate might also explain this pattern. A low percentage of waste/undeterminable pieces possibly requires an explanation – for instance, it could be a consequence of collection/preservation bias (Radovanović et al. 1984: 55) or very skilful production.

these negatives do not have sufficient elongation (length / width > 2) to be considered blades in the strict sense. As these two cores have very small dimensions (~10 mm) and mass (< 1 g), they might represent blade cores in the final phase of exploitation. All three flake cores have a different pattern of removals (unidirectional, bidirectional, and multidirectional), while their shape is conical/pyramidal in two cases and irregular in one case.

One blade core is fragmented, so it was not possible to observe all features on this core. Two blade cores were made on flakes, while for the remaining 7 cores it was not possible to determine their initial properties. The majority of blade cores are single-platform (unidirectional; n = 7), apart from one opposed-platform core and one core with multiple (more than two) platforms. The shape of blade cores is predominantly conical/pyramidal (n = 4), but there are single occurrences of other core shapes (tabular, bullet-shaped, polyhedral, plano-convex, and irregular). Debitage surfaces of blade cores are triangular (n = 3), rectangular (n = 4), semi-oval (n = 1), or irregular (n = 1). Blade

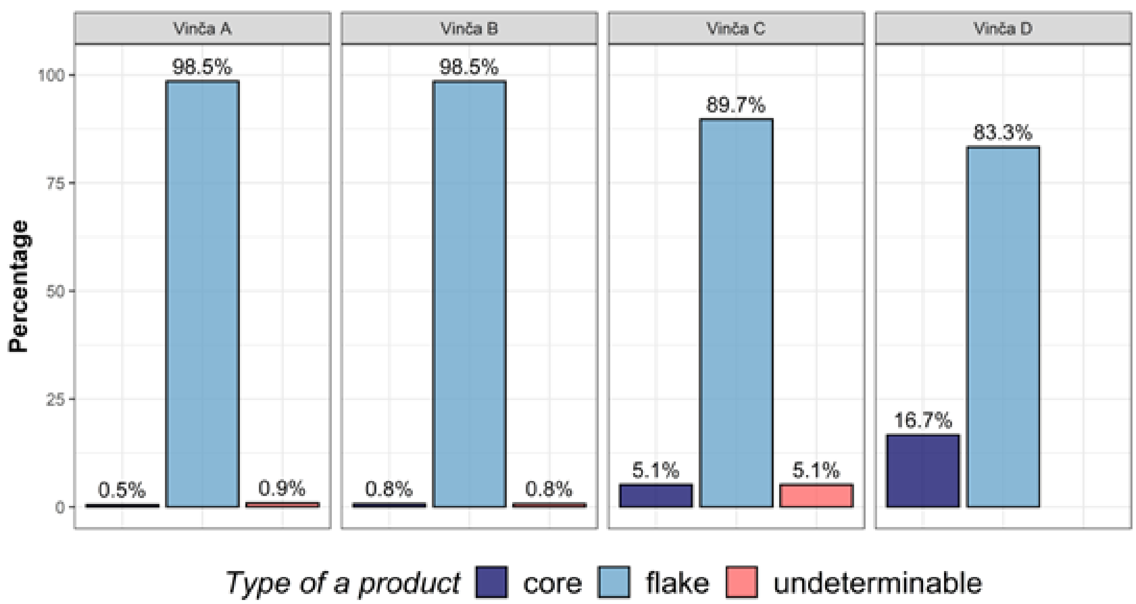

Fig. 3. Percentages of different types of knapping products in Milojčić's phases.

Cores

From a total of 13 obsidian cores, there are 10 blade cores and 3 flake cores. However, two out of the three flake cores have blade-like negatives – recurrent removal of flakes with parallel edges – but

negatives are moderately regular on 8 cores and very regular on only one core.

Obsidian cores have small dimensions (their dimensions are generally around 1 to 2 cm; see also Milić 2016: 211) and are much lighter than chert cores (Fig. 4), weighing from 0.2 to 4.5 g.

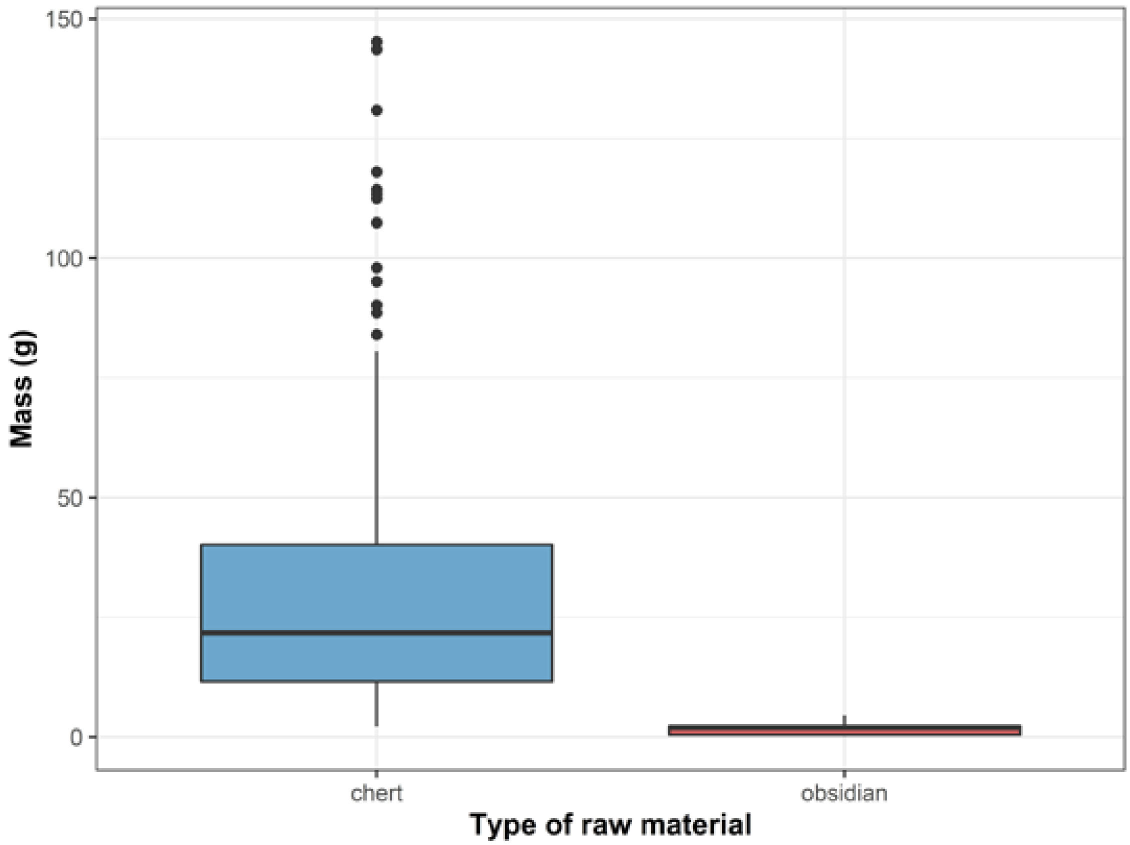

Fig. 4. Box-plot diagram comparing the mass of chert and obsidian cores (Radinović 2022, 50).

The differences in the mass of chert and obsidian cores are statistically significant as indicated by the Mann-Whitney U test ($n = 271$, $U = 3334.5$, $p < 0.01$), with a moderate effect size ($r = 0.36$). Such a high degree of exploitation of obsidian is not surprising given the fact that this exotic raw material probably had some symbolic value for the Neolithic communities in the area (Tripković 2003; Трипковић 2001).

Blank production

Of 1,231 flakes sensu lato, 961 (78.1%) are blades and the remaining 270 (21.9%) are flakes. The percentage of blades is probably even higher, as 57 flakes have blade-like features but cannot be classified as blades with certainty due to fragmentation. Moreover, there are 12 core rejuvenation flakes that are related to blade production, removed in order to renew the striking or the debitage surface of blade cores. Overall, it is clear that blade production was the main goal of the knapping process.

There is only one cortical flake, possibly indicating that the decortification process was not done within the settlement, while the presence of only two blades with a cortex suggests a similar conclusion. However, the presence of two crested blades and 12 rejuvenation flakes indicates on-site blade production, so prepared or semi-prepared laminar cores may have been brought to the settlement where the blade production took place (Bogosavljević Petrović 2015; Milić 2016).

A large percentage (87.6%) of flakes and blades are either intentionally or unintentionally fragmented. Apart from the intentional fragmentation of the prehistoric knappers (e.g., Anderson-Whymark 2015; Slavinsky et al. 2019), some blades were probably fragmented by the excavators of the site – Vasić was rewarding laborers that found obsidian during excavations, so they were intentionally fragmenting obsidian pieces to get higher wages (Garašanin, Garašanin 1953, 26, cited in Palavestra 2020: 79, footnote 70). Moreover, obsidian is a highly brittle material and obsidian pieces are often very thin, so many obsidian flakes might have been fragmented by different post-depositional factors (e.g., Burroni 2002).

Blades

There are 41 whole or almost whole blades in the studied collection, while the remaining blades represent proximal, medial, and distal fragments of blades or, rarely, longitudinally fragmented pieces (Siret fracture) and whole blades with pronounced edge damage. Some blades have breakages that are perpendicular to the flaking axis, which might indicate intentionality in producing regular pieces (Fig. 5). Pseudo-retouch is the most common taphonomic damage, but there are also other post-depositional traces in the form of edge damage, striations, concussions, etc.

The whole obsidian blades are shorter, narrower, thinner, and more standardised than chert blades (Fig. 6). The length of whole unretouched obsidian blades ranges from 12.3 to 61 mm, with a mean of 25.8 mm. The distribution of length of whole blades is not completely continuous and shows the existence of a certain number of outliers (Fig. 7), but there is no clear distinction between blades and bladelets/microblades (Tixier 1963, cited in Inizian et al. 1999, 73). The empirical observation made by Tixier is often uncritically paralleled to other collections (Inizian et al. 1999, 73), even though he suggested that the distinction between blades and bladelets should be established empirically on a case-by-case basis. There is a general trend of decrease in length of whole unretouched blades in younger phases (Table 1), but the Kruskal-Wallis H test shows no statistically significant differences between the groups (n =

Fig. 5. A selection of obsidian blades with regular breakages that are often perpendicular to the flaking axis, possibly indicating intentional fragmentation.

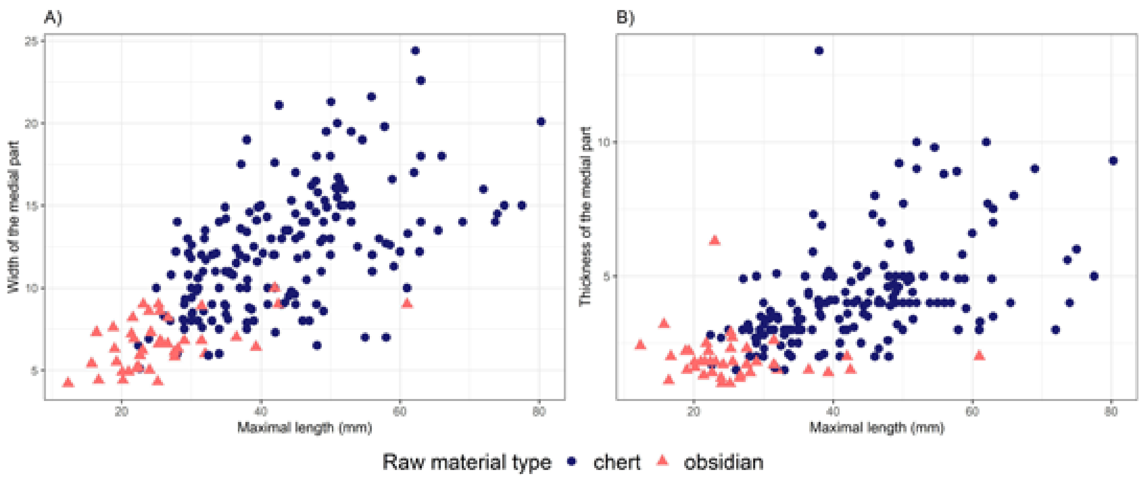

Fig. 6. Scatter-plots comparing the a) maximal length and width of the medial part and b) maximal length and thickness of the medial part of whole unretouched chert and obsidian blades.

40, H = 2.62, df = 2, p = 0.27), so sampling effects cannot be excluded. The length of whole blades becomes more standardised through time, as indicated by the values of coefficient of variation (Table 1), but the low sample sizes are not sufficient for making reliable conclusions.

The maximal length of many entirely preserved obsidian blades (Fig. 5) is generally larger than the maximal dimensions of cores (1 to 2 cm), supporting the conclusion that the obsidian cores are in the later stages of exploitation (see also Radovanović et al. 1984: 20). However, there is a possibility that the whole unretouched blades are not a representative sample of originally produced blades – e.g., Belo Brdo inhabitants might have intentionally fragmented only the larger blades, or thinner blades were more prone to breaking. Although there is a complex relationship between the dimensions of the striking platform and the size of blade blanks, and linear measurements are not suitable for precisely predicting blade size, larger striking platforms are generally expected for larger blades, especially when the punctiform platforms are excluded (see Muller, Clarkson 2014). This knowledge was used for roughly estimating the relative size of broken blades in comparison to entirely preserved blades. Based on the platform dimensions (Fig. 8), it seems that fragmented blades were generally as large as the entirely preserved blades or larger.

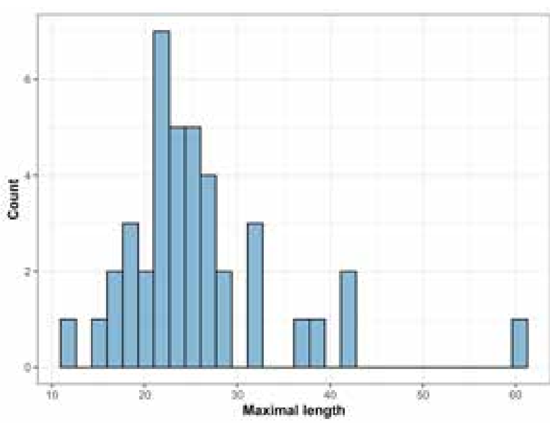

Fig. 7. Histogram showing the distribution of maximal length of whole unretouched obsidian blades.

As already mentioned when discussing obsidian cores, blades were mainly produced from unipolar cores. A similar conclusion is reached by observing blade negatives – they are predominantly parallel (n = 894), less commonly converging (n = 52), and very rarely diverging (n = 1) or multidirectional (n = 3). The Fisher's exact test shows no statistically significant differences in the directionality of removals for blades from different phases (n = 950, p = 0.23, Cramer's V = 0.08), indicating no changes in the knapping method. Concerning the platform preparation, predominantly triangular and trapezoidal striking platforms are most commonly (~1/2) smooth (plain) in all phases, followed by dihedral and damaged (~1/4), facetted and scarred platforms (~1/20), while punctiform and intentionally removed platforms are very rare.

One of the most important aspects of blade production is the choice of a knapping technique (e.g., (Inizian et al. 1999, p. 30; Pelegrin 1990). It is commonly acknowledged that there is an over-

Phase	Count	Mean (mm)	SD (mm)	Min (mm)	Max (mm)	CV
Vinča A	24	27.3	9.9	12.3	61	36.4
Vinča B	12	25.0	6.8	16.7	42.5	27.3
Vinča C	4	20.7	4.2	15.7	25.5	20.3

Table 1. Descriptive statistics for the length of whole unretouched blades by Milojčić's phases.

lap in the features of blades produced by different knapping techniques, so the determination is generally done at the assemblage level rather than inferring the technique for every individual blade (e.g., Damlien 2015; Kooyman 2000: 78). Similarly to Pelegrin and Inizian (2013), based on the presence of different technological stigmata in the sample, I excluded the knapping techniques that were unlikely to have been used for producing the majority of blades. However, as the research on the question of the knapping techniques was discussed mainly for chert (but see Pelegrin 2012), the results should be taken with some caution as there are probably some differences in the fracture mechanics of different raw materials (e.g., Damlien 2015). Moreover, multiple factors influence the observed technological stigmata, such as the properties of the percussor (e.g., Driscoll, Garcia-Rojas 2014; Lengyel, Chu 2014; Pelcin 1997; Pelegrin 2006: 45) or skill level (e.g., Herzlinger et al. 2017), further complicating the recognition of the knapping techniques.

Many features of obsidian blades from Belo Brdo – such as the thinness of blade profiles (mean thickness of the medial part ~ 2 mm) and striking platforms (mean thickness is 1.9 mm), the presence of a lip on 25% of blades with a preserved striking platform, the predominance of diffuse bulbs – are inconsistent with the application of direct percussion with a hard hammer (sensu Inizian et al. 1999: 74; Kooyman 2001, 79, Figure 43; Pelegrin, Inizian 2013). As the striking platforms are not concentrated, but rather spread/wide (Fig. 8), soft stone direct percussion might also be excluded (sensu Pelegrin, Inizian 2013). Punctiform and thin oval butts that are characteristic of pressure debitage (see Damlien 2015: 127) are rare (0.8%). The bulb of percussion is diffuse on 60% of blades, indicating the possible usage of soft hammer (rather than hard hammer) percussion, while there is no consensus on the bulb properties for indirect percussion and pressure blades (see Kooyman 2000: Figure 43; Pelegrin 2006). The percentage of blades with a bulbar scar is 53.6%,

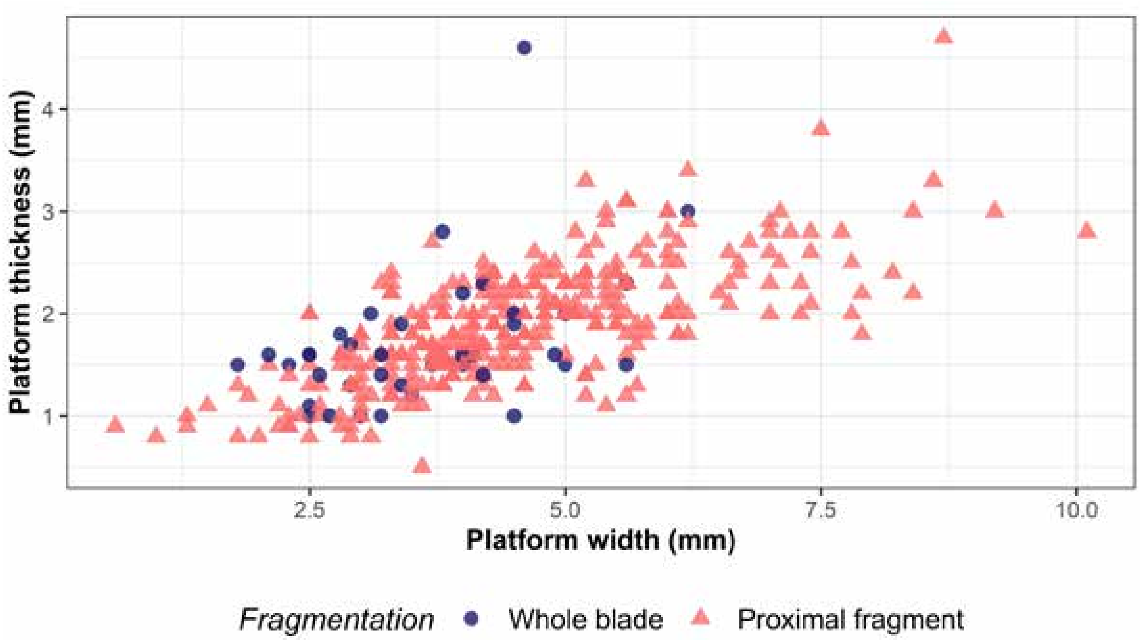

Fig. 8. Scatter plot showing striking platform dimensions for whole and fragmented blades (proximal fragments).

which is, according to Kooyman (2000: Figure 43), consistent with direct percussion using a soft hammer – in the case of the indirect or pressure technique the bulbar scar is rare. However, Table 3 in Damlien (2015; see also Pelegrin 2006: 47) shows that indirect percussion and pressure debitage can also produce moderately high percentages of blades with a bulbar scar (indirect – 45.6%; pressure – 58.1%), so these two knapping techniques cannot be excluded based on the frequency of bulbar scars. A mesial belly, typical of indirect percussion (e.g., Pelegrin 2006), appears only on one out of 41 whole blades from Belo Brdo.

Another important aspect for differentiating between various knapping techniques is regularity – blades produced by indirect percussion and especially pressure debitage are more regular than direct percussion blades (e.g., Buchanan et al. 2016; Inizian et al. 1999; Pelegrin 2006). Milić (2016) has suggested that obsidian blades in this collection are very regular and were possibly produced by pressure debitage. According to a subjective measure of blade regularity that was based on a visual assessment (e.g., Damlien 2015), 5 blades (0.5%) are irregular, 810 blades (85.1%) are moderately regular, and 137 blades (13.3%) are very regular. Percentages of irregular, moderately regular, and very regular blades somewhat differ among the phases (**Table 2**), but Fisher's exact test has shown that these differences are not statistically significant (n = 953, p = 0.22, Cramer's V = 0.05). The percentage of very regular blades is higher than expected for direct percussion techniques but lower than for indirect and pressure techniques (Damlien 2015, Table 3).

To assess the issue of blade regularity more formally and explore other aspects of blade shape that are related to the knapping technique (Radinović, Kajtez 2021), the Elliptic Fourier Analysis was applied to the outlines of whole obsidian blades. The first three principal components, which explain a total of 94.3% of blade outline variability, are elongation, side-to-side symmetry, and tip-base width ratio (Fig. 9). Based on the PCA plots (Fig. 9), it can be concluded that the obsidian blades from Belo Brdo are most similar to blades produced using direct percussion. However, certain blades have features that are not typical for direct percussion – they are somewhat more elongated than the majority of other obsidian blades from Belo Brdo; the maximal width of certain blades is located in the proximal part, which might be indicative of a pressure debitage (Fig. 9); e.g., Inizian et al. 1999; Pelegrin 2006; Radinović, Kajtez 2021). Another indication for the possible use of pressure debitage for blade production is the presence of a regular bullet-shaped core (Fig. 10), typical for this knapping technique (e.g., Inizian et al. 1999).

To summarise the insights based on different morphological and technical stigmata –direct percussion using a hard hammer and probably a soft stone hammer can be excluded as unlikely; the features that are typical for blades produced by indirect percussion and pressure debitage are not common in the studied sample; thus, direction percussion using a soft organic hammer seems to be a predominant knapping technique for producing the obsidian blades from the Late Neolithic levels of Vinča-Belo Brdo. However, there are some features of blades (bullet-shaped core, location of maximal width in the proximal part, somewhat higher percentage of very regular blades) that are consistent with the use of pressure debitage. Thus, this knapping technique might have been sporadically used for producing obsidian blades. Pelegrin (2012) defined five modes of pressure debitage – from the use of a hand-held pressure tool to the use of a lever – and suggested that the maximal width of blades is suitable for distinguishing between them. By comparing the distribution of the maximal width of very regular obsidian blades (0.5 to 0.7 mm) from Belo Brdo with the maximal width of experimentally produced blades in Figure 18.12 of his article, it can be concluded that modes 1, 2, 3, and 4 were possibly utilised by Belo Brdo inhabitants. However, these blades from Belo

Phase	Irregular (%)	Moderately regular (%)	Very regular (%)
Vinča A	0.5	85.2	14.2
Vinča B	0.3	82.9	16.8
Vinča C	1.3	92.4	6.3
Vinča D	0.0	100.0	0.0

Table 2. Percentages of irregular, moderately regular, and regular blades in Milojčić's phases.

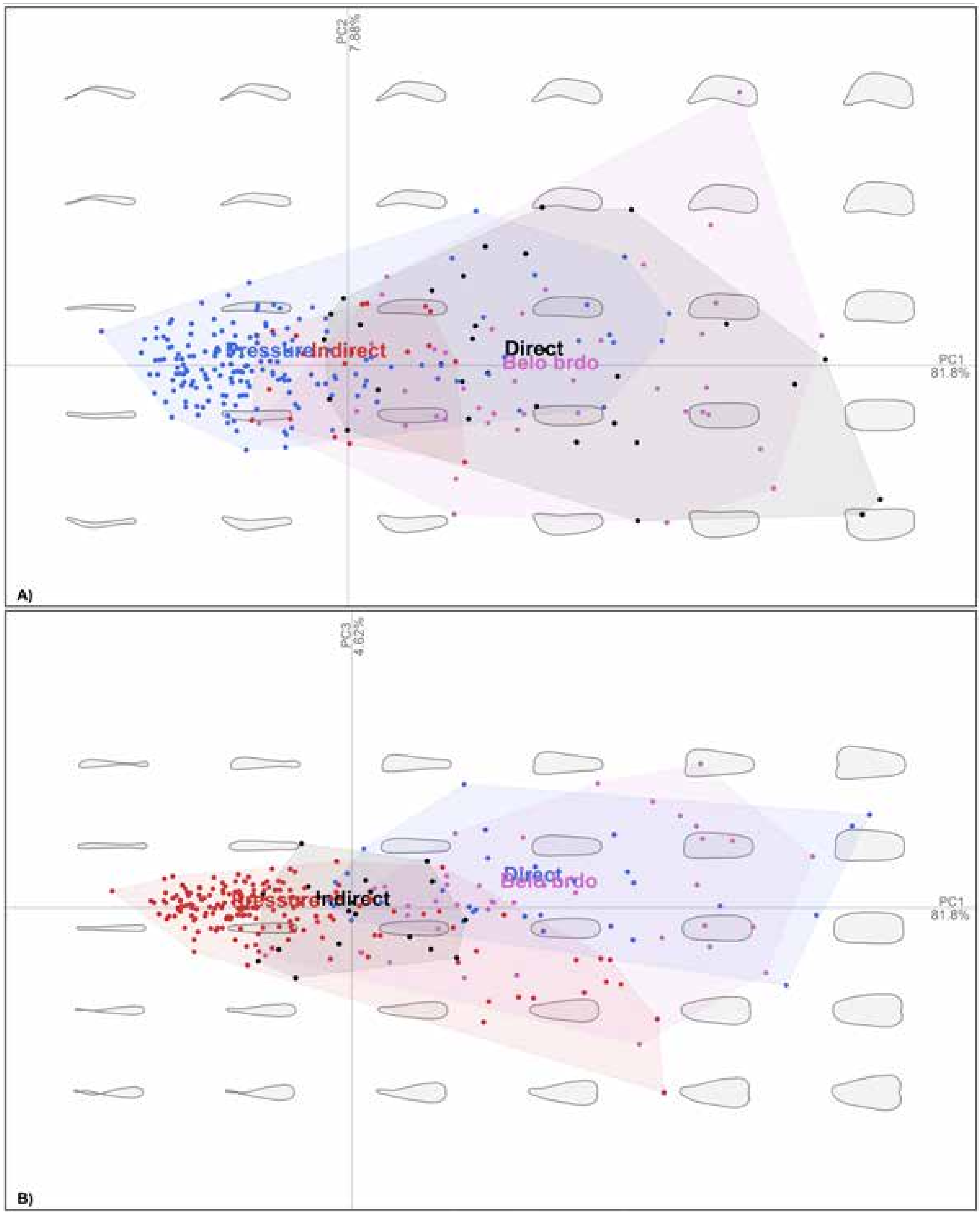

Fig. 9. Scatter plots of a) PC1 and PC2 and b) PC1 and PC3 showing the main shape differences between the whole unretouched obsidian blades from Vinča-Belo brdo and blades that were experimentally produced using different knapping techniques (see Radinović, Kajtez 2021): direct percussion (black), indirect percussion (red), pressure debitage (blue), Vinča-Belo brdo (purple).

Brdo are not as elongated and regular (symmetrical and standardised) as the blades produced by modes 3 and 4 (Radinović, Kajtez 2021, Fig. 7), so modes 1 and 2 seem most likely. Although mode 1 and 2 of pressure debitage require a high skill level, they can be fairly easily transmitted by observation and imitation, unlike more complex modes of pressure debitage (Pelegrin 2012). Thus, it is questionable if the presence of these modes of pressure debitage is indicative of craft specialisation (cf. Milić 2016: 223).

Fig. 10. Bullet-shaped core from Belo brdo site.

Retouch

Only 8 out of 270 (3.0%) of flakes are retouched on a lateral side (sidescrapers), a distal end (endscrapers), or an undeterminable side (scrapers) in the case of fragmented pieces. The percentage of retouched obsidian blades is also low, as only 70 out of 961 blades (7.3%) are retouched. Clarkson's index of invasiveness ranges from 0.03 to 0.41, with a mean of 0.11, indicating that the blades were usually only lightly retouched. A small number of retouched pieces and Clarkson's index of invasiveness show an opposing image to that of cores, where an effort was made to exploit the raw material as much as possible, which is an intriguing insight.

CONCLUSIONS

A large collection of obsidian finds from Belo Brdo, curated at the Archaeological Collection of the University of Belgrade, has had an important place in providing knowledge about the Late Neolithic on both a local and regional scale. In this study, it was shown how the preliminary data from new excavations of Belo Brdo questions some long-established facts that were based on this obsidian collection, such as the disappearance of obsidian during the Vinča D phase and large percentages of obsidian in relation to chert,[4] as well as the corresponding narratives. Thus, caution is needed when interpreting the material from this (and other) old collection(s), and the narratives that were based on it should be re-evaluated when possible.

On the other hand, this collection offers a rare opportunity to explore lithic technology and other aspects of Late Neolithic societies based on such a large quantity of finds. The amount of obsidian that was brought to the site was probably small in comparison to chert (see footnote 4), but it was used for producing a large number of small (short, narrow, and thin) blades. As there are almost no cortical pieces, while there are pieces from subsequent stages of core reduction (crested blades, core rejuvenation flakes, flakes, cores and waste), it seems that the obsidian was imported in the form of partially prepared cores or decorticated nodules to Belo Brdo, where the blade production occurred (see also Bogosavljević Petrović 2015: 84, 410; Milić 2021: 570). The very small dimensions of cores indicate that obsidian was fully exploited by Belo Brdo inhabitants, probably as they valued this raw material that originated from a distant source, although retouch was rarely applied to prolong the use of flakes and blades or (re)shape them. The predominant knapping technique for producing blades seems to be direct percussion using a soft organic hammer (*cf.* Milić 2016; Milić 2021: 573), while the pressure technique might also have been utilised sporadically. There seem to be no notable diachronic changes in the choices of the utilised knapping techniques, as suggested for the production of chert blades (Bogosavljević-Petrović 2015; 2018). However, the identification of knapping techniques in the archaeological record "remains as much a delicate matter as an interesting one" (Pelegrin 2006: 66).

Based on the very high degree of core exploitation, the production of fairly regular and standardised blades, and the low incidence of knapping errors (e.g., crushed platforms, overshot blades), it can be concluded that the knap-

4 It should be noted that the obsidian pieces are very light – the mass of all 916 obsidian blades and cores is between 338 and 436 g (taking into account the precision of the scales), so all the obsidian pieces could have been produced from a relatively small amount of raw material. In contrast, some chert cores from Belo Brdo weigh more than 100 g (Radinović, in preparation). Thus, it is questionable if the commonly used percentages of obsidian/chert pieces are good indicators of the amount of obsidian that was brought to the site.

pers at Belo Brdo were skilled at producing fine blades from obsidian cores. The blade production technology shows no notable diachronic changes over the course of some six centuries (from 9.3 to 3.8 m, see Tasić et al. 2015b), indicating that the technological knowledge was faithfully transmitted down the generations. Therefore, the obsidian production at Belo Brdo might best be explained by the concept of "skilled production and social reproduction" (Apel, Knuttson 2006). However, despite the possible presence of pressure debitage and the inference about the skilled production at Belo Brdo, craft specialisation should not be easily assumed – there are no indications of more complex modes of pressure debitage (modes 3 and higher; Pelegrin 2012), which require a very high skill level and a more intimate process of transmission of knowledge (Pelegrin 2012), nor does the current contextual data point to the existence of specialised workshops. Thus, there are no reasons to suggest that there was a (full-time) specialised production of obsidian tools, which is in line with most other evidence regarding artifact production in the Late Neolithic of the Central Balkans (see Amicone et al. 2020; Chapman 1981; 2020; Greenfield 1991; Kaiser and Voytek 1983; Porčić 2019; Radivojević, Rehren 2016; Spataro 2018; Vitezović, Antonović 2020; Vuković 2011).

Collections of artifacts from old excavations represent an important part of our cultural heritage, and care should be taken to preserve, document, explore, and present these collections. The results of this study show that, although caution is needed in generating insights into the past based on this old collection due to the shortcomings of Vasić's evidence (see above; Palavestra 2020), it can be a valuable source for making new inferences about the past.

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BIBLIOGRAPHY

Amicone, S., Mathur, A.R., Pavitra, R.D., Mirković-Marić, N., Pantović, I. and Kuzmanović-Cvetković, J. 2020.
Beneath the surface: Exploring variability in pottery paste recipes within Vinča culture. *Quaternary International*, 560: 86-101.

Anderson-Whymark, H. 2015.
Intentional breakage in the British Neolithic: some comments and examples. *Lithics–The Journal of the Lithic Studies Society*, (32): 16.

Andrefsky, William., Jr. 2005.
Lithics: Macroscopic Approaches to Analysis. Second Edition. Cambridge University Press, New York.

Bogosavljević Petrović, V. 2015.
Razvoj industrije okresanog kamena u vinčanskoj kulturi na teritoriji Srbije. Neobjavljena doktorska disertacija. Univerzitet u Beogradu – Filozofski fakultet.

Bogosavljević Petrović, V. 2021.
Chert microperforators from Vinča. *Zbornik Narodnog muzeja u Beogradu* XXV/1: 37-38.

Bogosavljević Petrović, V. 2018.
Standardization of chipped stone artefacts and pattering of lithic raw material: Procurement strategies in the Late Neolithic and Early Chalcolithic in Serbia – tradition, strategy or request?. In: *Artisan Rules*, eds. Jasna Vuković and Ina Miloglav, 89–119. Cambridge: Cambridge scholars publishing.

Bonhomme, V., Picq, S., Gaucherel, C. and Claude, J. 2014.
Momocs: outline analysis using R. *Journal of Statistical Software*, 56(13): 1-24.
Borić, D., 2016. A view of Vinča from Cambridge: Minns' reviews of the 1930s publications by Vasić. *Istraživanja* 27: 7-32.

Buchanan, B., Mraz, V. and Eren, M.I. 2016.
On identifying stone tool production techniques: an experimental and statistical assessment of pressure versus soft hammer percussion flake form. *American Antiquity,* 81 (4): 737-751.

Burroni, D., Donahue, R.E., Pollard, A.M. and Mussi M., 2002.
The surface alteration features of flint artefacts as a record of environmental processes. *Journal of Archaeological Science*, 29(11): 1277-1287.

Caple, J., Byrd, J. and Stephan, C.N. 2017.
Elliptical Fourier analysis: fundamentals, applications, and value for forensic anthropology. *International Journal of Legal Medicine*, 131(6): 1675-1690.

Chapman, J. 1981.
The Vinča culture of south-east Europe: studies in chronology, economy and society (Vol. 117). BAR.

Chapman, J. 2020.
The Vinča group-(Almost) 40 years on John Chapman (independent scholar). *Quaternary International*, 560: 5-19.

Clarkson, C. 2002.
An index of invasiveness for the measurement of unifacial and bifacial retouch: a theoretical, experimental and archaeological verification. *Journal of Archaeological Science*, 29(1): 65-75.

Damlien, H. 2015.
Striking a difference? The effect of knapping techniques on blade attributes. *Journal of Archaeological Science*, 63: 122-135.

Garašanin, M. 1979.
Vinčanska grupa, In: *Praistorija jugoslavenskih zemalja II – neolitsko doba*, ed. Alojz Benac, 144-207. Sarajevo: Akademija nauka i umjetnosti Bosne i Hercegovine – Centar za balkanološka ispitivanja i Svjetlost.

Глишић, J. 1968.
Економика и социјалноекономски односи у неолиту Подунавско-Поморавског басена. у: Неолит централног Балкана, ур. Лазар Трифуновић, 21-61. Београд: Народни музеј.
(Glišić, J. 1968.
Ekonomika i socijalnoekonomski odnosi u neolitu Podunavsko-Pomoravskog basena. u: Neolit centralnog Balkana, ur. Lazar Trifunović, 21-61. Beograd: Narodni muzej).

Greenfield, H. J. 1991.
A Kula ring in prehistoric Europe? A consideration of local and interregional exchange during the Late Neolithic of the Central Balkans. In: *Between bands and states*, (ed.) S.A. Gregg, 287-308. Occasional Paper 9, Center for Archaeological Investigation, Southern Ilinois University, Carbondale.

Hoggard, C.S., McNabb, J. and Cole, J.N. 2019.
The application of elliptic Fourier analysis in understanding biface shape and symmetry through the British Acheulean. *Journal of Paleolithic Archaeology*, 2(2): 115-133.

Inizan, M.-L., Reduron-Ballinger, M., Roche, H. and Tixier, J. 1999.
Technology and Terminology of Knapped Stone. Nanterre: CREP.

Kaczanowska, M. and Kozlowski, J. K. 1990.
Chipped Stone Industry of the Vinča Culture. In: *Vinča and its World, International Symposium The Danubium Region from 6000 to 3000 B.C.*, ed. D. Srejović, Belgrade: Serbian Academy of Sciences and Arts, Centre for Archaelogical Research Faculty of Philosophy, 35-47.

Kaiser, T. and Voytek, B. 1983.
Sedentism and economic change in the Balkan Neolithic. *Journal of Anthropological Archaeology*, 2(49): 323-353.

Kassambara, A. 2020.
ggpubr: 'ggplot2' Based Publication Ready Plots. R package version 0.4.0.

Kooyman, B.P. 2000.
Understanding stone tools and archaeological sites. UNM Press.

Kuhl, F.P. and Giardina, C.R. 1982.
Elliptic Fourier features of a closed contour. *Computer graphics and image processing*, 18(3): 236-258.

Lengyel, G. and Chu, W. 2016.
Long thin blade production and Late Gravettian hunter-gatherer mobility in Eastern Central Europe. *Quaternary International*, 406: 166-173.

Марић, М. 2011.
Алтернативни приступ реконструкцији вредности апсолутног репера са ископавања Милоја Васића на локалитету Бело брдо у Винчи 1911-1934. Гласник Српског археолошког друштва, 27: 273-286.

Marić, M. 2015.
Modelling obsidian trade routes during Late Neolithic in the South-East Banat region of Vršac using GIS. *Starinar*, (65): 37-52.

Marwick, B. 2017.
Computational reproducibility in archaeological research: basic principles and a case study of their implementation. *Journal of Archaeological Method and Theory*, 24 (2): 424–450.

Milić, M. 2014.
PXRF characterisation of obsidian from central Anatolia, the Aegean and central Europe. *Journal of Archaeological Science*, 41: 285-296.

Milić, M. 2016.
Obsidian exchange and societies in the Balkans and the Aegean from the late 7th to 5th millennia BC. Doctoral dissertation, UCL (University College London).

Milić, M. 2021.
Chemical and technological analyses of obsidian from Belovode. In: *The Rise of Metallurgy in Eurasia: Evolution, organization and consumption of early metal in the Balkans*, eds. Radivojević et al., Archaeopress, 233-235.

Muller, A. and Clarkson, C. 2014.
Estimating original flake mass on blades using 3D platform area: problems and prospects. *Journal of Archaeological Science*, 52: 31-38.

Muller, A., Clarkson, C. and Shipton, C. 2017.
Measuring behavioural and cognitive complexity in lithic technology throughout human evolution. *Journal of Anthropological Archaeology*, 48: 166-180.

Navarro, D. J. 2015.
Learning statistics with R: A tutorial for psychology students and other beginners. (Version 0.6) University of New South Wales. Sydney, Australia.

Palavestra, A. 2012.
Vasić pre Vinče (1900-1908). *Etnoantropološki problemi*, 7(3): 649-679.

Palavestra, A. 2013.
Čitanja Miloja M. Vasića u srpskoj arheologiji. *Etnoantropološki problemi*, 8(3): 681-715.

Palavestra, A. 2020.
Usamljeni arheolog. Terenski metod Miloja M. Vasića. Beograd: Filozofski fakultet, Univerzitet u Beogradu.

Palavestra, A. and Babić, S. 2016.
False analogy: Transfer of theories and methods in archaeology (the case of Serbia). *European Journal of Archaeology*, 19(2): 316-334.

Pelegrin, J. 1990.
Prehistoric lithic technology: some aspects of research. *Archaeological review from Cambridge*, 9(1): 116-125.

Pelegrin, J. 2006.
Long blade technology in the Old World: an experimental approach and some archaeological results. In: Skilled production and social reproduction, eds. J. Apel and K. Knutsson, 37-68.

Pelegrin, J. 2012.
New experimental observations for the characterization of pressure blade production techniques. In: *The emergence of pressure blade making*, ed. P.M. Desrosiers, 465-500. Springer, Boston, MA.

Pelegrin, J. and Inizan. M.-L. 2013.
Soft hammerstone percussion use in bidirectional blade-tool production at Acila 36 and in bifacial knapping at Shagra (Qatar). *Arabian Archaeology and Epigraphy* 24.1: 79-86.

Perlès, C. 2001.
The Early Neolithic in Greece: The First Farming Communities in Europe. Cambridge University Press.

Porčić, M. 2019.
Evaluating social complexity and inequality in the Balkans between 6500 and 4200 BC. *Journal of Archaeological research*, 27(3): 335-390.

R Core Team 2020.
R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Radinović, M. 2020.
Socijalne i demografske implikacije varijabilnosti antropomorfnih figurina i alatki od okresanog kamena na kasnoneolitskom lokalitetu Vinča-Belo Brdo, unpublished PhD, Beograd: Filozofski fakultet Univerziteta u Beogradu.

Radinović, M. and Kajtez, I. 2021.
Outlining the knapping techniques: Assessment of the shape and regularity of prismatic blades using elliptic Fourier analysis. *Journal of Archaeological Science: Reports*, 38: 103079.

Radivojević, M. and Rehren, T. 2016.
Paint it black: the rise of metallurgy in the Balkans. *Journal of Archaeological Method and Theory*, 23(1): 200-237.

Radovanović, I., Kaczanowska, M., Kozłowski, J.K., Pawlikowski, M. and Voytek, B. 1984.
The Chipped Stone Industry from Vinča (Excavation 1929-1934). Centre for Archaeological Research, Vol. 4. Beograd.

Robb, J. 2007.
The early Mediterranean village: agency, material culture, and social change in Neolithic Italy. Cambridge University Press.

Rohlf, F.J. 2017.
TPS Dig computer program. Stony Brook, New York.

Rohlf, F.J. 2019.
tpsUtil-TPS utility program. State University at Stony Brook, Stony Brook, New York.

Schier, W. 1996.
The relative and absolute chronology of Vinĉa: new evidence from the type site. In: *The Vinča culture, its role and cultural connections*, ed. F. Drasovean, 141-162. Timisoara: The Museum of Banat.

Schier, W. 2000.
Measuring change: the Neolithic pottery sequence of Vinĉa-Belo Brdo. *Documenta Praehistorica*, 27: 187–197.

Shea, J. J. 2013.
Stone tools in the Paleolithic and Neolithic Near East: A guide. Cambridge University Press.

Sheets, P.D. and Muto, G. R. 1972.
Pressure blades and total cutting edge: an experiment in lithic technology. *Science*, 175 (4022): 632-634.

Shennan, S. 1997.
Quantifying archaeology. University of Iowa Press.

Slavinsky, V.S., Rybin, E.P., Khatsenovich, A.M. and Belousova, N.E. 2019.
Intentional fragmentation of blades in the initial upper Paleolithic industries of the Kara-Bom site (Altai, Russia). *Archaeological Research in Asia*, 17: 50-61.

Slice, D. E. 2007.
Geometric morphometrics. *Annual Review of Anthropology*, 36: 261-281.

Sollberger, J. B. and Patterson, L.W. 1976.
Prismatic blade replication. *American Antiquity*, 41(4): 517-531.

Sørensen, M. 2006.
Rethinking the lithic blade definition: towards a dynamic understanding. In: *Skilled production and social reproduction*, eds. J. Apel and K. Knutsson, 277-296.

Spataro, M. 2018.
Origins of Specialization: The Ceramic Chaîne Opératoire and Technological Take-Off at Vinča-Belo Brdo, Serbia. *Oxford Journal of Archaeology*, 37(3): 247-265.

Srejović, D. 1981.
Kulture mlađeg kamenog doba na tlu Srbije. U: *Istorija srpskog naroda I*, ur. S. Ćirković, 15-30.

Срејовић, Д. 2001.
Кад смо били културно средиште света. У: Искуства прошлости, ур. В. Јовић, 115-140.
(Srejović, D. 2001.
Kad smo bili kulturno središte sveta. U: Iskustva prošlosti, ur. V. Jović, 115-140).

Srejović, D. and Jovanović, B. 1957.
Pregled kamenog oruđa i oružja iz Vinče. *Arheološki Vestnik*, 7: 256-296.

Sullivan, A. P. and Rozen, K.C. 1985.
Debitage analysis and archaeological interpretation. *American antiquity*, 50(4): 755-779.

Tasić, N. N. 2005.
Vinča–the third glance (excavations 1998–2002). *Prehistoric archaeology and anthropological theory and education*:1-8.

Tasić, N. 2011.
Interdisciplinary approach in archaeology – Case study Vinča, In: *Interdisziplinäre Forschungen zum Kulturerbeauf der Balkanhalbinsel*, eds. V. Nikolov, K. Sofia: Humboldt Kolleg, 53-72.

Tasić, N., Marić, M., Penezić, K., Filipović, D., Borojević, K., Borić, D., Reimer, P., Russell, N., Bayliss, A., Barclay, A., Gaydarska, B. and Whittle, A. 2015.
The end of the affair: formal chronological modelling for the top of the Neolithic tell of Vinča-Belo Brdo. *Antiquity*, 89: 1064-1082.

Tasić, N., Marić, M., Bronk Ramsey, C., Kromer, B., Barclay, A., Bayliss, A., Beavan, N., Gaydarska, B. and Whittle, A. 2015.
Vinča-Belo Brdo, Serbia: the times of a tell. *Germania*, 93: 1-76.

Tasić, N., Marić, M., Filipović, D., Penezić, K., Dunbar, E., Reimer, P., Barclay, A., Bayliss, A., Gaydarska, B., Whittle, A. 2016.
Interwoven strands for refining the chronology of the Neolithic tell of Vinča-Belo Brdo, Serbia. *Radiocarbon*, 58 (4): 795-831.

Tostevin, G. B. 2012.
Seeing lithics: A middle-range theory for testing for cultural transmission in the Pleistocene. American School of Prehistoric Research Monograph Series, Peabody Museum, Harvard University. Oxford, UK, and Oakville, CT: Oxbow Books.

Трипковић, Б. 2001.
Улога опсидијана у неолиту: Утилитарни предмети или средство престижа. Гласник Српског археолошког друштва 17: 21-42.

Tripković, B. 2003.
The quaility and value in neolithic europe: an alternate view of obsidian artifacts. In: eds. Ts. Tsonev and E. Montagnari-Kokelj, *The Humanized Mineral World: towards Social and Symbolic Evaluation of Prehistoric Technologies in South Eastern Europe,* Proceedings of the ESF Workshop, Sofia 3-6 September 2003. Etudes et Recherches Archeologiques de l'Universite de Liege, 119-123.

Tripković, B. 2004.
Obsidian deposits in the central Balkans? Tested against archaeological evidence. *Starinar*, 53-54; 163-179.

Tripković, B. 2006.
Marine goods in European prehistory: A new shell in old collection. *ANALELE BANATULU, Arheologie – Istorie*, 14, 1: 89-102.

Tripković, B. and Milić, M. 2008.
The origin and exchange of obsidian from Vinĉa-Belo Brdo. *Starinar* 58: 71-86.

Васић**, М. 1932.**
Преисториска Винча *1*. Београд: Државна штампарија Краљевине Југославије.

Васић**, М. 1936.**
Преисториска Винча *2*, Београд: Државна штампарија Краљевине Југославије.

Васић**, М. 1936.**
Преисториска Винча *3*, Београд: Државна штампарија Краљевине Југославије.

Васић**, М. 1936.**
Преисториска Винча *4*, Београд: Државна штампарија Краљевине Југославије.

Vitezović S., Antonović D. 2020.
Functional differentiation and possible regional specialisation of the Vinča culture settlements: Viewpoint from osseous and lithic industries. *Quaternary International*, 539: 39-48.

Voytek, B. 1990.
The use of stone resources. In: eds. Tringham, R.

and Krstić, *Selevac: A Neolithic Village in Yugoslavia* (No. 15), 437-494. Cotsen Institute of Archaeology.

Vuković, J. 2011.
Late Neolithic pottery standardization: application of statistical analyses. *Starinar*, 61: 81-100.

Wickham, H. 2016.
ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Wickham, H., François, R., Henry, L. and Müller, K. 2021.
dplyr: A Grammar of Data Manipulation. R package version 1.0.3.

Williams-Thorpe, O., S.E. Warren and J.G. Nandris 1984.
The Distribution and Provenance of Archaeological Obsidian in Central and Eastern Europe, *Journal of Archaeological Science* 11: 183-212.

REZIME

STARA KOLEKCIJA I NOVI UVIDI: TEHNOLOŠKA ANALIZA OPSIDIJANSKIH NALAZA IZ KASNONEOLITSKIH SLOJEVA LOKALITETA VINČA-BELO BRDO

KLJUČNE REČI: OPSIDIJAN, VINČA-BELO BRDO, KASNI NEOLIT, TEHNOLOGIJA, SEČIVA, TEHNIKA OKRESIVANJA, SPECIJALIZACIJA.

U Arheološkoj zbirci Filozofskog fakulteta u Beogradu deponovan je veliki broj nalaza od opsidijana, prikupljenih tokom iskopavanja Miloja Vasića između 1929. i 1934. godine. I pored duge istorije istraživanja Belog brda i alatki od okresanog kamena sa ovog lokaliteta, detaljna tehnološka analiza ovog materijala do sada nije sprovedena, već se uglavnom radilo o veoma opštim uvidima u ovu kolekciju. U ovoj studiji analizirano je 1261 nalaza od opsidijana iz slojeva kasnog neolita, sa ciljem da se sintezom rezultata tehnološke analize sa novim saznanjima o lokalitetu pruže novi uvidi o životu kasnoneolitskih zajednica na ovim prostorima. Podaci sa novih iskopavanja Belog brda (od 1998. godine) pokazali su da je validnost određenih aspekata Vasićeve kolekcije opsidijana upitna, verovatno usled određenih pristrasnosti u prikupljanju ili skladištenju nalaza – veoma visoki procenti opsidijana u određenim fazama dovedeni su u pitanje, s obzirom da je procenat opsidijana u odnosu na rožnac daleko manji kada se posmatra materijal sa novih iskopavanja; opsidijan ne nestaje sa Belo brda tokom finalne faze kasnog neolita (tj. nakon 3.8 m) kao što je zaključeno na osnovu Vasićeve kolekcije, već je prisutan i nakon toga. Sa druge strane, veliki broj nalaza u ovoj kolekciji svakako je omogućio da se steknu određeni uvidi u različite aspekte tehnologije izrade opsidijanskih alatki. Rezultati su pokazali veoma visok nivo iskorišćenosti jezgara, koja su mahom korišćena za proizvodnju „finih“ (kratkih, tankih i uskih) sečiva. Tehnološka analiza ukazala je da je za proizvodnju najvećeg broja sečiva verovatno korišćena tehnika direktnog okresivanja upotrebom mekog organskog čekića, dok je tehnika pritiska (modovi 1 i 2) mogla biti korišćena za dobijanje manjeg broja sečiva. Na osnovu različitih tehnoloških aspekata zaključeno je da su se obradom opsidijana bavile vešte zanatlije, koje su reprodukovale svoje znanje, s obzirom da nisu uočene dijahrone promene u obrascima okresivanja, ali nema naznaka da se radilo o specijalizovanoj proizvodnji opsidijanskih sečiva. Može se zaključiti da, iako je potreban oprez pri intepretaciji ove kolekcije opsidijanskih nalaza, ona može poslužiti za sticanje novih uvida o prošlosti.

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