

# Born again: multiple biographies of ground and abrasive stone tools in the Neolithic of Serbia

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**ABSTRACT** - *Ground and abrasive stone tools had a long, dynamic and complex life during which they could repeatedly pass through different segments of the operational chain until their final disposal. Those tools would wear out slowly and could be used for a long time with constant renewal. Even after being damaged, they would start a new life cycle through various recycling processes or in a secondary context. The aim of this paper is to consider the transformative processes within the ground and abrasive stone industry in the Neolithic of Serbia and clarify their use in terms of maintenance, secondary use, and recycling, as well as to show the most frequent examples of such technological practices. The focus is primarily on tools for everyday use and the ways in which they were rerouted through various segments of the operational chain.*

**KEY WORDS** - *ground and abrasive stone tools; maintenance; secondary use; recycling; Balkans*

## **Ponovno rojena: večkratne biografije kamnitih glajenih orodij in orodij za brušenje v neolitiku Srbije**

**IZVLEČEK** - *Kamnita glajena orodja in orodja za brušenje so imela dolgo, dinamično in kompleksno življenjsko dobo, v kateri so lahko večkrat prešla različne korake operacijske sekvence od obnavljanja do opustitve uporabe. Ta orodja se obrabljajo počasi, zato jih lahko s stalnim obnavljanjem uporabljamo dolgo časa. Čeprav poškodovana, so zaradi različnih postopkov recikliranja, tudi v sekundarnih kontekstih, začela nov življenjski cikel. V prispevku predstavljamo transformativne procese pri zbirih kamnitih glajenih orodij in orodij za brušenje v neolitiku Srbije in pojasnujemo njihovo uporabo v povezavi z vzdrževanjem, ponovno uporabo in recikliranjem ter predstavljamo najbolj pogoste primere tovrstnih tehnoloških praks. Izpostavljamo predvsem orodja za vsakodnevno uporabo in načine njihovega vračanja v različne stopnje operativne sekvence.*

**KLJUČNE BESEDE** - *glajena orodja in orodja za brušenje; vzdrževanje; ponovna uporaba; recikliranje; Balkan*

## **Introduction**

Stone has always been a highly valued raw material due to its natural properties. Because of its low solubility and incombustibility, it is essentially indestructible. The only imperfection could be its fragility, although it does not disappear even after breaking, and the remaining pieces can be used for a long

time – as a tool, decoration or building material. As such, the human commitment to stone as a raw material has a very deep history, and remained unchanged even after the appearance of metal. Due to the hardness, longevity, and durability of this raw material, stone tools had a long, dynamic, and complex life

cycle, during which they could repeatedly circulate through various segments of the operational chain, until their final disposal.

Techno-functional analyses of Neolithic ground and abrasive stone tools from several sites in Serbia (Fig. 1) contributed to the identification of all stages of the process through which one ground or abrasive stone tool could pass until it would end up as a discarded product in an archaeological context. Such an approach allowed the reconstruction of the life histories for most types of those tools.

This paper aims to consider the transformative processes within the ground and abrasive stone industry in the Neolithic of Serbia and clarify their use in terms of maintenance, secondary use, and recycling, as well as to show the most frequent examples of such technological practices. The focus is primarily on tools for everyday use and the ways in which they were rerouted through various segments of the operational chain.

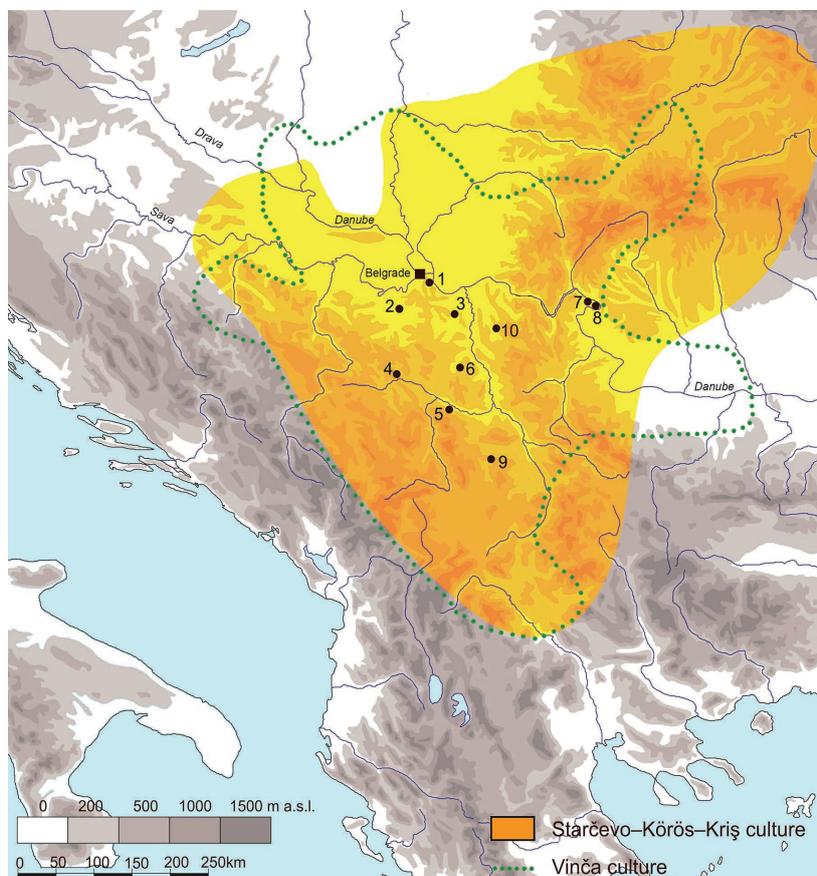
### Neolithic in Serbia: geographical and chronological framework

The Neolithic in the territory of today's Serbia was determined by two very significant cultures – the Starčevo and Vinča cultures (Fig. 1) (Garašanin 1979:145–149; Borić 2009:192; Tasić et al. 2015a; Whittle et al. 2016:2).

The Starčevo culture (c. 6200–5000 BC, Whittle et al. 2002; Minichreiter, Krajcar Bronić 2006) belonged to the Early Neolithic Starčevo–Körös–Criş cultural complex, spread across the large territory of South-Eastern Europe and the Pannonian Plain (Fig. 1). The Starčevo culture itself was present in the territory of today's North-Eastern Croatia and all of Serbia. This was the first Neolithic culture of the middle Danubian Basin. During that time, an economic and technological basis was formed within it, which enabled the appearance of the advanced and highly developed Late Neolithic Vinča and Sopot cultures in this

area. The latest palaeodemographic research activities suggest that the end of the Starčevo culture was marked by a significant decrease of the population, which suddenly increased again at the beginning of the Vinča culture, when changes began to occur in the material culture (Porčić et al. 2016:7–8).

The Vinča culture (5400–4500/4450 cal BC, Borić 2009; Orton 2012; Tasić et al. 2015a) was a Late Neolithic culture which continued on into the Starčevo culture, partially overlapping with it in the initial phase. Important changes occurred during the Vinča culture period: the organization of settlements was different, with intense construction of above-the-ground buildings (Tripković 2009; 2013), the technology of making and the style of decorating pottery were new (Vuković 2020), and the production of stone and bone tools increased, giving a special distinction to this culture (Antonović 2003; Vitezović 2013). In this period, the exchange network also began to spread, which probably also caused changes in the system of social organization (Dimitrijević, Tripković 2006; Tripković 2004).



**Fig. 1.** Map of the Neolithic sites mentioned in the paper: 1 Vinča; 2 Mali Borak; 3 Selevac; 4 Trsine; 5 Ladarište; 6 Divostin; 7 Ajmana; 8 Zbradila; 9 Pločnik; 10 Belovode.

The economy of the Starčevo and Vinča cultures was based on agriculture. Several types of cereals (emmer wheat, einkorn wheat, barley, *etc.*) were cultivated, domestic animals (goats, sheep, bovine and pigs) were bred, and hunting and fishing also had an important role as additional food sources. In such a stable economy, the production of specialized stone tools rose to a very high technological level, most visible at the end of the Vinča culture (Vitezović, Antonović 2019).

The sudden development of stone tools began at the end of the Starčevo and the beginning of the Vinča culture. Ground and abrasive stone tools became more numerous, more typologically diverse and more uniform in terms of the choice of raw materials. Use-wear traces indicate a prominent specialization of tools, and technological traces – a standardization in their production (Antonović 2003; Vitezović, Antonović 2019; Dimić 2020; Dimić, Antonović 2021a; 2021b; 2021c).

### Methods and materials

The manner in which a stone artefact was made, from the choice of raw materials to its final form, as well as the ways in which it was used, repaired, damaged, discarded or reused, represent technological sequences that, as part of a wider technological system, directly reflect traditions and cultural practices of a community (Lemonnier 1986.154; 1992.5–9; 2012.298–299; Dobres 2000.96–97; Miller 2007.4). Hence, the research of all these sequences within the ground and abrasive stone tools technology provides a lot of information linked to the structure of a given community, that is to say, the organization, choices and skills of the people who made these tools and the ways in which they would use them. The transformative processes through which the tools would pass, starting from the selection and processing of raw materials, through use, damage, repairs and other types of reuse, until the final discarding, depict the life history of an artefact (Skibo, Schiffer 2008; Schiffer 2010), and isolated activities within it represent sequences of the behavioural, *i.e.* operational chain (Lemonnier 1986; Dobres 2000; Skibo, Schiffer 2008). By studying and defining the life histories of ground and abrasive stone artefacts within a settlement, it is possible to interpret the cultural practices and technological patterns of the people who lived in it.

The assemblages from several Neolithic sites in Serbia were analysed from the typological and technological perspectives. Collections from certain sites could not

be included in the statistical analysis in this discussion due to the selective approach in the gathering of stone tools, which was a common practice in the archaeological research activities in Serbia up to the end of the 20<sup>th</sup> century. Pločnik thus remained outside of the statistical analysis even though it yielded a unique example of the secondary use of abrasive tools, as mentioned in the discussion (Dimić, Antonović 2021b; Dimić, *in preparation*). The sites selected have collections which comprise all the stone finds discovered during research conducted in the entire or the largest part of a given Neolithic settlement.

### Vinča

The Neolithic settlement in Vinča is located on the right bank of the Danube, about 15km downstream from Belgrade. The site has been researched, with interruptions, for more than a century: 1908, 1911–1913, 1924, 1929–1934, 1978–1986 and from 1998 to the present. The most extensive research activities were carried out from 1929 to 1934, when an area of about 2000m<sup>2</sup> and a layer with a thickness of up to 11m were investigated. The most recent research, which has been ongoing since 1998, has been carried out on an area of 300m<sup>2</sup> and provided the most representative sample for the study of abrasive stone objects (Tasić et al. 2015a.95). All the phases of the Vinča culture are represented at the site (5770/5565–4570/4460 cal BC; Tasić et al. 2015a.128). Remains of the Starčevo group have also been found in the deepest layers of the settlement, linked to the layer with pit-houses (Tasić et al. 2015a.125). The analysis of the material from precisely this site laid the foundations for the study of the ground stone industry (Antonović 1992). A sample of a total of 3000 examples of ground and abrasive stone tools from all research campaigns was analysed, but only those collected during research after 1998 were statistically analysed.

### Pločnik

This site is located in the south-west of Serbia, 21km west of Prokuplje. It was discovered in 1927, during the construction of the Prokuplje–Kuršumlija railway section. The first archaeological excavations of the site began in 1928 (Grbić 1929), and an area of about 500m<sup>2</sup> was explored at that time. The site was then researched on several occasions from 1960 to 1978, on an area of 765.5m<sup>2</sup> (Stalio 1960; 1962; 1964; 1967; 1973a; 1973b). The most extensive research activities in Pločnik were carried out from 1996 to 2013 (Kuzmanović Cvetković 2017; Radivojević et al. 2021a), when it was confirmed that it was a large Vinča me-

tallurgical centre. The settlement spread across c. 70ha (*Rassmann et al. 2021*). Five cultural horizons were singled out, in which all phases of the Vinča culture are represented (5389/5003 cal BC to 4446/4231 cal BC, *Marić et al. 2021b.451–453*). Ground and abrasive stone tools form a sample of 305 whole and fragmented tools. The tools were analysed in two stages, 2012–2013 (72 examples found in *Dimić, Antonović 2021b*) and 1996–2011 (233 examples found in *Dimić in preparation*).

### **Divostin**

Divostin is located in Central Serbia, 7km west of Krajujevac. The site has been known since 1952, and systematic research was carried out in the period from 1968 to 1970, within an American-Yugoslav project (*McPherron, Srejšović 1988*). An area of about 2400m<sup>2</sup> was researched in a 0.4–1.8m thick layer. The settlement itself covered the area of c. 15ha, while the surface finds were discovered on an area of about 50ha (*Bogdanović 1988.35*). Research activities confirmed the existence of two basic settlement phases – Divostin I from the Starčevo period (started at c. 6300, *McPherron et al. 1988; Porčić et al. 2020*) and Divostin II from the Late Vinča period (4740/4635–4675/4535 cal BC, *Whittle et al. 2016.21*). After the Vinča period, the site was no longer inhabited in prehistoric times. Ground and abrasive stone tools make up a sample of 658 whole and fragmented objects of this type (*Prinz 1988; Galdikas 1988*).

### **Mali Borak**

During protective archaeological excavations at the Kolubara coal mine in 2006–2010, three large prehistoric sites – Crkvine, Masinske Njive and Jaričište – were located in a row, at a distance of only a few hundred metres from each other – Masinske Njive at a distance of 900 metres from Crkvine, and at half that distance from Jaričište (*Blagojević, Arsić 2008a; 2008b; 2008c; 2009*). The settlement at Crkvine was inhabited during the later phase of the Vinča culture (*Živanović, Spasić 2008.205*). The neighbouring site of Masinske Njive lasted from the Late Neolithic / Early Eneolithic to the Early Bronze Age and it was inhabited by members of the Vinča culture (Vinča B1/B2; 5355/5215–5275/5070 cal BC, *Whittle et al. 2016.18*), as well as some cultures that did not originate from the Central Balkans, such as the Tiszapolgár, Lasinja, Baden, Lengyel and Cernavodă III cultures (*Blagojević, Arsić 2009.73*). The next site towards the west, Jaričište (6200–5500 BC, *Radivojević et al. 2021b.14*), was inhabited during the Starčevo and Vinča cultures, and then

during the Middle and Late Eneolithic (Baden culture, Boleráz–Cernavodă III and Balaton–Lasinja; *Blagojević, Arsić 2009.74*). It is interesting to note that the stone industry from the site of Crkvine shows no similarities with those from Masinske Njive and Jaričište, even though late Vinča ceramics have been recorded at all three sites. Judging by the stone industry, most prominently the ground stone tools production, the site of Crkvine seems like a completely separate world with no close ties with the inhabitants of the other two settlements. More than 20000 stone objects, mostly tools (only 0.1% of this number are decorative and cult objects; *Antonović 2013*) originate from the three sites mentioned.

At Crkvine, 5175 stone finds were collected from the researched area of about 3000m<sup>2</sup>, out of which 1320 examples (25.5%) were from chipped stone. Only 680 examples can be fully identified typologically as groundstone tools. The most numerous are tools with a cutting edge, followed by abrasive tools. The largest number of stone finds (61.35%) are flakes made during the production of ground stone tools with a cutting edge made from tuff. A large number of semi-finished products and flakes that occurred during their production indicate production within the settlement (*Antonović 2013*).

A total of 6619 stone objects were collected at the site of Masinske Njive, with 4957 examples belonging to the chipped stone industry. Out of the 1662 finds of the ground and abrasive stone industry, 1045 examples were typologically defined, and several types and variants of tools were recorded among them. It was not possible to determine the shape of 617 examples, and the most numerous among them were pieces of raw material or atypical fragments, flakes from ground tools, as well as products of the making of axes, adzes and chisels shaped by knapping. This large sample, however, did not provide solid evidence of an organized production of ground stone tools at Masinske Njive, which was otherwise preliminarily observed in chipped stone tools. Production within the settlement certainly existed, but on a small scale, as evidenced by a small number of pieces of raw material, a slightly larger number of flakes from the production of ground stone objects, as well as numerous ground stones (*Antonović 2013*).

Jaričište is the largest settlement in Mali Borak, with an explored area of 8ha (*Blagojević, Arsić 2008; Marić 2013.18*). At first glance, the stone industry from this

site shows great similarities with that from Masinske Njive. These are macroscopically very similar raw materials, as well as a large number of chipped stone tools. In the stone material examined so far, 60.96% of the finds belong to the chipped stone industry, and 39.04% of them have been identified as ground and abrasive stone tools, dominated by grindstones. A high percentage of pieces of raw material, semi-finished products and flakes from the process of making stone tools, as well as numerous grindstones, indicate production within the settlement. More than half of the ground stone finds have been typologically defined, which sets Jaričište apart from the previous two sites, where a significantly lower percentage of defined tools was recorded (Antonović 2013).

### Neolithic ground and abrasive stone tools

The ground and abrasive stone tools industry had already been fully developed when it appeared in the Neolithic of Serbia, with already clearly defined and formed types of tools. From the oldest to the youngest Neolithic settlement in Serbia, there is no essential difference in the ground and abrasive stone industry, the types of tools remained the same, just like most of the raw materials, but there are noticeable changes in the numerical representation of certain types of tools and raw materials (Antonović 2003.131). The only more prominent novelty was the appearance of white rocks among the raw material for the making of tools with a cutting edge, although this brought only a visual change, but not a typological or a technological one. On the other hand, abrasive tools remained constant throughout the entire Neolithic. At the end of this period, new types began to multiply, which had to respond to new demands of the society which was being developed technologically.

The division into ground and abrasive stone tools was made on the basis of the raw material from which they were produced, the manner in which they were made and their function.

The term ground stone tools refers to those tools whose final shape was obtained by grinding and polishing of their surfaces (Fig. 2). Their semi-finished products were made by knapping, and traces of this would often not be completely removed by the final processing. In the Neolithic of Serbia, ground stone tools were made from fine-grained rocks of various origins (hornfels, epidote schist, metamorphic sandstone, magnesite, etc., Antonović 2003.16–23; Antonović, Resimić-Šarić, Cvetković 2005; Dimić 2013.36; 2020; in preparation). These rocks are characterized by a conchoidal fracture, and hence semi-finished axes, adzes and chisels were mostly made from macroflakes, which gave them their recognizable and unique appearance (Antonović 2014). The primary function of these tools was for use in woodworking.

Axes are tools with a symmetrical profile (Fig. 2.a), whose cutting edge is in the plane of symmetry (Semenov 1976.125). Several types of axes with minimal differences in their shapes have been recorded at Neolithic sites in Serbia.

Adzes are asymmetrical tools (Fig. 2.b), whose cutting edge is not in the plane of symmetry (Semenov 1976.125). At Starčevo and Vinča sites, especially in Central Serbia, adzes were the dominant type among tools with a cutting edge, and sometimes even in the complete ground stone material (Antonović 2003.55).

Chisels are tools with a cutting edge that were sorted into a special group due to their small dimensions (Fig. 2.c). By their shape, they equally resemble axes and

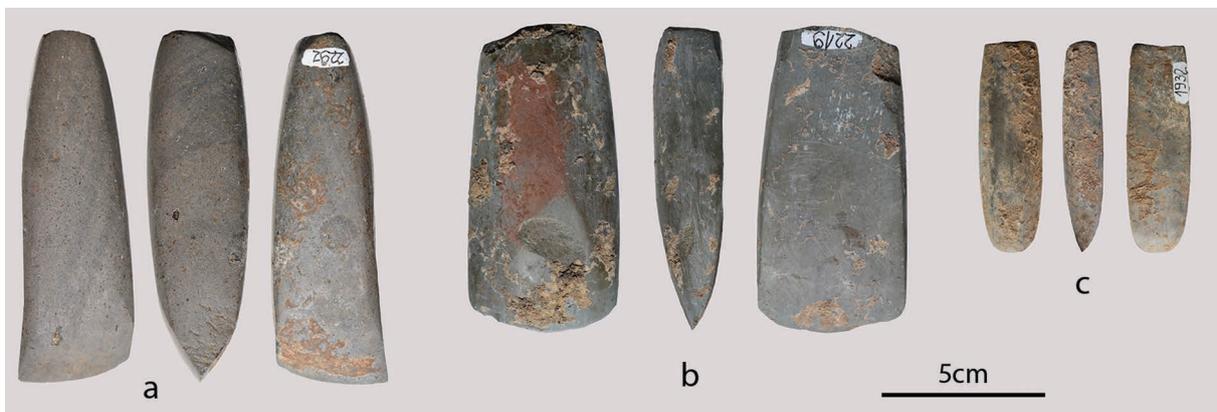


Fig. 2. Ground stone tools: a axe (Pločnik); b adze (Pločnik); c chisel (Pločnik).

adzes. These tools have been discovered on a large number of sites of the classic Starčevo and Vinča cultures, in a considerable variety of shapes, but they are, therefore, mostly found in small numbers.

Abrasive tools were made from rocks with abrasive properties (Figs. 3–4), such as sandstones and various types of magmatic rocks with a high contents of quartz (Antonović 2003.23–29; Antonović, Dimić 2022). Tools made of such rocks were produced by pecking, and polished surfaces were obtained during use, and thus such tools are separated into a special group different from ground stone tools. Abrasive tools include grindstones, whetstones, handstones, querns and mortars.

Grindstones, being tools for processing objects made of hard materials, were made exclusively from rocks with abrasive properties, such as sandstones, and more rarely from magmatic rocks containing quartz (Fig. 3.a–c). Several types of grindstones have been found at Neolithic sites in Serbia, differing by the shape and size, which depended on the types of objects that were being processed on them. The basic types were large stationary grindstones and small hand ones.

Whetstones (Fig. 3.d) differ from grindstones mostly by the raw material used for making them, namely fine-grained, softer rocks such as sandstones with no quartz or phyllites.

Handstones (Fig. 4.c) did not gain their form by intentional processing, but through use instead. They were pebbles of a suitable shape, of hard and solid rocks, most commonly magmatic, used to crush grainy fruits, grains, pigments, *etc.* Another type of handstones, namely, loaf-shaped handstones (Fig. 4.b) represented the mobile (upper) parts of saddle-formed querns, which were, due to their morphological properties, held with both hands and rolled over a quern slab while mincing or grinding wheat (Florin *et al.* 1958; Lindström Holmberg 1993; 1998.129; Dimić 2015.391–394; Antonović, Dimić 2022). The only typological difference between querns and loaf-shaped handstones which may (but need not) be indicative are the smaller dimensions of handstones compared to querns. On the other hand, the traceological differences are clear in terms of the orientation of linear

traces along the length, or otherwise along the width, of the working surface of the tool.

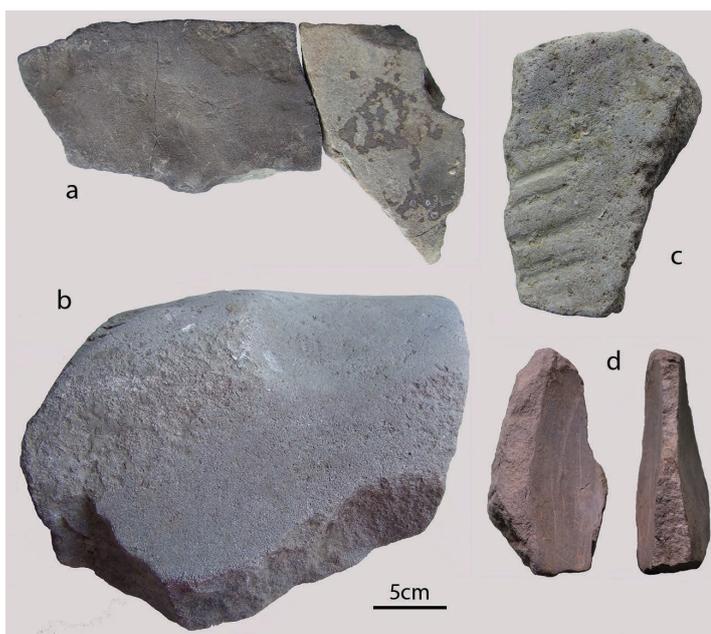
Querns are massive stone objects with a flat or slightly concave working surface, used to crush grains or other grainy fruits (Fig. 4.a,e). They were most commonly made from fine- to medium-fine-grained magmatic rocks or from fine-grained compact sandstones. When made from sandstones, it is difficult to distinguish querns from static grindstones, especially when they are in the form of smaller fragments.

Mortars are massive stone objects, similar to querns, differing from them by a larger recess on the working surface (Fig. 4.d). They were most probably used for crushing hard materials rather than crushing grains, as querns were used for the latter task.

### Long life of ground and abrasive tools

Ground and abrasive stone tools represented the peak in the production of prehistoric stone tools. They had the most complex and very dynamic life cycle. Due to the hardness and durability of stone, as well as its ability to be reused even after breaking, these tools could repeatedly circulate through different segments of the operational chain until they were finally discarded.

The life cycle of a ground or abrasive stone tool would begin with the procurement of the raw material, con-

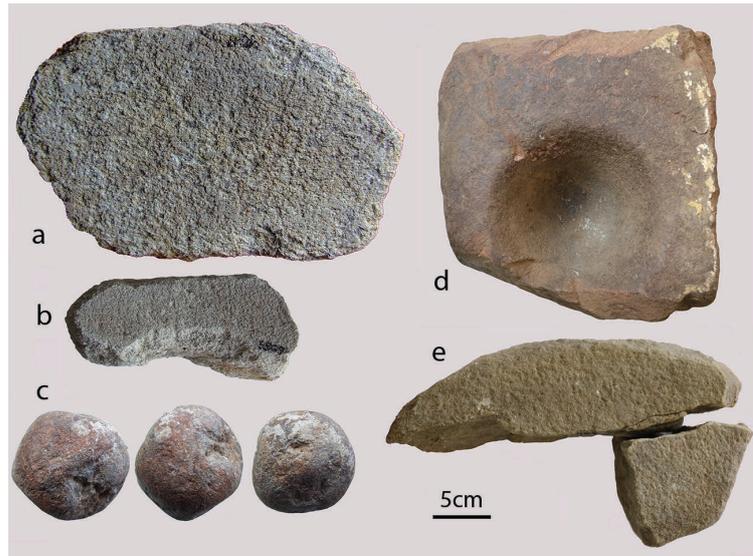


**Fig. 3. Abrasive stone tools: a–c grindstones (Vinča); d whetstone (Belovode).**

tinue with the production of a semi-finished artefact by knapping, followed by the grinding of the final product. After that the tool would be primarily used, often repaired after any smaller damage, and sometimes recycled or secondarily used before being discarded. Before reaching its final destination – an archaeological context – a stone tool could change its form and purpose several times during its life cycle (Fig. 5).

The first step of the operational chain – procurement of the raw material – would take place outside of a settlement. For the time being, it is not known whether the raw material was extracted in an organized quarry or collected on the surface of the terrain. No quarry with clear traces of Neolithic exploitation has been discovered in Serbia so far, but there are places where surface stone collection and even primary processing of amorphous blocks separated from the parent rock could have been carried out (e.g., the site of Trsine near Čačak, *Bogosavljević-Petrović 1998.3–5*). These are secondary deposits of stone raw materials where the rock material was deposited by successive erosion and fluvial processes (torrents and denudation). Sometimes, pieces of raw material would be brought to the settlement, where the rock would be turned into a finished product in workshops, as was recorded in Vinča, Crkvine in Mali Borak, Selevac, Ajmana, and Zbradila (*Voytek 1990.451; Antonović 2003.51; 2011.209–211; 2013.35–36, Fig. 4*). Completed semi-finished products would then be taken into the settlement, for further processing by grinding.

Semi-finished tools with a cutting edge were made by knapping. After separating a stone block for making tools, rough knapping would be performed in order to make a rough pre-form of the artefact that was to be

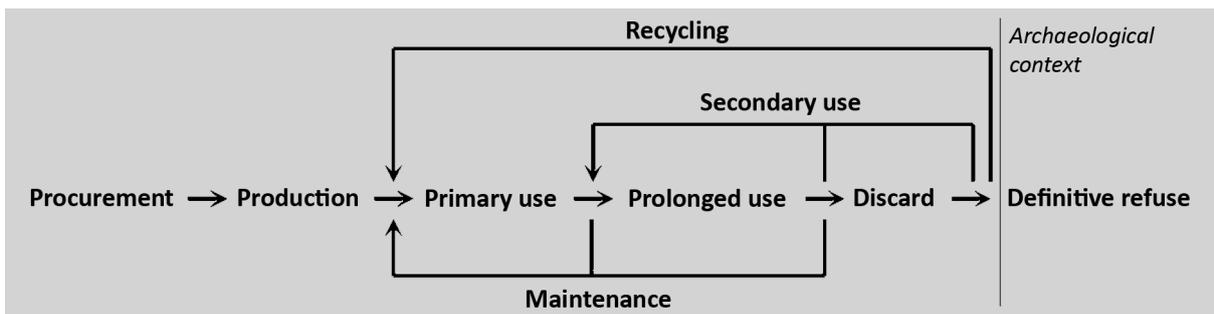


**Fig. 4. Abrasive stone tools: a quern (Jaričište); b loaf-shaped handstone; c handstone (Vinča); d mortar (Pločnik); e quern (Mali Borak, Jaričište).**

made (Fig. 6.a–d). Knapping was performed on both sides, the ventral and dorsal, as indicated by semi-finished products found. Finer flaking would usually be performed on the dorsal side, so that the platform would be on the ventral side (Fig. 6e).

Pecking is a technique similar to knapping, and it was used in the processing of rocks which do not have a conchoidal fracture. It was usually used for raw materials derived from secondary deposits, which had gained the suitable shape and smooth, round surface, similar to that of ground stone tools, through actions of natural processes, most commonly water (Fig. 4.c).

Grinding represented the final technique used in the processing of stone, with which the ground stone tools would be given their final form (Fig. 2). It was used to remove surfaces that were still not smooth after the previous processing, to correct the shape and form the cutting edge, which would thus become more resistant to damage.



**Fig. 5. Life cycle of ground and abrasive stone tools (scheme modified after Schiffer 1972).**

The final processing of tools could have been performed within a settlement, but also at the actual sources where the raw material had been obtained, thus leaving this point in the field of speculations. Organized workshops in settlements or places at raw material deposits where tools could have been ground have not been clearly defined as yet in Serbia.

Some tools could have been broken immediately after flaking and before final grinding, without any traces of use (Fig. 7). Such tools could have been used, in an unchanged form, in their basic function, but they could also have been used secondarily or be rerouted to the recycling process.

#### Primary use

Primary use is the action for which the tool was originally designed. Ground stone tools with a cutting edge (axes, adzes, chisels) were commonly used in woodworking. In the Neolithic, these tools consisted of two elements, a stone head and a wooden shaft to which those stone parts would be attached.

Axes are tools whose primary purpose was to cut down trees and split wood. Since the cutting edge was in the plane of symmetry, the use-wear marks were created evenly on both sides of the cutting edge. Those are short parallel furrows, slanting in relation to the cutting edge, accompanied by a polishing of the surface (Fig. 8.a). The orientation of the furrows can also be followed by longer, arched, isolated scratches. The cutting edge itself would get damaged during work (bluntness, flake negatives) and this damage usually looks like untidy knapping (Semenov 1976.125–129; Antonović 2003.53; Dimić 2015.54–57; 2020.364–394).



Fig. 7. Semi-finished adze from Mali Borak, Crkvine.

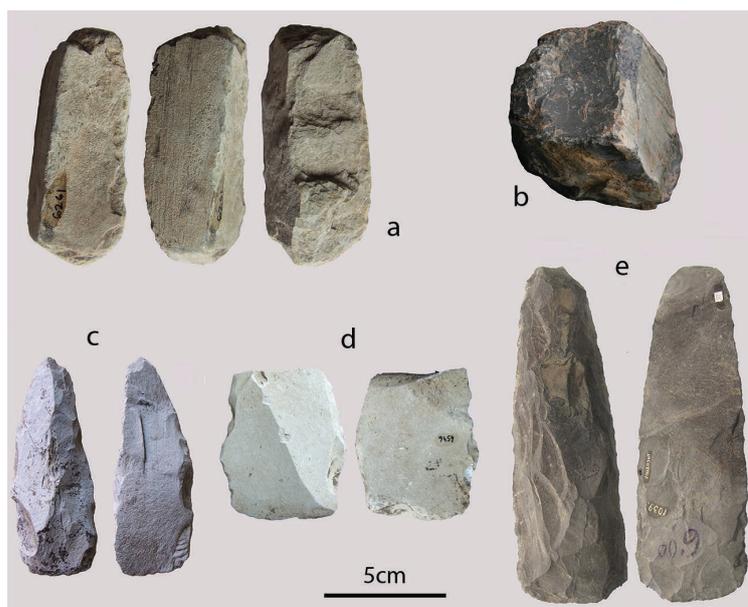


Fig. 6. Production of ground stone tools: a–b blocks of pre-formed raw material (Vinča and Mali Borak, Jaričište); c–d macroflakes – the first phase in production of roughouts (Mali Borak, Jaričište and Crkvine); e semi-finished adze prepared for final grinding (Vinča).

Stone adzes are tools that are very similar to axes according to their morphology, however, the adzes have an asymmetric shape, and were wedged in the handle so that the cutting edge would extend perpendicularly in relation to the longitudinal axis of symmetry of the handle (Semenov 1976.126; Antonović 2003.54; Dimić 2015.56–58; 2020.364–394). The asymmetric shape of adzes corresponded to their function, namely, hollowing and hewing wood, and they were used in the production of various types of wooden objects. Use-wear traces are dominant on the dorsal side, although they can also be found on the ventral side in longer-used examples. Depending on the length and intensity of use, the traces are in the form of fine parallel furrows, perpendicular to the cutting edge, followed by surface polishing, dullness of the cutting edge, as well as micro- and macro-flake negatives (Fig. 8.b).

Chisels were, almost as a rule, less common than axes at the Neolithic sites found in Serbia, and much rarer than adzes. Chisels were used almost exclusively in woodworking, and only exceptionally for splitting bones, too. Their abundance at a given site certainly indicates the more developed specialized production of wooden objects. They differ from axes and adzes by the manner in which they were

used. Chisels were not used for direct percussion, and instead force was applied by indirect hits of a stick against the ends of the tool or shaft, while the cutting edge was placed at a certain angle on the wood so as to penetrate it under pressure (Dimić 2020,364–394). Use-wear traces are very similar to those on the adzes blade, with the chisels showing a slightly more intense gloss on both sides of the blade (Fig. 8.c).

Abrasive stone tools (grindstones, whetstones, querns, handstones, mortars) were used both for food processing and also in the manufacturing of bone and stone tools. As such, their original use was for crushing, grinding, and abrasion.

Grindstones refer to tools used for grinding objects made of hard materials (stone, bone, antlers, ceramic, wood). This is why the working surface of such tools was smooth and recessed, while traces of previous processing by pecking would often remain visible in the outer parts of a given item. In whetstones, the working surface is also slightly concave, and always very smooth, almost polished (Fig. 3.d). This characteristic of the working surface is the result of using whetstones for working on objects made of me-

dium to hard materials (antlers, bone, certain types of rocks and minerals, such as marble and calcite). The experimental use of whetstones for sharpening the cutting edges of axes, adzes and chisels showed that even such a use would leave no traces in the form of grooves, only concave surfaces (Dimić 2020,338). Other use-wear traces, first and foremost grooves, cannot usually be identified on grindstones and whetstones, probably because of the use of water in grinding and polishing, which would erase all grooves (Miller 2007,59). Also, depending on the type of tools which were processed by these tools, wide (stone and antler tools) or shallow channels (small bone tools) with a regular or flared U cross-section can be seen on the working surface of grindstones (Figs. 3.c, 12).

The use of handstones is usually linked to wheat grinding, since they were often found alongside querns. However, judging by the use-wear traces on them they were multifunctional tools, also used as retouching tools, hammers and anvils. Out of all abrasive tools, it is difficult the most to fit spherical handstones into the category of ground stone tools, because they had not gained their shape through intentional processing; their ground, levelled and slightly flatten surfaces were created during use.

Use-wear traces on querns are rough surfaces which, almost as a rule, follow fine grooves parallel with the longitudinal axis of the tool (Fig. 4.a). The same use-wear traces can be spotted on elongated two-handed handstones ('loaf-shaped'), however, in this case, these use-wear traces always spread transversally (Fig. 4.b). They were used for grinding cereals and grainy fruits, water chestnuts, and so on.

Massive stone mortars with a working surface in the form of a recipient were most probably used for crushing hard materials such as pigments, pottery, mollusc shells, etc. Findings from late Vinča layers at Selevac were linked to early metallurgy and the crushing of malachite, which was further used in copper smelt-

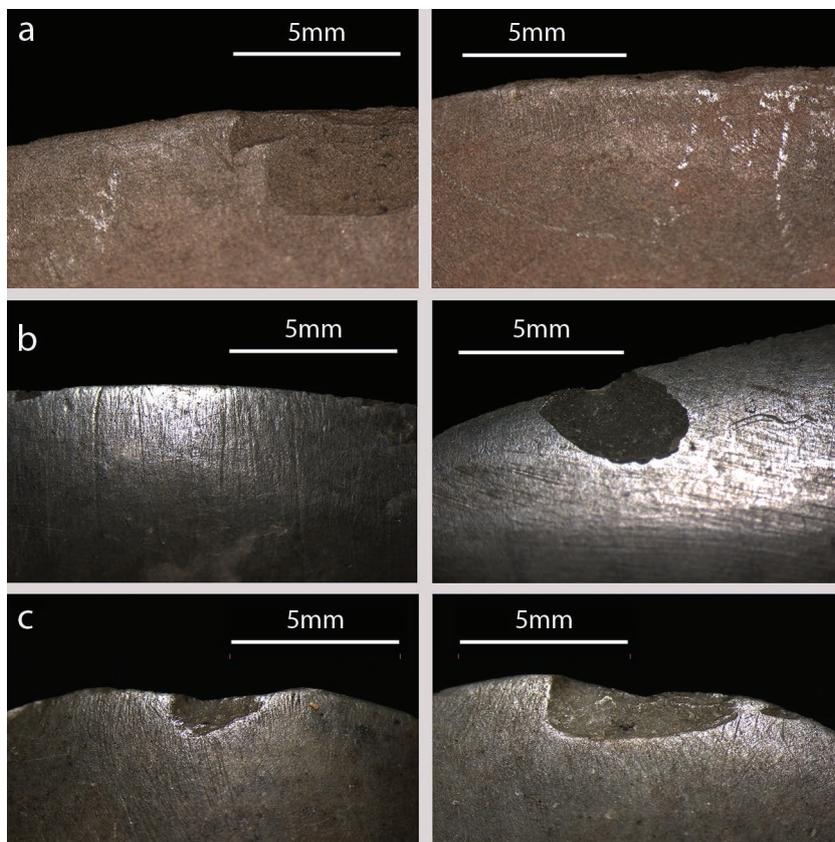


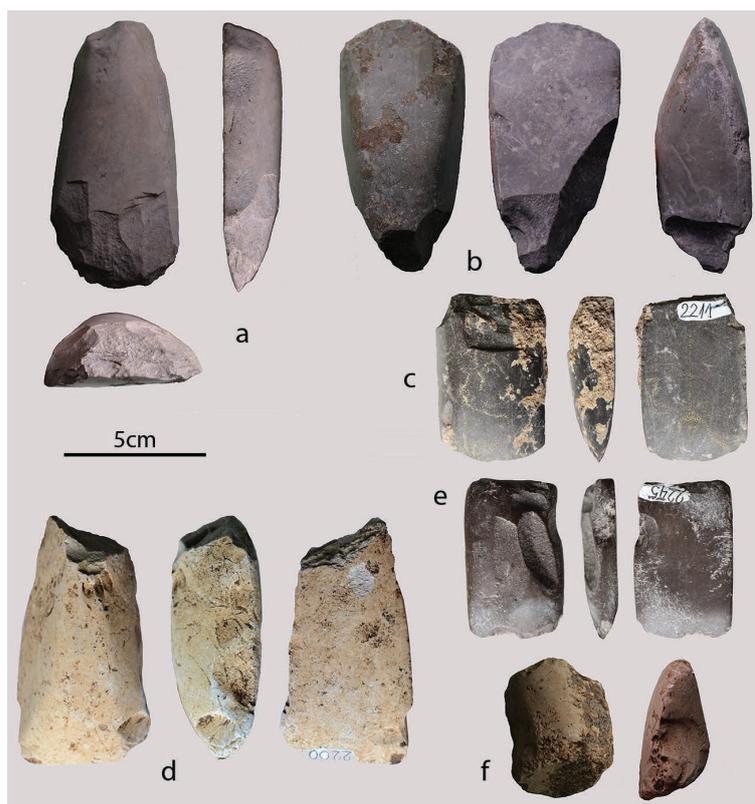
Fig. 8. Traces of primary use: a axe (Pločnik); b adze (Vinča); c chisel (Vinča).

ing (Spears 1990.503). It is believed that mortars from Potporanj were used for crushing mollusc shells, which would then be added, in this ground form, as admixtures in making pottery (Joanović 1982.9). Several typical examples of mortars from Pločnik should also be added to this group (Antonović, Dimić 2022.275), and it represents a transitional form between a grindstone and a mortar. The object was made from a thick slab of sandstone, which had become so concave from use in the central part that it gained the form of a mortar (Fig. 4.d).

### **Maintenance and prolonged life of artefacts**

Maintenance represents the rerouting of an artefact back to the manufacturing process in order to keep its primary function. The properties and efficiency of an object in terms of the task it was originally designed for would thus be maintained (Schiffer 2010.32–34). Maintenance is the common set of technological procedures applied to a partially damaged tool, applied so as to restore the characteristics needed for fulfilling the intended task (Fig. 9). Through this practice, a tool would not be discarded, recycled, or secondarily used yet (*i.e.* it would not start a new life cycle), but rather its primary life was preserved and thus extended.

When it comes to ground stone tools, maintenance through sharpening and repair was usually performed on the cutting edge, or on the proximal end, used to affix the tool to the shaft. The repairing of the proximal end is considerably rarer than the sharpening of the cutting edge. If the cutting edge was dull, it was repaired by resharpening, and if it was partially damaged, by retouching and then sharpening. The sharpening of stone tools involved grinding and possibly a final polishing of the cutting edge. This type of repair is recognizable by pronounced processing traces, and often by a complete absence of use-wear traces on the cutting edge. The difference between new, unused tools and repaired tools with a cutting edge is that there are visible use-wear traces on the proximal end of the repaired ones, and the shape of the entire tool would often be changed depending on the length of use.



**Fig. 9. Traces of maintenance: a adze with renewed cutting edge (Belovode); b adze with renewed proximal end (Belovode); c–e long used adzes (Pločnik); f adze at the end of life cycle (Belovode).**

Ground stone tools with a cutting edge could have remained in use in their primary function for a very long time by means of constant maintenance and careful use. Typical examples of tools that had been used for a very long time are those with a stubby appearance, in which the ratio of length to width is significantly reduced, and the angle of the cutting edge significantly increased (Fig. 9.c–e), making it questionable if they could still be used for their primary use (Dimić 2020.315–318). The shape of these tools could reach the lower limit of functionality or lose it completely by going through the process of maintenance and use multiple times (Fig. 9.f). Such tools could then be redirected to the recycling process (Fig. 14) or used without any changes in form in a secondary function (Fig. 11) or transferred to a secondary context, thus starting a second life cycle.

Maintenance of abrasive tools is much less common, primarily due to their massiveness and the size of the working surface, which, even after minor damage or partial fragmentation, still had the potential to perform the same function for which the tool was intended. Traces of maintenance are most noticeable in querns and loaf-shaped handstones, on which the

working surface was roughened by pecking. Traces typical of this practice are represented by a concave polished work surface with regularly spaced small recesses. The use of that percussive technique in repairs was a frequent reason for the fragmentation of massive abrasive tools (Fig. 4.e). On fragmented tools that have been discarded, and not rerouted to recycling or secondary use, it is sometimes possible to see the place of the last stroke that caused the fracture. For tools with multiple simultaneous functions, such as those that simultaneously served as grindstones, work plates, and anvils, fragmentation would occur most often after striking at the thinnest, most worn-out part.

The same as in the case of ground stone tools, abrasive stone tools show traces of very long exploitation. Long use, with or without regular maintenance, is characteristic of abrasive tools that were used until the working surface would become so recessed and concave that it would no longer be usable for the basic function of the tool. In those cases, it would often happen that the opposite side of the tool was used until it would become worn out in the same way, eventually leading to the breaking of the tool at its thinnest part (Fig. 10). The extensive usage lasted as long as the form of the tool reached the lower limit of the functionality or lost it. Such an item was either discarded, or, if there was enough usable raw material left, it was redirected to a secondary use or recycling, depending on the tradition and cultural practice of the community (Fig. 3.b).

### Secondary use

When it comes to secondary use, no modifications of tool forms would occur before performing the new task (Jacquier, Naudinot 2015.270–271; Schiffer 2010.33). If a worn-out tool or the remaining fragment of a tool had a satisfactory shape and technical properties, it



Fig. 10. Worn out mortar from Pločnik.

could be secondarily used for a function other than the primary one, without any modification. In addition, whole or fragmented ground and abrasive stone tools could be used in different secondary contexts as well.

Therefore, after damage which prevented rerouting a tool to the repairing process, ground stone axes and adzes were secondarily used as hammers, pounders, or retouchers (Fig. 11).

Secondary use is most commonly recorded on abrasive tools. Fragments of bigger grindstones, querns, and mortars would become smaller grindstones, handstones or grindstones for awls and needles, bone and wood handles, and so on (Fig. 12).

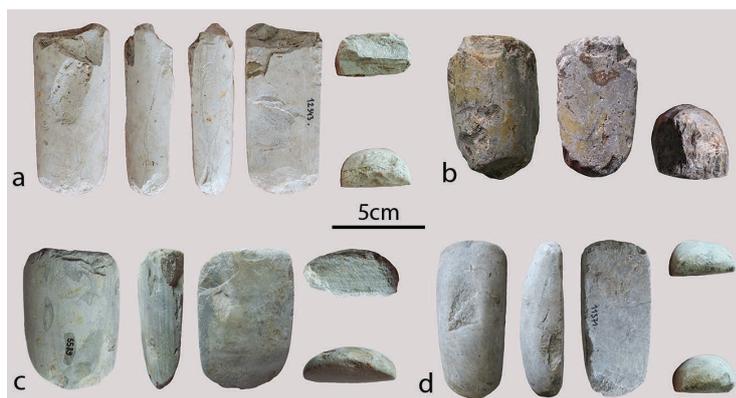
Finally, abrasive tools were used as building stones in house and furnace substructures. Usually, they were mixed with pottery sherds, like in Vinča. At Pločnik, there is a unique situation in the Neolithic of Serbia, where numerous abrasive tools with minor damage, practically still functional, were used as building stones (Fig. 13, Marić et al. 2021a.291). It can be assumed that this settlement was the centre for the manufacture of abrasive tools and their inhabitants thus had the privilege of rejecting tools with minor damage and repurposing them as building stones. This is a reflection of a specific technological choice, derived most likely from the fact that the site was surrounded by easily accessible deposits of quality sandstone.

### Recycling

Recycling refers to changes in the form of an artefact in order to adapt it to a new function (Jacquier, Naudinot 2015.270–271; Schiffer 2010.33), or to use it as a raw material. A prerequisite for recycling is an optimal amount of raw material that would remain after a tool was damaged.

Ground stone axes, adzes and chisels were usually recycled by knapping into hammers, pounders, or even cores for chipped stone tools (Fig. 14). After knapping, the polishing process would sometimes completely erase the initial traces of manufacture, so it is not always easy to recognize a recycled tool and distinguish it from one that was in secondary use. Proximal and medial parts of ground stone axes, adzes and chisels were mostly used for recycling.

Abrasive tools have rarely gone through the recycling process and were more often used in



**Fig. 11. Secondary use:** a,d *medium part of a tool with a cutting edge, secondarily used as hammer (Jaričište)*; b *proximal part of a tool with a cutting edge, secondarily used as hammer (Belovode)*; c *distal part of a tool with a cutting edge, secondarily used as hammer (Jaričište)*.

secondary functions, or in a secondary context, without any change of the final shape which they acquired through primary usage. Some of the frequent examples of recycled abrasive tools are fragments of querns whose shape was adjusted through knapping or pecking so they could be used as handstones (Fig. 4.b).

## Discussion

Techniques for processing stone raw materials were largely standardized, and hence the manner in which secondary use, maintenance, repairing and recycling of stone tools would be performed was also largely uniform.

The availability of raw materials, the degree of the development of the related crafts, as well as technological traditions and practices, greatly influenced the general appearance of the ground stone industry in every settlement. The degree and variety of artefact reuse modes could indicate how different Neolithic communities solved certain problems, as well as the technological choices made in solving them. The degree of recycling shows how close a settlement was to the raw material source, how accessible a given raw material was and whether craftsmen who were making stone tools were present in the settlement. It has to be kept in mind that maintenance could be performed as a regular domestic activity in every household, which differs from the professional production of stone tools

in workshops specially organized for the production of tools.

The scenario set out above is reflected in some Neolithic settlements. Pločnik, Vinča, and Divostin were large production centres for ground and abrasive stone tools in the Vinča culture. They imply the use of available sources of raw material and the existence of skilful craftsmen, but also of a social organization, in which some settlements were specialized for raw material procurement, some for the production of semi-finished tools, and others for the manufacturing of final products (Vitezović, Antonović 2019).

In Divostin, 72% of all ground stone tools with a cutting edge made of porcelanite<sup>1</sup> were semi-finished items (Prinz 1988.264). Some tools were made from large thick flakes with clearly visible bulbs for percussion and striking platforms. More than half of the porcelanite tools were only partially polished or have no traces of polishing whatsoever (Prinz 1988.258). Numerous porcelanite tools, although without a clearly defined platform and bulbs for percussion, or else traces of cleavage, had shapes suggesting that they were made of flakes. The concentration of debris in some parts of the excavated area indicate the zone, or several zones, where ground



**Fig. 12. Pločnik: grindstone for bone awls and needles.**

<sup>1</sup> Beth Prinz (1988) identifies the raw material as porcelanite, while Alan McPherron (1988) believed it to be magnesite. The raw material belongs to the group of so-called light white rock, which were typical for the Late Vinča ground stone industry in Central Serbia.

stone tools were manufactured. A large pit (Feature 40) was completely filled with *c.* 1 m<sup>3</sup> of debris derived from the production of ground stone tools, and 120 ground stone tools were found in Sector D, which is almost twice the expected distribution. Macroflakes of adequate size for the production of axes and adzes were not discovered in the entire excavated area at Divostin (Prinz 1988.258; McPherron 1988.225). On the basis of all this, it can be assumed that the final processing of semi-finished products and ground tools, most prominently those made of porcelanite, was conducted in the actual settlement, on already prepared large flakes, which have not been discovered within the settlement. It can be assumed that they were brought to the settlement for final processing, thus implying that several settlements or at least working camps participated in the production chain.

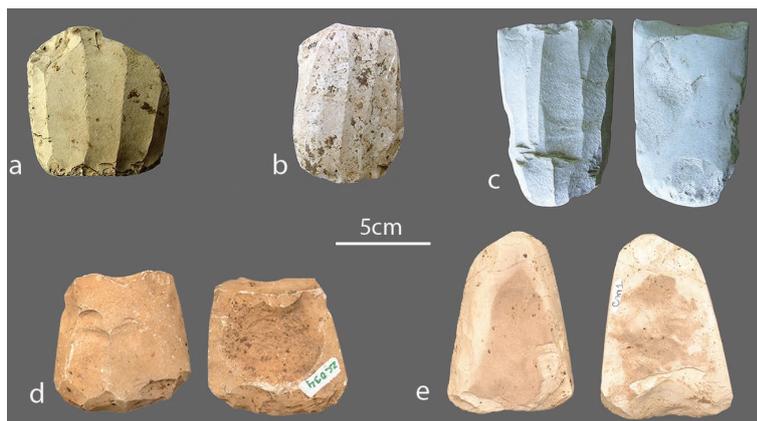
In Vinča, during the research which has been ongoing since 1998, examining layers of the final phase of the Vinča culture on an area of 450 m<sup>2</sup> (Tasić et al. 2015b.1069), all stone finds were collected with special care taken in registering their horizontal stratigraphy. In that area, where 10 houses were discovered, 1800 mostly fragmented artefacts made of ground and abrasive stone were collected. Only a small number originated from houses, mainly those linked to food preparation (Borojević et al. 2020). Most of the finds were deposited in areas around the houses. Out of the total number of finds collected, 72.85% are abrasive tools (61.95% for processing objects made of hard

materials, 11.2% for food preparation), and only 7.05% are defined as tools with a cutting edge, with only a third of them finally processed. No workshop for the production of ground and abrasive stone tools was recorded in this entire area. A possible answer for such a situation was provided by dug-out U 830 north of house 01/02, which abuts its northern wall. Aside from a huge amount of fragmented pottery, animal bones that were not exposed to atmospheric influences for a long time, indicating their rapid deposition, were also found along with waste stone material. In addition to used cores from the production of chipped stone tools and a small number of flakes from the production of ground stone tools, 186 examples of abrasive tools were found, with 71.5% of them being fragmented grindstones. It could be assumed that the final processing of stone tools by polishing was carried out in the area around the houses, which was regularly cleaned and the waste material was deposited in a pit that only served as a landfill. The few flakes found in U 830 may indicate occasional repairs made to damaged ground stone tools before final processing by grinding.

Pločnik, with its remarkable collection of large abrasive stone tools discarded after short-term use, suggests a closeness of raw material deposits and probably numerous very skilful craftsmen who made the stone tools. Out of 305 tools, there are only 2% semi-finished products, and the rest are finished products or tools used without any processing traces (*e.g.*, hammers, some abrasive tools, *etc.*). The technology for making ground stone tools indicates standardization, both in terms of forms and raw material choice throughout the entire life of the settlement (Dimić, Antonović 2021b). Adzes made of 'light white stone' are especially prominent among ground stone tools with a cutting edge, and they also represent the only non-metal objects found together with massive metal items in several hoards (Šljivar 1996; Šljivar et al. 2006.261–265). The most recent hoard of adzes was found during the last examination of the site in 2013. It was located in front of the wattle and daub building (feature 1), right next to its outer wall, and it is associated with massive grinding stones. For now, this is the only place that can be interpreted as a workshop at this settlement (Marić et al. 2021a.286–288). Use-wear traces can be noted on 86% of the final processed tools, and the rest are unused tools or fragments. Traces of repairs were identified on 11% of the tools. About 11.5% of the tools have traces of recycling processes, while a smaller number, only 2.6%, were successfully recycled. Secondary use was recorded on 4%



**Fig. 13. Pločnik: foundation of Feature 11 comprising damaged abrasive stone tools (Marić et al. 2021a.291).**



**Fig. 14. Recycled tools: a–c proximal ends of tools used as cores for chipped stone tools (Crkvine Vinča); d–e distal end of tools with a cutting edge, retouched and used as scrapers (Ladarište).**

of the tools received for analysis, although this number is significantly higher in reality. We would like to point out that there is a large number of abrasive tools with an uncertain context, and that a large amount of these tools were discarded during excavations before any specialized processing, which unfortunately was a decades-long practice that is slowly changing in Serbian archaeology. In photographs from the field, abrasive tools can be clearly seen in the substructures of buildings (Fig. 13), although they have not been subsequently found in the material. Abrasive tools that arrived for analysis make up 40% of the collection, including a significant amount of static grindstones and whetstones used for processing stone items. A small number of tools from the collection (16%) had been exploited for a very long time, both in a primary and secondary use.

Three settlements in Mali Borak were probably production and recycling centres for the whole area. Judging by the stone finds, especially those made of ground and abrasive stone, one gets the impression that all three sites were collection centres of a kind. A considerable amount of large pieces of raw material, flakes from the production process and semi-finished products confirm the manufacturing character of these settlements. However, a significant number of damaged and broken tools, as well as unsuccessful semi-finished products that were discarded because they could not be shaped into a final tool, show that these places were also used for waste deposits. The material was deposited in pits, which were numerous in all three sites (Blagojević, Arsić 2008a; 2008b; 2008c; 2009; Živanović, Spasić 2008). At Jaričište, out of a total of 5000 pieces of ground and abrasive stone tools, almost 30% were final products and only 1.32%

have traces of use. The rest of the assemblage consists of damaged artefacts with some traces of unsuccessful repairing and recycling, and pieces of raw material. At Masinske Njive, out of almost 1700 ground and abrasive stone items, 46% are final products, but only 2.1% have traces of use, 55% are also damaged items with traces of unsuccessful repairing and recycling, and pieces of raw material. At Crkvine, out of 635 artefacts of ground and abrasive stone tools, 65% are final products with traces of maintenance and traces of recycling are visible on 12.3%. The only place which can be defin-

edas a workshop was found at Crkvine, which was probably the centre for the production of chipped and ground tools made of white tuff.

### Conclusion

On the basis of a large number of secondarily used and recycled artefacts, as well as tools that were in use over a long period of time, it can be concluded that the utilization of raw materials was maximized on the entire territory of Serbia during the Neolithic. Studying multiple biographies of ground and abrasive stone tools can show the place in the technological chain of every Neolithic settlement individually. The maximal usage of raw materials through processes of reuse is not a modern attainment, but instead is a practice which existed from the earliest times, which survived up to today, with a smaller or larger amount of technological changes. Techniques for processing stone raw materials in Serbia during the Neolithic were mostly standardized, and hence this was also the case with the manner of their secondary use, recycling, maintenance and repairs. Consequently, the knowledge of the operational chain of ground and abrasive stone tools enables an analytical focus on defining the ways in which these artefacts may have been primarily used or reused, and ultimately discarded. It is obvious that not all of the settlements were engaged in every step of managing the raw materials, tool production and recycling, suggesting some sort of craft specialization among them (Vitezović, Antonović 2019). Technological and functional studies of assemblages of stone artefacts are thus extremely important for a more comprehensive understanding of the social practices and ways of life in the Neolithic, both in this region and elsewhere.

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